CITY OF BOULDER
PLANNING BOARD MEETING AGENDA
DATE: November 17, 2016
TIME: 6 p.m.
PLACE: 1777 Broadway, Council Chambers

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1. **CALL TO ORDER**

2. **APPROVAL OF MINUTES**
   The October 20, 2016 and November 3, 2016 minutes are scheduled for review.

3. **PUBLIC PARTICIPATION**

4. **DISCUSSION OF DISPOSITIONS, PLANNING BOARD CALL-UPS/CONTINUATIONS**
   A. Call Up Item: 236 Pearl Street; Floodplain Development Permit (LUR2016-00085); Wetland Permit (LUR2016-00091). This decision may be called up before Planning Board on or before November 17, 2016.

   B. Call Up Item: 4525 Palo Pkwy Subdivision Final Plat (TEC2016-00031). Request for approval of a Final Plat to replat an existing approximately 3.2-acre parcel as one lot suitable for development and grant easements. The call up period expires on November 22, 2016.

5. **PUBLIC HEARING ITEMS**
   A. AGENDA TITLE: Planning Board public hearing to consider a public request for map changes to the Boulder Valley Comprehensive Plan (BVCP) for 3261 3rd Street.

   B. AGENDA TITLE: City Council request for Planning Board to reconsider a Boulder Valley Comprehensive Plan map change for 0, 693, 695 Broadway (Table Mesa Shopping Center). The public hearing on this matter was concluded at the October 13, 2013 Planning Board meeting.

   C. AGENDA TITLE: Public Hearing and Recommendation to City Council for Acceptance of the Boulder Wastewater Collection System Master Plan (WWCSMP) and Action on the Proposed Amendments to the Comprehensive Plan (BVCP) Wastewater Utility Summary.

   D. AGENDA TITLE: Public Hearing and Recommendation to City Council for Acceptance of the Boulder Stormwater Master Plan and Action on the Proposed Amendments to the Comprehensive Plan (BVCP) Flood and Stormwater Utility Summary.

6. **MATTERS FROM THE PLANNING BOARD, PLANNING DIRECTOR, AND CITY ATTORNEY**
   A. Discussion of Planning Board Subcommittee Regarding Community Benefit

   B. Letter to City Council

7. **DEBRIEF MEETING/CALENDAR CHECK**

8. **ADJOURNMENT**

CITY OF BOULDER PLANNING BOARD
MEETING GUIDELINES

CALL TO ORDER
The Board must have a quorum (four members present) before the meeting can be called to order.

AGENDA
The Board may rearrange the order of the Agenda or delete items for good cause. The Board may not add items requiring public notice.

PUBLIC PARTICIPATION
The public is welcome to address the Board (3 minutes* maximum per speaker) during the Public Participation portion of the meeting regarding any item not scheduled for a public hearing. The only items scheduled for a public hearing are those listed under the category PUBLIC HEARING ITEMS on the Agenda. Any exhibits introduced into the record at this time must be provided in quantities of ten (10) to the Board Secretary for distribution to the Board and admission into the record.

DISCUSSION AND STUDY SESSION ITEMS
Discussion and study session items do not require motions of approval or recommendation.

PUBLIC HEARING ITEMS
A Public Hearing item requires a motion and a vote. The general format for hearing of an action item is as follows:

1. Presentations

a. Staff presentation (10 minutes maximum*)
b. Applicant presentation (10 minute maximum*). Any exhibits introduced into the record at this time must be provided in quantities of ten (10) to the Board Secretary for distribution to the Board and admission into the record.
c. Planning Board questioning of staff or applicant for information only.

2. Public Hearing

Each speaker will be allowed an oral presentation (3 minutes maximum*). All speakers wishing to pool their time must be present, and time allotted will be determined by the Chair. No pooled time presentation will be permitted to exceed ten minutes total.

- Time remaining is presented by a Green blinking light that means one minute remains, a Yellow light means 30 seconds remain, and a Red light and beep means time has expired.
- Speakers should introduce themselves, giving name and address. If officially representing a group, homeowners' association, etc., please state that for the record as well.
- Speakers are requested not to repeat items addressed by previous speakers other than to express points of agreement or disagreement. Refrain from reading long documents, and summarize comments wherever possible. Long documents may be submitted and will become a part of the official record.
- Speakers should address the Land Use Regulation criteria and, if possible, reference the rules that the Board uses to decide a case.
- Any exhibits introduced into the record at the hearing must be provided in quantities of ten (10) to the Secretary for distribution to the Board and admission into the record.
- Citizens can send a letter to the Planning staff at 1739 Broadway, Boulder, CO 80302, two weeks before the Planning Board meeting, to be included in the Board packet. Correspondence received after this time will be distributed at the Board meeting.

3. Board Action

d. Board motion. Motions may take any number of forms. With regard to a specific development proposal, the motion generally is to either approve the project (with or without conditions), to deny it, or to continue the matter to a date certain (generally in order to obtain additional information).
e. Board discussion. This is undertaken entirely by members of the Board. The applicant, members of the public or city staff participate only if called upon by the Chair.
f. Board action (the vote). An affirmative vote of at least four members of the Board is required to pass a motion approving any action. If the vote taken results in either a tie, a vote of three to two, or a vote of three to one in favor of approval, the applicant shall be automatically allowed a rehearing upon requesting the same in writing within seven days.

MATTERS FROM THE PLANNING BOARD, DIRECTOR, AND CITY ATTORNEY
Any Planning Board member, the Planning Director, or the City Attorney may introduce before the Board matters which are not included in the formal agenda.

ADJOURNMENT
The Board's goal is that regular meetings adjourn by 10:30 p.m. and that study sessions adjourn by 10:00 p.m. Agenda items will not be commenced after 10:00 p.m. except by majority vote of Board members present.

*The Chair may lengthen or shorten the time allotted as appropriate. If the allotted time is exceeded, the Chair may request that the speaker conclude his or her comments.

CITY OF BOULDER
PLANNING BOARD ACTION MINUTES
October 20, 2016
1777 Broadway, Council Chambers

A permanent set of these minutes and a tape recording (maintained for a period of seven years) are retained in Central Records (telephone: 303-441-3043). Minutes and streaming audio are also available on the web at: http://www.bouldercolorado.gov/

PLANNING BOARD MEMBERS PRESENT:
John Gerstle, Chair
Liz Payton, Vice Chair
John Putnam
Leonard May
Crystal Gray

PLANNING BOARD MEMBERS ABSENT:
Bryan Bowen
Harmon Zuckerman

STAFF PRESENT:
Susan Richstone, Deputy Director of Planning
David Driskell, Executive Director, PH&S
Kurt Firnhaber, Deputy Director of Housing
Lesli Ellis, Comprehensive Planning Manager
Hella Pannewig, Assistant City Attorney
Cindy Spence, Administrative Specialist III
Jean Gatza, Senior Planner
Kalani Pahoa, Urban Designer
Jim Robertson, Chief Urban Designer
Philip Kleisler, Planner II

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1. CALL TO ORDER

Chair, **J. Gerstle**, declared a quorum at 6:09 p.m. and the following business was conducted.

2. APPROVAL OF MINUTES

On a motion by **C. Gray** and seconded by **L. Payton** the Planning Board voted 5-0 (**B. Bowen** and **H. Zuckerman** absent) to approve the October 6, 2016 and October 13, 2016 minutes as amended.

3. PUBLIC PARTICIPATION

1. **Davis Bacher** expressed concerns regarding bicycle safety and access in the city.
2. **Stephanie Minutillo** suggested amending the draft of Section 4.03 of the Boulder Valley Comp Plan Update to include the creation of a Renewable Energy Generation Plan to foster community solar garden development in the city and county.

3. **Laura Tyler** spoke on behalf of the South Boulder Creek Action Group which supports the annexation of CU South for flood mitigation.
4. **M. L. Robles** spoke regarding Middle Income Housing Strategy specifically the prioritization of the Neighborhood Innovative Pilot Program implementation in 2017.
5. **David Adamson** spoke in support of Middle Income Housing Strategy on behalf of Goose Creek Neighborhoods.

4. DISCUSSION OF DISPOSITIONS, PLANNING BOARD CALL-UPS / CONTINUATIONS

5. DISCUSSION ITEMS

A. AGENDA ITEM: Middle Income Housing Strategy - update on the draft middle income goal and strategy components

Staff Presentation:
K. Firnhaber and **J. Sugnet** presented the item to the board.

Board Questions:
K. Firnhaber, **J. Sugnet**, and **S. Richstone** answered questions from the board.

Board Comments:
<u>Key Issue #1</u>: Proposed middle income housing goal?

- **C. Gray** said that she did not believe that the proposed strategy was "bold" enough. She encouraged the staff to be "bolder" if they want to be serious, given that out of the 3500 proposed units, 2500 would be market rate. She disagreed that was "bold" since there needs to be more certainty surrounding the market.
- **J. Putnam** agreed but added that staff needs to be realistic. He stated that unless the city were to contribute money, buy properties and build structures, he was not sure how to stretch the numbers as proposed.
- **L. May** stated the strategy is a good start but not a comprehensive approach. It falls short due to too much focus on market rate. In addition, it needs analysis to achieve higher levels of permanent affordability. He proposed incentive based zoning. The strategy will not preserve rental and ownership affordability. He would like to see a policy with no net loss at either an absolute number or a percentage.
- **L. Payton** agreed with **L. May**. She questioned if the goal was a percentage or an absolute number. It seemed unclear. If there are tools (e.g. demolition ordinance) that keep the housing standard affordable for high income households from growing, that may keep the affordable housing more balanced.
- **L. May** said that the approach and mix of unit types in the strategy are correct. He is concerned with affordability in the next 20 years. He suggested the "for sale" units be deed restricted so they can be held onto in the future. Therefore, what may be affordable today will not become unaffordable in the future.
- **J. Gerstle** agreed with **L. May** regarding the permanent affordable housing. He stated that we should be proactive by looking at significant changes in the demo ordinances to maintain the existing facilities. He encouraged the City of Boulder to be an active player

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financially to ensure that existing homes remain affordable and not demolished and that new affordable housing is established.

- **J. Putnam** added that before a goal is set, it would be helpful for City Council to see not the one number (the goal), but rather what it would look like.

<u>Key Issue #2</u>: Proposed policies and tools to preserve and create middle income housing?

- **C. Gray** proposed that annexations should be 50% lower to moderate income. The other 50% should be maintaining the middle.
- **L. Payton** supports polices #1, #2, #3, and #4. She has concern prioritizing the middle-income goal over other community goals such as climate change. She would like to add a policy regarding demolition.
- **J. Gerstle** agreed that revising the demolition regulation would be appropriate.
- **J. Putnam** agreed that demolitions, additions and expansions need review.
- **C. Gray** agreed. She suggested incorporating land use policies such as expanding the use of OAUs. ADUs could be reviewed as well.
- **L. Payton** supports the idea of funding for building or buying existing middle income housing so it can be permanently affordable deed restricted. It will keep things affordable in the future, unlike having them at market rate.
- **J. Gerstle** stated that the city needs to become an active player in obtaining these houses and placing deed restrictions.
- **J. Putnam** explained that that approach would be more expensive per unit than affordable housing and the city would need to choose between affordable and middle income housing.
- **L. May** added that cost would not be the only factor but where we would end up in future. Regarding incentive zoning, he stated that height falls along with FAR. If entitlements are expanded to build more, then possibly 100%, up to 150% AMI, should fall within the affordable category.
- **J. Putnam** disagreed regarding height and that it would fall in that category.
- **C. Gray** appreciated secondary middle income housing tools.
- **L. Payton** didn't see co-ops as a housing type for middle income. She suggested that if new construction were proposed, co-ops should be a possibility under this goal.

<u>Key Issue #3</u>: Proposed next steps and timeline?

- **J. Putnam** stated the Next Steps are general which is appropriate. It would be helpful to think about a neighborhood based pilot sooner than later. Smaller based areas to test ideas with community engagement would be a good start.
- **L. May** agreed that it would need to be on a smaller scale to receive support.
- **L. Payton** stated the need to address the shift, which is occurring, of single family housing used towards rental or investment properties.
- **J. Gerstle** stated that this situation is why he is skeptical to rely on market rate and feels the city should be more active with deed restricted housing. He proposed the city look at financial options to becoming more active in the market itself and the implications of revising the demolition rules to review the economic consequences.
- **L. Payton** asked that public outreach be more explicit.
- **C. Gray** agreed with **L. Payton**.

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<u>Key Issue #4</u>: Updating the inclusionary housing ordinance to include a middle-income requirement?

- **C. Gray** and **J. Gerstle** agreed with staff recommendation.
- **L. May** stated that in terms of the commercial linkage fees, it would be good to have scenarios to entertain the higher range in the fees. He said that there should be a cost benefit comparison. He agreed with the inclusionary housing.

B. AGENDA ITEM: Update on 30th and Pearl Redevelopment Scenario Analysis

Staff Presentation:
D. Driskell and consultants **John Koval** and **Peter Weber**, with Coburn Partners, presented the item to the board.

Board Questions:
D. Driskell, **K. Firnhaber**, **John Koval** and **Peter Weber** answered questions from the board.

Board Comments:
<u>Key Issue #1</u>: Proposed Scenarios

- **L. Payton** stated that for commercial spaces, it would be good to have locally owned businesses located on site. Perhaps that could be done through land use regulations and avoid subsidies.
- **J. Putnam** stated that, given the goals of TVAP, if there is a development of an RFP, there may be some weight given to different proposals that may have creative ideas. He suggested that it may be worth looking at a component to encourage creativity to obtain other goals for the city. It may help encourage street activation in that area. It may be difficult to have community industrial use in the area.
- **L. May** agreed with **L. Payton** and **J. Putnam**. He said that Scenario #4 would meet the range and goals. He suggested having another analysis done to increase flats and decrease townhouse. It would be consistent where housing needs are in the center and expensive. He would also like to see an analysis that if market rate units were deed restricted, so that over time they fell into the affordable category (150% AMI), how would that change the money that the city would need to contribute.
- **L. Payton** disagreed. When you build flats, you're spawning sprawl. Townhomes need to be retained, especially in Boulder Junction. She encouraged on-site affordable daycare.
- **L. May** said that this would be a good place for density.
- **J. Gerstle** agreed with providing family services and that family friendly stacked apartments would be a great addition. In Scenario #4, he remarked that the available yard space would be small. He was skeptical as to the value of raising a family. He asked to consider the stacked flats alternative.
- **L. May** suggested increasing the number of units at this site.
- **L. Payton** disagreed with the notion of stacked apartments as it would not be ideal for raising children.

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<u>Key Issue #2</u>: Staff Recommendation

- **J. Putman** stated that the staff recommendation of Scenario #4 would be a good place to start. He suggested finding ways to create more commercial in the plan to enrich the community. Perhaps the introduction of a co-op housing element or daycare for examples. The core for Scenario #4 in terms of balance is heading in the right direction.
- **L. Payton** agreed. She supports townhome units on-site to assist with the missing middle income housing.
- **J. Gerstle** agreed. It would be essential to have mix of market rate and subsidized housing on-site. Scenario #4 makes sense, but implies a contribution from the city.
- **C. Gray** supports the staff recommendation and suggested pushing harder for commercial diversity. She would Like to see more affordability on-site. She would suggest increasing the city subsidy.
- **L. May** agreed with most of the board's comments. He suggested enhancing focus on neighborhood services for families. He questioned if row houses would be an essential part of the mix of homes at this location and would like to see more analysis on that. Ultimately he would like to see the number of units increased and the amount of money that the city would need to subsidize decreased. In addition, he would like to see a study performed regarding less parking provided. Finally, he would like to see if more market rate units were provided at the start as deed restricted but built to sell as market rate now and what that would do for sale price of the units over time.
- **L. Payton** and **C. Gray** disagreed with **L. May** regarding the row houses.

6. MATTERS FROM THE PLANNING BOARD, PLANNING DIRECTOR, AND CITY ATTORNEY

A. BVCP Update

Staff Presentation:
L. Ellis and **J. Gatza** presented the item to the board.

Board Comments:
<u>BVCP Future Forums – Community Engagement</u>

- **L. Payton** suggested answering public's questions prior to the general breakouts.
- **L. May** suggested letting the public know if board members will be attending.

<u>December 15, 2016 Planning Board Meeting Agenda Topics</u>

- **L. Payton** would like to discuss the Governance Policy at the meeting. She would like a copy of the resilience report prior to the meeting.
- **J. Gerstle** would like someone from CU South at the meeting.
- Board members agreed with the proposed agenda.

B. Debrief of Community Benefit Subcommittee Meeting

- **L. May** and **J. Putnam** gave a review of topics discussed to the board.

C. Scheduling of Affordable Housing Review for Planning Board

- **L. Payton** requested that a review of affordable and inclusionary housing and

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financing be offered to the board at an upcoming meeting.

- This has been scheduled for the January 19, 2017 Planning Board meeting.

D. C. Gray requested for the board to have a follow up review regarding "Right of Way Dedication".

E. L. May requested for the boar to have a follow up review regarding Attention Homes density across several sites.

7. DEBRIEF MEETING/CALENDAR CHECK

A. Change Start Time for Planning Board Meeting – December 15, 2016

- Due to the full agenda scheduled for the December 15, 2016 Planning Board meeting, it was agreed by all board members to convene at 5:00 p.m. rather than 6:00 p.m.

B. Schedule Planning Board Meeting – January 12, 2017

- **C. Spence** polled the board regarding the availability of members for the addition of a Planning Board meeting on January 12, 2017. All board members, except **J. Putnam**, could attend. The meeting will be scheduled.

8. ADJOURNMENT

The Planning Board adjourned the meeting at 10:33 p.m.

APPROVED BY

_____

Board Chair

_____

DATE

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M E M O R A N D U M

TO: Planning Board

FROM: Jessica Stevens, Floodplain and Wetland Administrator

DATE: November 3, 2016

SUBJECT: **Call Up Item:** 236 Pearl Street
Floodplain Development Permit (LUR2016-00085)
Wetland Permit (LUR2016-00091)

This decision may be called up before Planning Board on or before **November 17, 2016.**

A floodplain development permit and wetland permit were approved by Public Works Development Review staff on November 2, 2016 for the construction of a residence and associated improvements at 236 Pearl Street.

The applicant proposes the construction of two attached single family residences at 234 and 236 Pearl Street impacting the regulatory areas of Sunshine Canyon Creek. The proposal includes encroachments within the low functioning outer buffer for a portion of the 236 Pearl residence and driveway, boring under the creek for an electrical line and the relocation of a stormwater outfall with minor impacts to the creek channel bank.

The applicant has demonstrated compliance with the City's floodplain regulations. The project will not adversely impact nearby properties. A copy of the floodplain development permit and a vicinity map showing the location of the improvements is attached.

Approximately 1512 square feet of buffer and 17.5 feet of stream bank will be impacted during construction. The proposal is a 73 percent reduction in the impervious area within the buffer from the previous development. The impacts will be mitigated through the planting of native riparian shrubs and seed mixes in accordance with the City of Boulder Wetland Protection Program Best Management Practices Revegetation Rules.

The floodplain development permit and wetland permit were approved by Public Works Development Review staff on November 3, 2016 and the decision may be called up before Planning Board on or before November 17, 2016. There is one Planning Board meeting within the 14 day call up period on **November 17, 2016**.

Questions about the project should be directed to the Floodplain and Wetlands Administrator, Jessica Stevens at 303-441-3121 or by e-mail at stevensj@bouldercolordo.gov.

Attachments:

A. Floodplain Development Permit
B. Vicinity Map - Floodplain
C. Wetland Permit
D. Vicinity Map - Wetland

CITY OF BOULDER
Planning and Development Services

1739 Broadway, Third Floor • P.O. Box 791, Boulder, CO 80306-0791
phone 303-441-1880 • fax 303-441-4241 • web boulderplandevelop.net

Land Use Review Floodplain Development Permit

Date Issued: November 2, 2016

Expiration Date: November 3, 2019
(Pursuant to Subsection 9-3-6(e), B.R.C. 1981)

Permit Number: LUR2016-00085

Contact Information

STEPHEN SPARN
1731 15TH STREET #250
BOULDER, CO 80302

Project Information

Location: 236 PEARL ST

Legal Description: LOT 2 PEARL SUBDIVISION FINAL

Description of Work: FLOODPLAIN DEVELOPMENT PERMIT: Construction of a storm sewer outfall within the conveyace zone of Sunshine Creek.

Type of Floodplain Permit: Floodplain Review W/O Analysis

Creek Name: Sunshine

Flood Protection Elevation: Not applicable

Conditions of Approval

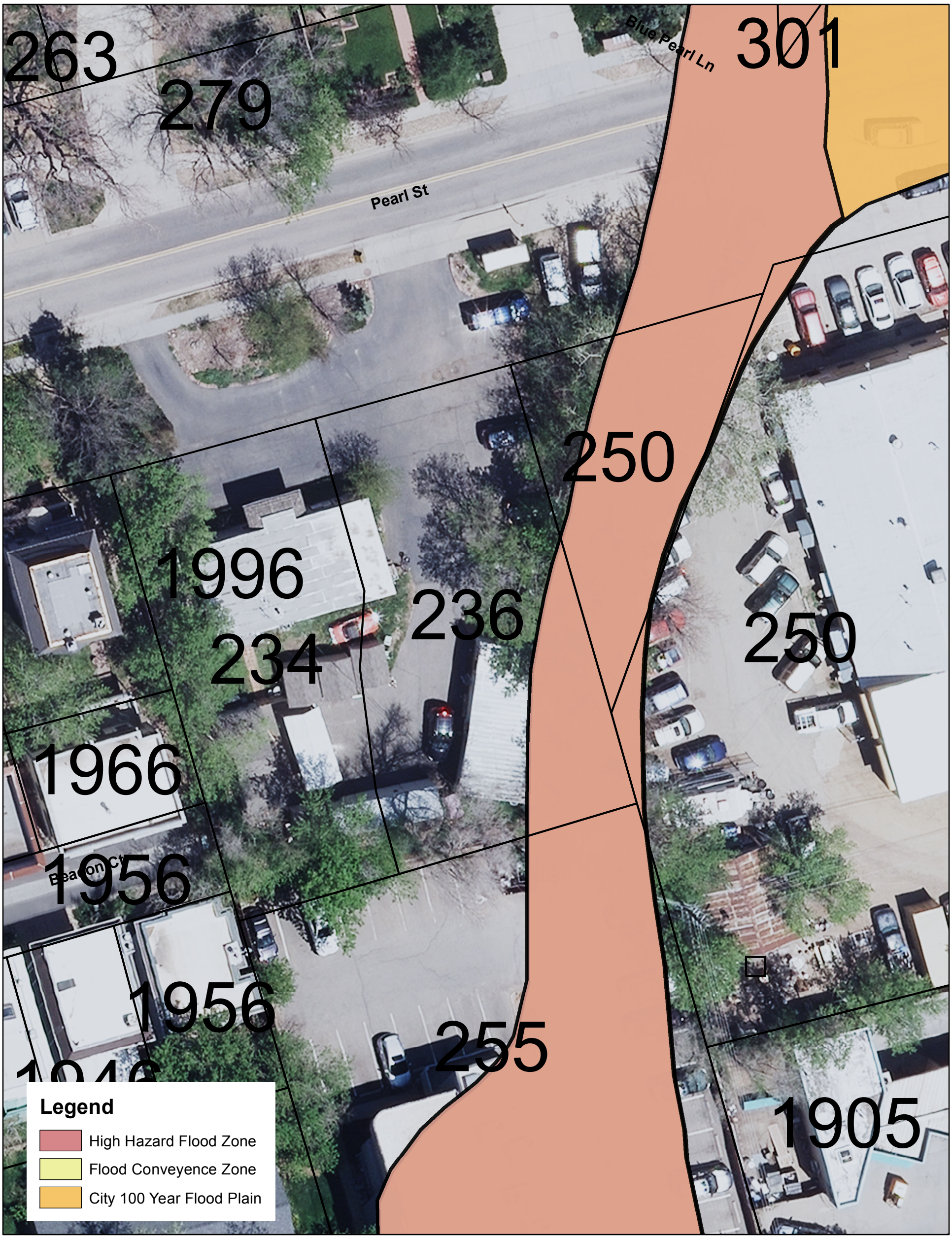
- The proposed project/activity is approved on the basis that it satisfies applicable requirements of Chapter 9-3-3, "Floodplain Regulations," Boulder Revised Code 1981. Other floodplain requirements as set forth in Chapter 9-3-3 which are not specifically outlined in the conditions of approval below remain applicable to this project/activity.
- Improvements shall be constructed in accordance with the plans submitted as part of the floodplain development permit application.
- A licensed professional engineer shall confirm in writing that all improvements have been completed in conformance with this Floodplain Development Permit.
- The applicant shall obtain a site inspection and approval from the City of Boulder Floodplain and Wetlands Coordinator upon completion of the projects.

Inspections

To schedule an inspection, call 303-441-3280 and refer to your permit number (LUR2016-00085).

- Final Floodplain Inspection

236 Pearl Street



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For information call (303) 441-3266 or visit us on the web at http://www.bouldercolorado.gov/pwplan

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Planning and Development Services

1739 Broadway, Third Floor • P.O. Box 791, Boulder, CO 80306-0791
phone 303-441-1880 • fax 303-441-4241 • web boulderplandevelop.net

Wetland Permit

Date Issued: 11/2/2016

Expiration Date: November 2, 2019
(Pursuant to Subsection 9-3-9(k), B.R.C. 1981)

Permit Number: LUR2016-00091

Contact Information

WESTERN ECOLOGICAL RESOURCE
711 WALNUT ST
BOULDER, CO 80302
303-449-9009

Project Information

Location: 234 PEARL ST

Legal Description: LOT 2 PEARL SUBDIVISION FINAL

Description of Work: Standard wetland permit application.

Conditions of Approval

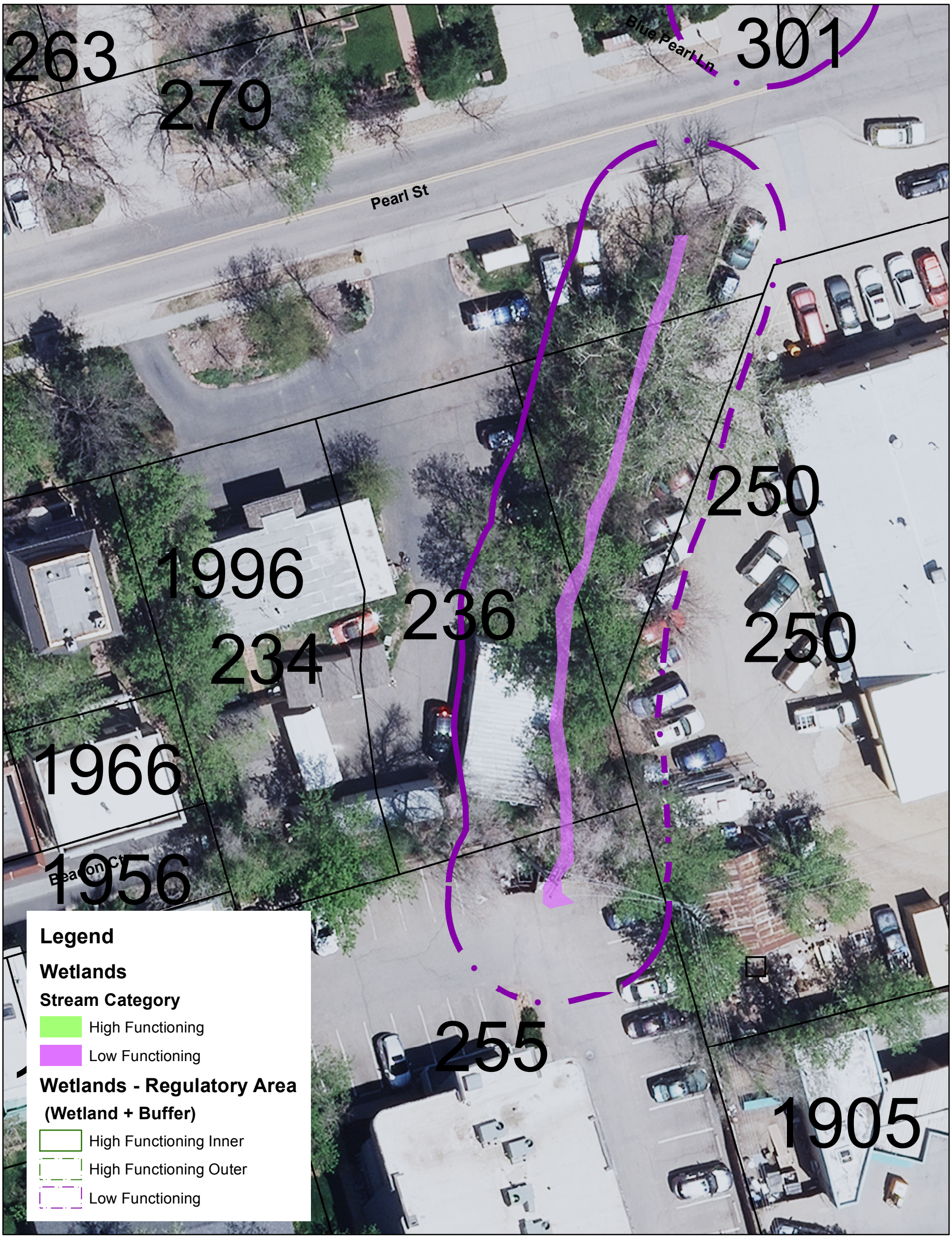
- The proposed project/activity is approved on the basis that it satisfies applicable requirements of Chapter 9-3-9, "Wetlands Protection," Boulder Revised Code 1981. Other wetland requirements as set forth in Chapter 9-3-9 which are not specifically outlined in the conditions of approval below remain applicable to this project/activity.
- The improvements shall be constructed to minimize and mitigate impacts to the existing wetlands in conformance with the conditions of the City of Boulder Wetland Permit issued for this project.
- Improvements shall be constructed in accordance with the site plan submitted as part of the building permit application.
- Best management practices shall be applied to all phases of the project and shall conform to the requirements of the "City of Boulder Wetland Protection Program: Best Management Practices" adopted July ,1995.
- Temporary impacts shall be planted with native vegetation in accordance with the Wetland Protection Program Best Management Practices Revegetation Rules.

Inspections

To schedule an inspection, call 303-441-3280 and refer to your permit number (LUR2016-00091).

- Wetland Mitigation Inspection

236 Pearl Street



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For information call (303) 441-3266 or visit us on the web at http://www.bouldercolorado.gov/pwplan

MEMORANDUM

TO: Planning Board
FROM: Shannon Moeller, Case Manager
DATE: November 8, 2016
SUBJECT: **Call Up Item:** 4525 Palo Pkwy Subdivision Final Plat (TEC2016-00031). Request for approval of a Final Plat to replat an existing approximately 3.2-acre parcel as one lot suitable for development and grant easements. The call up period expires on November 22, 2016.

Attached is the disposition of approval (**Attachment A**) to permit a proposed subdivision entitled Palo Park Filing No. 4 Replat C (see **Attachment B**). The proposal is consistent with the previously approved Site Review, which was approved by Planning Board on May 26, 2016. As a condition of the approved Site Review, a subdivision (i.e., final plat) is required to create a buildable a lot and grant easements drainage, utilities and public access across the site.

Background. The 3.2-acre property is undeveloped and is located north of the eastern terminus of Palo Parkway (see Figure 1 below) and is bounded to the east by the Pleasant View Fields soccer sports complex. It was initially platted as Outlot E on the Palo Park Filing No. 4 subdivision, a planned unit development subdivision recorded under the jurisdiction of Boulder County on April 11, 1984. Following the original platting of the land, Outlot E was conveyed to the Boulder Valley School District (BVSD). The area directly the west of the subject property was later platted with smaller residential lots under Palo Park Filing No. 4 – Replat B.

Figure 1: Vicinity Map

The city purchased the site from BVSD in 2006 with the goal of developing affordable housing. In early 2015 City Council authorized the transfer of the land to Boulder Housing Partners (BHP) to work in partnership with Flatirons Habitat for Humanity (Habitat) to pursue the entitlements and financing needed to develop the site. Following the approval of the transfer, BHP and the city executed a Land Transfer Agreement and Interim Permanent Affordable Covenant. If developed as planned, the site will achieve a series of desired outcomes identified by City Council as part of the agreement to transfer the land to BHP. On Jan. 5, 2016 the City Council approved on second reading the annexation of the property into the city with an initial zoning designation of Residential - Mixed 2 (RMX-2). On May 26, 2016 the Planning Board approved the Site Review of the property for construction of 44 residential units and a community center in nine buildings surrounding a central park.

The project is zoned Residential - Mixed 2 (RMX-2), which is described as "medium density residential areas which have a mix of densities from low density to high density and where complementary uses may be permitted" (section 9-5-2(c), B.R.C. 1981). There is no minimum lot size in the RMX-2 zone district. Rather, the allowable intensity of development in the zone district is controlled by maximum requirements for the number of dwelling units per acre (10 – up to 20 by review) and minimum open space requirements (15% for lots with residential uses).

Public Comment. Required public notice was provided in the form of written notifications to adjacent property owners of the subject property. In addition, a public notice sign was posted on the property. Therefore, all public notice requirements of section 9-4-3, "*Public Notice Requirements*," B.R.C. 1981 were met. No inquiries were received on the proposal.

Conclusion. Per section 9-12-10, "Final Plat Procedure," B.R.C. 1981, the city manager is required to notify the Planning Board in writing within seven days of the disposition of the final plat application. Staff has reviewed the application for compliance with the Subdivision Regulations of Chapter 9-12, "Subdivision," B.R.C. 1981 and finds that the proposal would meet the Standards for Lots and Public Improvements, as set forth in section 9-12-12, B.R.C. 1981 and the approved Site Review.

Staff has attached the approved final plat (**Attachment B**) for the Planning Board's review. The proposal was approved by Planning and Development Services staff on November 8, 2016 and the decision may be called up before Planning Board on or before **November 22, 2016**. There is one Planning Board meeting within the 14-day call up period on **November 17, 2016**. Questions about the project or decision should be directed to Shannon Moeller at 303-441-3137 or via email moellers@bouldercolorado.gov.

Attachments.
Attachment A: Disposition of Approval
Attachment B: Approved Final Plat for Palo Park Filing No. 4 Replat C

CITY OF BOULDER
Planning and Development Services

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phone 303-441-1880 • fax 303-441-3241 • email plandevelop@bouldercolorado.gov
www.boulderplandevelop.net

CITY OF BOULDER PLANNING DEPARTMENT NOTICE OF DISPOSITION

You are hereby advised that the following action was taken by the Planning Department based on the standards and criteria of the Land Use Regulations as set forth in Chapter 9-12, B.R.C. 1981, as applied to the proposed development.

DECISION:	**Approved with Condition**
PROJECT NAME:	**PALO PARK FILING NO. 4 REPLAT C**
DESCRIPTION:	**Final Plat to replat the property as Lot 1, Palo Park Filing No. 4 Replat C and grant easements necessary for the Boulder Housing Partners and Habitat for Humanity residential development approved by Site Review LUR2016-00027.**
LOCATION:	**4525 PALO PKWY**
COOR:	**N07W03**
LEGAL DESCRIPTION:	**Outlot E, Palo Park Filing No. 4** **City of Boulder, County of Boulder, State of Colorado**
APPLICANT:	**Lauren Schevets**
OWNER:	**Housing Authority of the City of Boulder, Colorado d/b/a Boulder Housing Partners**
APPLICATION:	**TEC2016-00031 Subdivision/Final Plat**
ZONING:	**RMX-2**
CASE MANAGER:	**Shannon Moeller**

THIS IS NOT A SITE SPECIFIC DEVELOPMENT PLAN APPROVAL AND NO VESTED PROPERTY RIGHT IS CREATED BY THIS APPROVAL.

Approved On: 11/8/2016
Date

By:
David Driskell, Executive Director of Community Planning and Sustainability

This decision may be appealed to the Planning Board by filing an appeal letter with the Planning Department within two weeks of the decision date. If no such appeal is filed, the decision shall be deemed final fourteen days after the date above mentioned.

Appeal to Planning Board expires: 11/22/2016

CONDITIONS OF APPROVAL

1. The subdivision is approved subject to the terms of the Subdivision Agreement.

Address: 4525 PALO PY

PALO PARK FILING NO. 4 REPLAT C

A REPLAT OF OUTLOT E, PALO PARK FILING NO. 4

LOCATED IN THE SW 1/4 OF THE SE 1/4 OF SECTION 17, T1N, R70W OF THE 6TH P.M.

CITY OF BOULDER, COUNTY OF BOULDER, STATE OF COLORADO

TOTAL AREA = 3.216 ACRES

SHEET 1 OF 2

DEDICATION

KNOW ALL MEN BY THESE PRESENTS: THAT THE HOUSING AUTHORITY OF THE CITY OF BOULDER, COLORADO, A COLORADO HOUSING AUTHORITY, D/B/A BOULDER HOUSING PARTNERS, IS THE OWNER OF THAT PARCEL OF LAND SITUATED IN THE CITY OF BOULDER, AND LYING WITHIN SW 1/4 OF THE SE 1/4 OF SECTION 17, T1N, R70W OF THE 6TH P.M., DESCRIBED AS FOLLOWS:

OUTLOT E, PALO PARK FILING NO. 4, COUNTY BOULDER, STATE OF COLORADO

THAT THE UNDERSIGNED HAS CAUSED SAID PROPERTY TO BE LAID OUT, SURVEYED, SUBDIVIDED AND PLATTED UNDER THE NAME OF "PALO PARK FILING NO. 4 REPLAT C," A SUBDIVISION IN THE CITY OF BOULDER, COUNTY OF BOULDER, STATE OF COLORADO, AND BY THESE PRESENTS DOES HEREBY GRANT TO THE CITY OF BOULDER THAT REAL PROPERTY DESIGNATED AS A "UTILITY EASEMENT" ON THE ACCOMPANYING PLAT AS AN EASEMENT FOR THE CONSTRUCTION, INSTALLATION, OPERATION, MAINTENANCE, REPAIR AND REPLACEMENT FOR ALL SERVICES, INCLUDING WITHOUT LIMITING THE GENERALITY OF THE FOREGOING: TELEPHONE AND ELECTRIC LINES, WORKS, POLES, UNDERGROUND CABLES, GAS PIPELINES, WATER PIPELINES, SANITARY SEWER LINES, STREET LIGHTS, CULVERTS, HYDRANTS, DRAINAGE DITCHES AND DRAINS AND ALL APPURTENANCES THERETO. IT IS EXPRESSLY UNDERSTOOD AND AGREED BY THE UNDERSIGNED THAT ALL EXPENSES AND COSTS INVOLVED IN CONSTRUCTING AND INSTALLING WATER, PIPELINES AND APPURTENANCES, SANITARY SEWER WORKS AND LINES, GAS SERVICE LINES, ELECTRICAL SERVICE WORKS AND LINES, STORM SEWERS AND DRAINS, STREET LIGHTING, GRADING AND LANDSCAPING, CURBS, GUTTERS, STREET PAVEMENT, SIDEWALKS, AND OTHER SUCH UTILITIES AND SERVICES SHALL BE GUARANTEED AND PAID FOR BY THE SUBDIVIDER OR ARRANGEMENTS MADE BY THE SUBDIVIDER THEREFORE WHICH ARE APPROVED BY THE CITY OF BOULDER, AND SUCH SUMS SHALL NOT BE PAID BY THE CITY OF BOULDER, COLORADO, AND THAT ANY ITEM SO CONSTRUCTED OR INSTALLED AND ACCEPTED BY THE CITY OF BOULDER, COLORADO, SHALL BECOME THE SOLE PROPERTY OF THE CITY OF BOULDER, EXCEPT ITEMS OWNED BY MUNICIPALLY FRANCHISED OR PERMITTED UTILITIES, WHICH ITEMS, WHEN CONSTRUCTED OR INSTALLED, SHALL REMAIN THE PROPERTY OF THE OWNER OR THE PUBLIC UTILITY, AND SHALL NOT BECOME THE PROPERTY OF THE CITY OF BOULDER.

THE UNDERSIGNED DOES FURTHER GRANT TO THE CITY OF BOULDER THAT REAL PROPERTY DESIGNATED AS A "10' PUBLIC ACCESS EASEMENT" ON THE ACCOMPANYING PLAT AS AN EASEMENT FOR PUBLIC INGRESS AND EGRESS, AND FOR THE CONSTRUCTION, INSTALLATION, OPERATION, MAINTENANCE, REPAIR AND REPLACEMENT OF TRANSPORTATION IMPROVEMENTS AND LANDSCAPING AND UTILITIES AND APPURTENANCES THERETO. IT IS EXPRESSLY UNDERSTOOD AND AGREED BY THE UNDERSIGNED THAT ALL EXPENSES AND COSTS INVOLVED IN CONSTRUCTING AND INSTALLING SAID IMPROVEMENTS SHALL BE GUARANTEED AND PAID FOR BY THE SUBDIVIDER OR ARRANGEMENTS MADE BY THE SUBDIVIDER THEREFORE WHICH ARE APPROVED BY THE CITY OF BOULDER, AND SUCH SUMS SHALL NOT BE PAID BY THE CITY OF BOULDER, COLORADO, AND THAT ANY ITEM SO CONSTRUCTED OR INSTALLED AND ACCEPTED BY THE CITY OF BOULDER, COLORADO, SHALL BECOME THE SOLE PROPERTY OF THE CITY OF BOULDER.

THE UNDERSIGNED DOES FURTHER GRANT TO THE CITY OF BOULDER, THOSE PORTIONS OF REAL PROPERTY DESIGNATED AS "DRAINAGE EASEMENT" ON THE ACCOMPANYING PLAT AS EASEMENTS FOR DRAINAGE CONVEYANCE AND STRUCTURES TO CONTAIN STORM RUN-OFF FROM THE SUBDIVISION, AND FOR THE CONSTRUCTION, INSTALLATION, OPERATION, MAINTENANCE, REPAIR AND REPLACEMENT OF UTILITIES, INCLUDING WITHOUT LIMITING THE GENERALITY OF THE FOREGOING: CULVERTS, DRAINAGE DITCHES AND DRAINS, FLOOD CONTROL IMPROVEMENTS AND ALL APPURTENANCES THERETO. IT BEING EXPRESSLY UNDERSTOOD AND AGREED BY THE UNDERSIGNED THAT ALL EXPENSES AND COSTS INVOLVED IN CONSTRUCTING AND INSTALLING THE DRAINAGE IMPROVEMENTS AND OTHER SUCH UTILITIES AND SERVICES SHALL BE GUARANTEED AND PAID FOR BY THE SUBDIVIDER OR ARRANGEMENTS MADE BY THE SUBDIVIDER THEREFOR WHICH ARE APPROVED BY THE CITY, AND SUCH SUMS SHALL NOT BE PAID BY THE CITY, AND THAT ANY ITEM SO CONSTRUCTED OR INSTALLED WHEN ACCEPTED BY THE CITY SHALL REMAIN THE PROPERTY AND MAINTENANCE RESPONSIBILITY OF THE SUBDIVIDER.

FOR THE APPROVAL OF "PALO PARK FILING NO. 4 REPLAT C" AND THE DEDICATIONS AND CONDITIONS WHICH APPLY THERETO THIS _____ DAY OF _____, 20___.

HOUSING AUTHORITY OF THE CITY OF BOULDER, COLORADO
A COLORADO HOUSING AUTHORITY, D/B/A BOULDER HOUSING PARTNERS

BY: _____
JIM KOCZELA, CHIEF FINANCIAL OFFICER

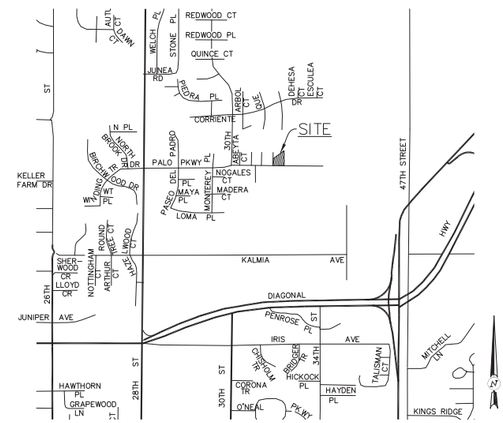
STATE OF COLORADO)
) SS.
COUNTY OF BOULDER)

THE FOREGOING INSTRUMENT WAS ACKNOWLEDGED BEFORE ME THIS _____ DAY OF _____, 2016, BY JIM KOCZELA AS CHIEF FINANCIAL OFFICER OF THE HOUSING AUTHORITY OF THE CITY OF BOULDER D/B/A BOULDER HOUSING PARTNERS.

WITNESS MY HAND AND SEAL.
MY COMMISSION EXPIRES: _____

[SEAL]

_____
NOTARY PUBLIC



VICINITY MAP

1" = 1000'

SURVEY NOTES

1. BASIS OF BEARINGS: THE WESTERLY LINE OF THE SUBJECT PROPERTY, BEING MONUMENTED AS SHOWN HEREON, WITH THE LINE ASSUMED TO BEAR N00°16'30"W.
2. THE SIZE AND TYPE OF MONUMENTS FOUND ARE SHOWN HEREON.
3. THE SURVEY FIELD WORK ON THIS SITE WAS COMPLETED ON 03/24/15.
4. NOTICE: ACCORDING TO COLORADO LAW, YOU MUST COMMENCE ANY LEGAL ACTION BASED ON ANY DEFECT IN THIS SURVEY WITHIN THREE YEARS AFTER YOU FIRST DISCOVERED SUCH DEFECT. IN NO EVENT, MAY ANY ACTION BASED UPON ANY DEFECT IN THIS SURVEY BE COMMENCED MORE THAN TEN YEARS FROM THE DATE OF THE CERTIFICATION SHOWN HEREON. CRS-13-80-105 (3)(a).
5. HERITAGE TITLE COMPANY COMMITMENT NUMBER 451-H0459601-036-JY7 AMENDMENT NO. 2, DATED OCTOBER 17, 2016 AT 7:00 A.M., WAS ENTIRELY RELIED UPON FOR RECORDED INFORMATION REGARDING RIGHTS-OF-WAY, EASEMENTS AND ENCUMBRANCES IN THE PREPARATION OF THIS SURVEY. THE PROPERTY SHOWN AND DESCRIBED HEREON IS ALL OF THE PROPERTY DESCRIBED IN SAID TITLE COMMITMENT.
6. PLATS REFERENCED OR USED FOR THIS SURVEY: PALO PARK FILING NO. 4, DATED 04-11-1984.
7. LOT IS TO BE USED FOR MULTI FAMILY RESIDENCES.
8. THE PROPERTY IS ZONED RMX-2.
9. THE FEMA FLOOD INSURANCE RATE MAP, PANEL 08013C0392J AND PANEL 08013C0411J, DATED DECEMBER 18, 2012, INDICATES THAT PORTIONS OF THE SITE ARE LOCATED WITHIN ZONE AE, AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD. FLOODPLAIN DESIGNATION SUBJECT TO CHANGE.

SURVEYOR'S CERTIFICATE

I, A. JOHN BURI, A DULY REGISTERED PROFESSIONAL LAND SURVEYOR IN THE STATE OF COLORADO, DO HEREBY CERTIFY THAT THIS PLAT WAS PREPARED UNDER MY SUPERVISION AND IS BASED ON A BOUNDARY SURVEY MADE BY SCOTT, COX & ASSOCIATES, INC., AND TO THE BEST OF MY KNOWLEDGE AND BELIEF CORRECTLY SHOWS THE LOCATION AND DIMENSIONS OF THE LOTS, IN SUBSTANTIAL COMPLIANCE WITH C.R.S. 38-51-106.

COLORADO REGISTERED A. JOHN BURI 24302 PROFESSIONAL LAND SURVEYOR

A. JOHN BURI, PLS 24302
FOR AND ON BEHALF OF
SCOTT, COX & ASSOCIATES, INC.

LEGEND

○	FOUND MONUMENT AS NOTED
●	SET #5 REBAR WITH RED PLASTIC CAP, P.L.S. 24302.
(S51°43'26"W, 0.30')	CALCULATED OR RECORD POSITION TO FOUND MONUMENT
(R)	RECORD MEASUREMENT
(CALC)	CALCULATED DIMENSION
(AM)	AS MEASURED DIMENSION

APPROVALS

_____
DIRECTOR OF PLANNING

_____
DIRECTOR OF PUBLIC WORKS AND UTILITIES

CITY MANAGER'S CERTIFICATE

IN WITNESS WHEREOF, THE SAID CITY OF BOULDER HAS CAUSED ITS SEAL TO BE HEREUNTO AFFIXED BY ITS CITY MANAGER THIS _____ DAY OF _____, 20___.

ATTEST:

_____ _____
CITY CLERK CITY MANAGER

CLERK AND RECORDER'S CERTIFICATE

STATE OF COLORADO)
) SS.
COUNTY OF BOULDER)

I HEREBY CERTIFY THAT THIS INSTRUMENT WAS FILED IN MY OFFICE AT _____ O'CLOCK ___ M., THIS _____ DAY OF _____, 20_____, AND IS RECORDED AT RECEPTION # _____.
FEES PAID: $_____.

_____ _____
CLERK AND RECORDER DEPUTY

SCOTT, COX & ASSOCIATES, INC.
consulting engineers • surveyors
1530 55th Street • Boulder, Colorado 80303
(303) 444 - 3051

Designed by AJB	Date	Scale	Drawing no.		Sheet
Drawn by JAS	10/25/16	AS NOTED	15257E-1		1
Checked by AJB	Revision	Description		Date	Project no. 15257E

FINAL PLAT

PALO PARK FILING NO. 4 REPLAT C

A REPLAT OF OUTLOT E, PALO PARK FILING NO. 4

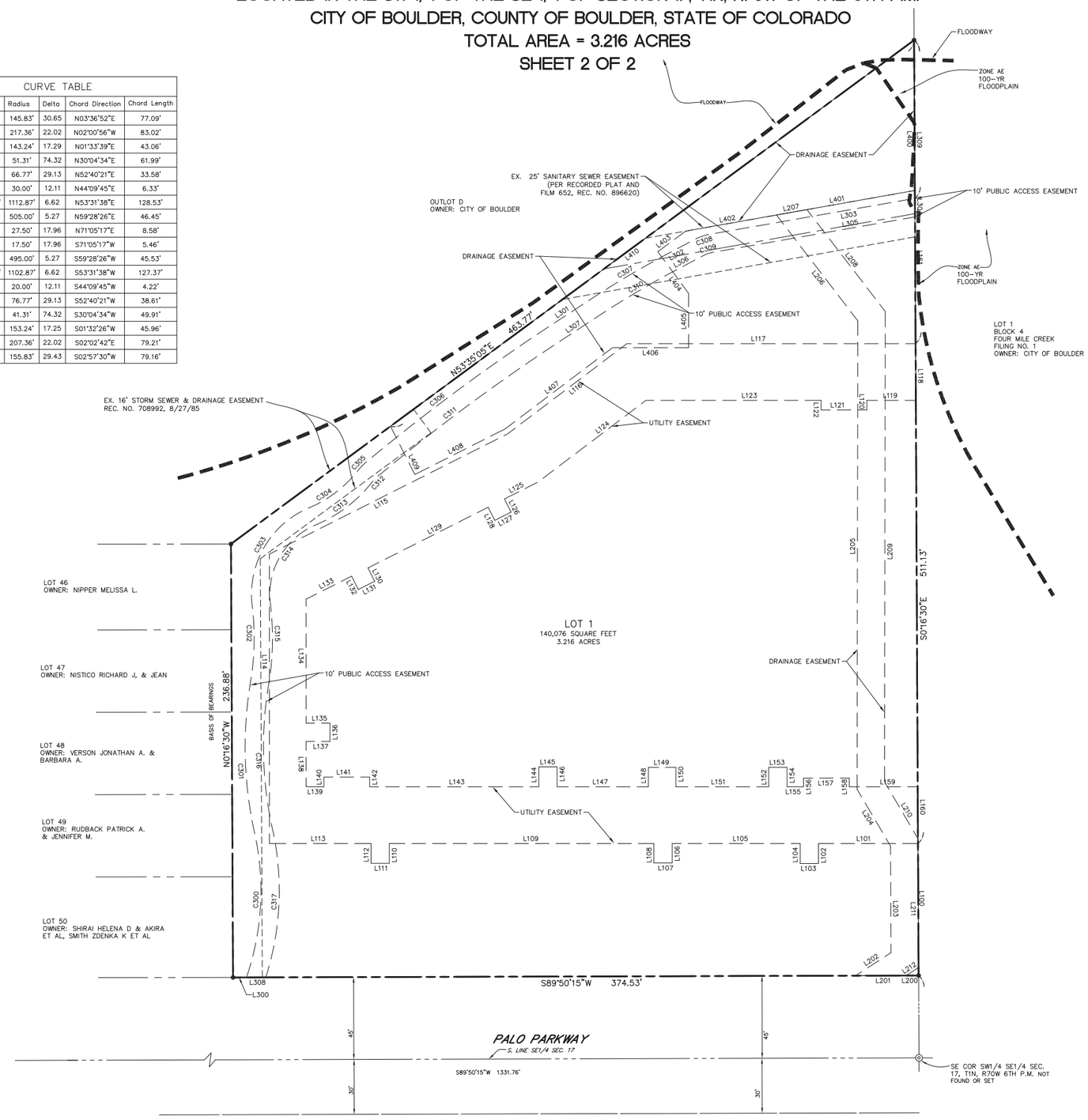
LOCATED IN THE SW 1/4 OF THE SE 1/4 OF SECTION 17, T1N, R70W OF THE 6TH P.M.

CITY OF BOULDER, COUNTY OF BOULDER, STATE OF COLORADO

TOTAL AREA = 3.216 ACRES

SHEET 2 OF 2

CURVE TABLE					
Curve #	Length	Radius	Delta	Chord Direction	Chord Length
C300	78.02'	145.83'	30.65	N03°36'52"E	77.09'
C301	83.53'	217.36'	22.02	N02°00'56"W	83.02'
C302	43.23'	143.24'	17.29	N01°33'39"E	43.06'
C303	66.56'	51.31'	74.32	N30°04'34"E	61.99'
C304	33.94'	66.77'	29.13	N52°40'21"E	33.58'
C305	6.34'	30.00'	12.11	N44°09'45"E	6.33'
C306	128.60'	1112.87'	6.62	N53°31'38"E	128.53'
C307	46.47'	505.00'	5.27	N59°28'26"E	46.45'
C308	8.62'	27.50'	17.96	N71°05'17"E	8.58'
C309	5.48'	17.50'	17.96	S71°05'17"W	5.46'
C310	45.55'	495.00'	5.27	S59°28'26"W	45.53'
C311	127.44'	1102.87'	6.62	S53°31'38"W	127.37'
C312	4.23'	20.00'	12.11	S44°09'45"W	4.22'
C313	39.03'	76.77'	29.13	S52°40'21"W	38.61'
C314	53.59'	41.31'	74.32	S30°04'34"W	49.91'
C315	46.14'	153.24'	17.25	S01°32'26"W	45.96'
C316	79.70'	207.36'	22.02	S02°02'42"E	79.21'
C317	80.04'	155.83'	29.43	S02°57'30"W	79.16'



LEGEND

- FOUND MONUMENT AS NOTED
- SET #5 REBAR WITH RED PLASTIC CAP, P.L.S. 24302.
- EXISTING FLOODPLAIN BOUNDARY
- EXISTING EASEMENT
- PROPOSED EASEMENT

LINE TABLE		
Line #	Length	Direction
L100	72.13'	N00°16'30"W
L101	54.36'	N90°00'00"W
L102	10.92'	S00°00'00"W
L103	10.00'	N90°00'00"W
L104	10.92'	N00°00'00"E
L105	69.90'	N90°00'00"W
L106	10.64'	S00°00'00"W
L107	10.00'	N90°00'00"W
L108	10.64'	N00°00'00"E
L109	144.52'	N90°00'00"W
L110	10.82'	S00°00'00"W
L111	10.00'	N90°00'00"W
L112	10.82'	N00°00'00"E
L113	55.49'	N90°00'00"W
L114	158.13'	N00°00'43"W
L115	145.95'	N63°11'55"E
L116	81.53'	N52°52'39"E
L117	157.71'	N89°59'38"E
L118	31.00'	S00°16'30"E
L119	26.77'	S89°59'38"W
L120	5.24'	S00°09'15"E
L121	25.00'	S89°50'45"W
L122	5.30'	N00°09'15"W
L123	95.68'	S89°59'38"W
L124	73.93'	S52°52'39"W
L125	20.54'	S63°11'55"W
L126	8.04'	S26°48'05"E
L127	10.00'	S63°11'55"W
L128	8.04'	N26°48'05"W
L129	73.56'	S63°11'55"W
L130	8.15'	S26°48'05"E
L131	10.00'	S63°11'55"W

LINE TABLE		
Line #	Length	Direction
L132	8.15'	N26°48'05"W
L133	27.89'	S63°11'55"W
L134	67.75'	S00°00'43"E
L135	13.09'	N90°00'00"E
L136	10.00'	S00°00'00"E
L137	13.08'	N90°00'00"W
L138	24.75'	S00°00'43"E
L139	9.74'	N90°00'00"E
L140	5.29'	N00°00'00"E
L141	25.00'	N90°00'00"E
L142	5.29'	S00°00'00"E
L143	92.39'	N90°00'00"E
L144	10.90'	N00°00'00"E
L145	10.00'	S90°00'00"E
L146	10.90'	S00°00'00"W
L147	49.89'	N90°00'00"E
L148	10.63'	N00°00'00"E
L149	15.00'	S90°00'00"E
L150	10.63'	S00°00'00"W
L151	50.75'	N90°00'00"E
L152	10.64'	N00°00'00"E
L153	10.00'	S90°00'00"E
L154	10.64'	S00°00'00"W
L155	8.99'	N90°00'00"E
L156	4.77'	N00°00'00"E
L157	25.00'	S89°59'39"E
L158	4.77'	S00°00'00"E
L159	37.37'	N90°00'00"E
L160	31.00'	S00°16'30"E
L161	165.84'	S00°16'30"E
L200	6.79'	S89°50'15"W
L201	27.68'	S89°50'15"W

LINE TABLE		
Line #	Length	Direction
L202	23.14'	N57°01'33"E
L203	58.20'	S00°16'30"E
L204	36.05'	N30°27'29"W
L205	255.96'	N00°05'14"E
L206	72.92'	N37°31'56"W
L207	16.91'	N79°56'05"E
L208	70.23'	S37°31'56"E
L209	256.96'	S00°05'20"W
L210	36.01'	S30°27'29"E
L211	70.44'	S00°16'30"E
L212	8.07'	S57°01'33"W
L300	7.36'	N89°50'15"E
L301	24.84'	N56°50'16"E
L302	17.51'	N62°06'36"E
L303	113.79'	N80°03'57"E
L304	10.14'	S00°16'30"E
L305	112.09'	S80°03'57"W
L306	17.51'	S62°06'36"W
L307	24.84'	S56°50'16"W
L308	10.54'	S89°50'15"W
L309	86.48'	S00°16'30"E
L400	82.15'	S00°16'30"E
L401	72.23'	S79°56'05"W
L402	36.36'	S79°56'05"W
L403	18.90'	S53°35'05"W
L404	28.29'	S36°24'55"E
L405	29.74'	S00°00'00"E
L406	41.60'	S89°59'59"W
L407	73.61'	S52°54'08"W
L408	55.14'	S63°11'55"W
L409	29.53'	N26°48'05"W
L410	355.46'	N53°35'05"E

TRUE NORTH
Scale: 1" = 30'

0 15 30 60

SCOTT, COX & ASSOCIATES, INC.
consulting engineers • surveyors
1530 55th Street • Boulder, Colorado 80303
(303) 444 - 3051

Designed by AJB	Date 10/25/16	Scale 1"=30'	Drawing no. 15257E-1	Sheet 2
Drawn by JAS	Revision	Description	Date	Project no. 15257E
Checked by AJB				

FINAL PLAT

Agenda Item 4B

C I T Y O F B O U L D E R
PLANNING BOARD AGENDA ITEM

MEETING DATE: November 17, 2016

AGENDA TITLE: Planning Board public hearing to consider a public request for map changes to the Boulder Valley Comprehensive Plan (BVCP) for 3261 3rd Street.

REQUESTING DEPARTMENT:
David Driskell, Executive Director, Planning, Housing + Sustainability (PH+S)
Susan Richstone, Deputy Director for Planning (PH+S)
Lesli Ellis, Comprehensive Planning Manager (PH+S)
Jay Sugnet, Senior Planner (PH+S)
Caitlin Zacharias, Planner I (PH+S)

Suggested Motion Language:
Staff requests Planning Board consideration of this matter and action in the form of the following motions:

A. Motion to approve a Boulder Valley Comprehensive Plan Land Use Map change to *Low Density Residential and Open Space – Other* for 3261 3rd St. (Request #25) as shown and described in **Attachment A**;

B. Motion to approve a Boulder Valley Comprehensive Plan Area I, II, III Map change to *Area II* for a portion of 3261 3rd St. (Request #25) as shown and described in **Attachment A**;

The purpose of this item is for the Planning Board to hold a hearing on a public request for changes to the Boulder Valley Comprehensive Plan (BVCP) Land Use and Area maps. This is part of a series of hearings and meetings scheduled for Aug. 30 through early 2017 that address Area I requested map changes (requires approval by the two city bodies) and Area II requested map changes (requires approval by City Council, Planning Board, Board of County Commissioners and Planning Commission).

The **Nov. 17 hearing** is a continuation of the joint City Council/Planning Board public hearing that was held on **Oct. 13.** to focus on the four Area I requested map changes (i.e., Naropa, 385 Broadway, Mt. Calvary Church, and Table Mesa Shopping Center). The reason Nov. 17 is a continuation is that Oct. 13 was also technically the first hearing for the Area II requests for the purpose of legal notice. The **Nov. 17 public hearing will focus on the 3261 3rd St.** request that requires approval by four bodies and for which the county Planning Commission and Board of Commissioners have already taken action. City Council held a public hearing for 3261 3rd St**.** on Nov. 10 and will deliberate and vote on Dec. 13.

The other Area II requested map changes regarding **Twin Lakes** is on hold until the County Planning Commission reconsiders their decision from Sept. 27. A joint public hearing with the Planning Board and City Council to consider the Twin Lakes request is not expected until early 2017.

Attachment A is the staff report and recommendation for the 3261 3rd St. request. The full staff memo for

all the requested land use changes is available here[1].

Summary of Recommended Map Changes:

3261 3rd St. (#25)	**Change to Low Density Residential and Open Space – Other Change to Area II** – This recommendation creates a more logical service area boundary while ensuring compatible redevelopment for the single-family home site (see Attachment A).

County Action on 3rd Street

On Sept. 21, the County Planning Commission approved the staff recommended land use changes. A meeting summary is available here[2]. On Sept. 27, the Board of County Commissioners also approved the staff recommended land use changes. A meeting summary is available here[3]. Below is a high level summary of the issues discussed by both Planning Commission and the Board of County Commissioners regarding 3261 3rd St.:

- **Density** – supportive of the staff recommendation because it would not result in additional housing units on the site.
- **Blue Line amendments** – recognition that a comprehensive review of potential changes in Area II / III mapping would take place for this and about a dozen other properties, if a November ballot measure to shift the Blue Line is approved.

The BVCP, jointly adopted by the city and county and updated at least every five years, guides development and preservation in the Boulder Valley. The BVCP articulates a vision for the future and details policies that represent long-standing community values. The public map change request process is one track within the much larger BVCP update. Each phase entails extensive community dialogue and engagement. The webpage for the project, www.BoulderValleyCompPlan.net, includes the full project schedule and a link to the 2010 plan and maps.

Next Steps

The schedule for the Area II request for **Twin Lakes** is pending the outcome of the County Planning Commission reconsideration of the Twin Lakes decision. A city hearing is not likely occur until early 2017.

- Dec. 13 – **City Council deliberate and vote** on the Area II request for 3261 3rd St.
- Jan. 24 – **Joint Study Session of City Council and Planning Board** to review scenarios, analysis, community engagement results from fall, survey results, and CU South.
- Spring 2017 – **City Council Study Session** to review the Draft Plan and Focus Areas.

Approved By:

David Driskell, Executive Director
Department of Community Planning and Sustainability

ATTACHMENTS

A. 3261 3rd St. (Request #25) Staff Report

[1] https://bouldercolorado.gov/bvcp/bvcp-changes
[2] http://www.bouldercounty.org/doc/landuse/bvcp150001staffrec20160927.pdf
[3] http://www.bouldercounty.org/doc/landuse/bvcp150001bocc20160927.pdf

Request #25 — 3261 3rd Street

Existing BVCP Land Use Map

Existing Planning Area Map

Site Photos

Request Summary

- Requester: Margaret Wilson et al. (Wilson family)
- Type of Request: Area II/III boundary change
- Brief Description of Request: Area III to Area II **(Minor Adjustment to the Service Area Boundary)**
- Approval Required: Four-body

Existing Conditions

- BVCP Designation: LR
- Zoning (county): Rural Residential (RR) & Forestry (F)
- Lot Size: 32,278 sq. ft. (0.741 acres)
- Existing Buildings: 1,818 sq. ft. residence; 1,416 sq. ft. agricultural outbuilding

Jobs and Housing Assumptions

- Current Estimated Dwelling Units: 1- 4 with LR
- Future Estimated Dwelling Units: 1-2 with only the portion of property east of blue line designated as LR
- Future Estimated Jobs: 0

STAFF RECOMMENDATION FOR REQUEST #25

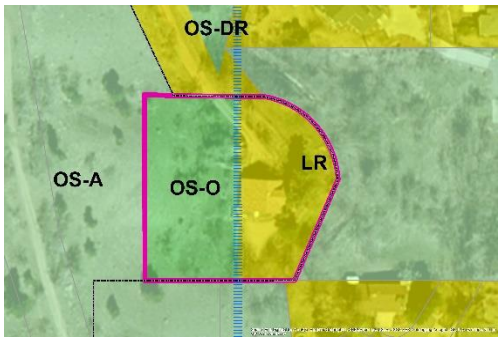
Staff recommends approval of the proposed area change for the parcel from Area III to Area II only for the portion of the property east of the blue line. Staff recommends that the

portion of the property west of the blue line remain in Area III and receive an open space designation.

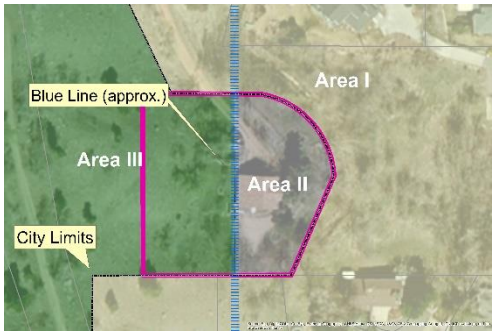
Staff recommends 1) approval of the proposed area change from Area III to Area II for the portion of the property east of the blue line and 2) a land use designation change on the western portion of the property to Open Space - Other for the following reasons:

- Creation of a more logical service area boundary: an Area III to Area II change for the portion of the property east of the blue line is consistent with other "western edge" properties along 3rd St.
- Compatibility with the surrounding area: The existing use is a single-family home and the developable area of the property will not be expanded with a change from Area III to Area II under county zoning. The proposed land use designation change for the portion of the property west of the blue line ensures the preservation of open space and neighborhood character along the western edge and is consistent with other western edge properties along 3rd St.
- Correction of a mapping error: analysis of previous comprehensive plan maps indicates that the Area II/III boundary may have originally bisected the property and was moved in error to the eastern edge of the property during the 1997 digitization of maps.

Recommended Land Use Designation



Recommended Planning Area Boundary



The current proposed blue line ballot measure may have implications for this property. Proposed changes to the blue line would require voter approval. Staff recommends an open space land use designation on the portion of the lot currently west of the blue line regardless of any potential shifts in the blue line. Furthermore, the corresponding zoning on the property should not create any additional building lots.

OVERVIEW

The Board of County Commissioners previously reviewed a Subdivision Exemption request for this property (SE-14-0006: Wilson Lot Recognition) on Aug. 5, 2014 and Mar. 10, 2015. The purpose of this request was to gain recognition as a legal lot. Per Resolution 2015-59, the Board approved the request with the condition that the applicant first pursue a re-designation from Area III to Area II and subsequent annexation to the city.

SITE DESCRIPTION

The property is located in unincorporated Boulder County and comprises 0.741 acres. It lies to the south of Hawthorn Rd. and west of 3rd St. The property abuts the foothills, is surrounded directly by open space and also has contiguity with neighboring residential uses. The Silver Lake

Ditch runs along the eastern boundary. Access to the property is provided by an easement that connects it to Hawthorn Ave.

The blue line bisects the property. From Kalmia down to Alpine, the description of the location of the blue line is indicated as "Low Confidence," as it is defined in this area as located "150 feet west of the center of 3rd Street" (Sec. 128A, Charter of the City of Boulder). This description does not specify the point along the street from which that measurement should be taken, e.g. from the street centerline or curb edge.

The property is considered a "western edge" property, which refers to properties along the western boundary of the city's Service Area. The City of Boulder *Guidelines for Annexation Agreements* of "mostly developed residential properties in Area II," which includes guidelines for the western edge properties, does not apply to this property, as it is in Area III in its entirety. This area designation is atypical for western edge properties along 3rd St., all of which have a portion east of the blue line in the Service Area (either in Area I or II).

Site History

3261 3rd St. is owned by the Wilson family. The property was formed in 1956, when it was sectioned off from a larger parcel. In that process, it became a substandard lot by Boulder County's standards, as it did not meet the minimum size requirement of 1 acre. The property has a 1,818 sq. ft. residence and a 1,416 sq. ft. agricultural outbuilding. The latter structure collapsed and is currently unusable.

The Wilson family first applied for a Subdivision Exemption process to gain recognition as a legal lot in 2012 (SE-12-0009) as well as a Limited Impact Special Use Review for approval of the residence as a historic accessory dwelling unit (LU-12-0014). The prior docket had a conditional approval based on the landmarking of the historic home on the property that was built in the late 19th century, and the latter docket was denied. The requirement expired after one year, and the applicants resubmitted a Subdivision Exemption request in 2014, noting that the historical designation requirement is not appropriate due to the structural damage to the residence and prospective cost of repairs. The request was conditionally approved subject to the Board of County Commissioners resolution (2015-59) described above.

Planning Area Designation

The Area III – Rural Preservation designation of this property refers to the planning area where the city and county intend to preserve existing rural land uses and character. Staff believes the designation of this property as Area III in its entirety represents a mapping error for the following reasons: maps from the 1990 Boulder Valley Comprehensive Plan (BVCP) major update and before reveal that the property was bisected by the blue line, as is the case today, and that the Area II/III boundary followed the blue line on the western edge of the city. In 1997, the comprehensive plan maps were digitized and show the Service Area boundary along the eastern edge of the property, where it remained through the most recent update of the BVCP in 2010. The 1997 map also defined the blue line as the western boundary of the city's Service Area. The position of the blue line as defined in the City Charter did not change in this period. Therefore, the shift of the Service Area boundary to the eastern edge of the property created a misalignment between the blue line and the western boundary of the Service Area. Staff was not able to find

evidence that this shift took place through an amendment process; a digitizing error as part of the conversion of maps to digital media is a possibility.

Land Use Designation
3261 3rd Street has a designation of Low Density Residential. Earlier BVCP maps prior to 1990 appear to show the property as split between "Open Space & Other Parks" and "Low Density Residential" along the same boundary as the blue line. The designation of this property as Low Density Residential in its entirety is traceable back to the 1989-1990 annual review of the comp plan, when the parcel is shown without an open space designation. This may have occurred through minor map corrections to the BVCP land use map regarding open space designations for developed properties at the west end of Hawthorn.

Blue Line
The changes to the blue line under consideration would entail a shift in the line to include western edge properties in the Service Area, including 3261 3rd St. On Aug. 16, City Council approved the blue line ballot measure for the ballot this fall. The November election results will determine the status of approval or denial of the blue line amendments. The implications for this property of the potential shift in the blue line are discussed in the "Analysis" section below under "Compatibility with Surrounding Land Uses."

COMMUNITY INPUT

One comment was received at the Aug. 8 open house on land use change requests. The commenter expressed concerns about the number of houses that may be built on the property.

In 2014 and 2015, several comments received by the county regarding SE-14-0006: Wilson Lot Recognition generally concerned the following topics:

- Importance of maintaining existing footprint of the house.
- Protection of views.
- Compatibility with the adjacent neighborhood and open space.

Other individual opinions expressed include the following: support for the historic preservation of the existing home; concern regarding the environmental sensitivity of the area in light of the impact of the 2013 flood on Hawthorn Ave., the Silver Lake Ditch and the base of the foothills; and concerns regarding the condition of the house as a potential hazard.

ANALYSIS

Criteria for minor adjustments to the Service Area Boundary
The property meets the requirements for a minor adjustment to the Service Area boundary, as outlined in Sec. 2.b.(1) of the Amendment Procedures:

<u>Maximum size and minimum contiguity</u>. The property is less than 10 acres in size and therefore meets the size requirement. The property demonstrates 70 percent contiguity of its perimeter with city limits, and therefore meets the requirement for 1/6 contiguity with the existing service area.

Logical Service Area boundary. Moving the eastern portion of the property to Area II results in a more logical Service Area Boundary. The portion east of the blue line of all other western edge properties along 3rd St. is in the Service Area (Area I or II).

Compatibility with the surrounding area and overall intent of the comprehensive plan. Maintaining the eastern portion of the property as Low Density Residential and changing the existing western portion of 3261 3rd St. to Open Space - Other would be consistent with the adjacent low density residential neighborhood and open space lands, as described in detail below.

The area and land use designation changes are consistent with the overall intent of the comprehensive plan. The changes recognize the existing development on the property and therefore include that portion of the property within the growth boundary of the city. The changes are furthermore consistent with the preservation of open space, as the portion of the property west of the blue line will remain in Area III and receive an Open Space - Other designation. The portions west of the blue line of all other western edge properties along 3rd St. either have an open space designation or a conservation easement.

Other criteria
Due to the size of the property, moving 3261 3rd St. to Area II would not 1) have major negative impacts on transportation, environment, services, facilities or the budget or 2) materially affect land use and growth projections, service provision to the immediate area or overall Service Area, or the city's Capital Improvements Program. Finally, the proposed area change should not create development potential for land that logically should be considered as part of a larger Service Area expansion.

Compatibility with Surrounding Land Uses
The property is contiguous with both open space and residential uses. The use of the property has been residential since the late 19th century, when the house currently on the property was built. Density is one factor in an assessment of neighborhood compatibility. The current Low Density Residential land use designation of 3261 3rd St. allows only residential development and specifies two to six housing units per acre. With 0.741 acres, the property could therefore accommodate up to four dwelling units. Per city regulations, however, only the portion of the property east of the blue line would be eligible for development. Under current conditions, this area comprises roughly .34 acres, or 15,000 sq. ft.

The current draft proposed shift of the blue line to the western edge of the property would result in the entirety of the property, or 32,278 sq. ft., lying to the east of the blue line and thus eligible for development. Staff recommends designating the portion of the property west of the current location of the blue line as Open Space - Other. This land use designation would ensure compatibility with other western edge properties, open space and the character of the surrounding neighborhood.

Staff recommends maintaining the current land use designation of Low Density Residential on the remaining portion of the property east of the current location of the blue line. In addition, should the owner pursue annexation, staff recommends limiting the following: potential for

additional building lots, overall house size and number of units. Potential options to explore include: 1) allowing one unit total with size limitations or 2) allowing one additional unit with size limitations that also offers community benefit, e.g. permanently affordable housing.

Final determination of developable area on the property per city regulations would result from technical staff analysis as part of the annexation process. Factors that could affect the developable area of this property include, but are not limited to the following: slope, soil, height, side yard bulk plane, side yard wall articulation and solar access.

Availability of Services
The site is in proximity to existing development and infrastructure.

Access
The existing width of access per platted easement most likely meets city standards and would be resolved in the annexation process.

Water, Wastewater, and Sanitary Sewer
City water lines and sewer mains exist in the surrounding neighborhood. The map to the right shows the existing sewer system mains. See **Attachment E-1** for additional information.

Figure 1: Existing Sewer Mains
Source: Wastewater Utility Master Plan, 2009

The site has electrical and gas service but no well or water service and relied upon a cistern to supply water needs until 2009, when the property became vacant. The septic system on the property is in need of replacement. Connecting to the system and any needed upgrades would be the responsibility of the owner.

The options for consideration for access to nearby utilities from this property include the extension of water and sewer 1) from Hawthorn Ave. along the driveway access or 2) through adjacent properties. The properties to the southeast of the subject property are privately-owned and would therefore require the provision of a public utility easement. The properties due east and south of the subject property are owned by city open space.

Environment
Open Space
Considerations regarding connectivity with open space and appropriate sensitivity to open space resources should be coordinated with the city should this property be reviewed for annexation. Due to its location next to the foothills, changes to the property could have visual impacts to surrounding open space. Any redevelopment of the property should respect the scenic qualities of the surrounding OSMP lands and not cause greater impacts on ecological systems or water delivery infrastructure than those which exist already in this area (e.g., fences friendly to wildlife movement and ongoing access to the Silver Lake Ditch).

Slope
The extreme slope on the property in addition to the geologic conditions identified by the Pendleton Maps which designate the property as in an area of "Potential Mass Movement Hazard and Consolidation/Swell Constraint" would require geotechnical investigations and engineered drainage plans. These potential constraints could affect the requester's ability to carry through the expressed desire for redevelopment.

There is a potential that engineering treatments including but not limited to structural shoring and hillside stabilization may be necessary; further analysis to determine what treatments might be necessary would be conducted in the annexation process.

Hydrology, Wetlands and Floodplain
The property is not in a floodplain and does not contain wetlands. There are no known hydrological issues with the property.

Other
Historic Preservation
Research indicates the frame house at 3261 3rd St. was built sometime between 1870 and 1900. At the time of annexation, the historic significance would need to be evaluated.

Summary of Analysis
The recommendation for approval of the proposed area change from Area III to Area II for the portion of the property east of the current location of the blue line acknowledges that the existing development on the property should lie within the growth boundary of the city. This area change creates a more logical service boundary consistent with other western edge properties along 3rd Street. In addition, the recommendation for a land use designation change on the western portion of the property to Open Space - Other ensures the preservation of open space and neighborhood character along the western edge and is also consistent with other western edge properties along 3rd St.

ATTACHMENTS

A-1. Availability of Services

Water

All properties east of 3261 3rd St. that are within the city service area (Area I and II) are connected to the city's water line. The closest water line to the site is found along 3rd St. to the south. Two large pipes, with a diameter of 20 and 24 inches, are located east of the site along 4th St. The site is served by Water Pressure Zone 3, which generally serves areas above an elevation of 5,450 feet.

Figure 2: Existing Water Mains

Stormwater

The major drainage way (or creek) associated with this site is Goose Creek. In looking at the site at a closer detail, the majority of the stormwater near the surrounding site is channeled to an irrigation canal that runs north along the east side of site. This irrigation canal continues to travel north and meets the Mesa Reservoir. The existing storm drains are sized for existing levels of development and any new development may require new storm sewers or up-sizing of existing systems. A 12-inch culvert is located directly east of the site, which channels the water onto Forest Ave. Redevelopment of the site may require up-sizing this culvert to maintain adequate hydraulics.

Figure 3: Existing Storm Mains

Waste Water

City sewer mains are found in the surrounding neighborhoods of the site and the closest main to the site is found along 3rd St. to the south. Only local sewer mains surround the site; collector sewer mains are found further east along Balsam Ave. and North St.

Figure 3: Existing Sewer Mains

LINKS: City of Boulder Public Works Department Master Plans

- Comprehensive Flood and Stormwater Plan, 2004
- Stormwater Master Plan, 2007 – update in progress
- Water Utility Master Plan, 2011
- Wastewater Utility Master Plan, 2009
  - Wastewater Collection System Master Plan – update in progress
  - Wastewater Treatment Plant Master Plan
  - Water Quality Strategic Plan

C I T Y O F B O U L D E R
PLANNING BOARD AGENDA ITEM

MEETING DATE: November 17, 2016

AGENDA TITLE: City Council request for Planning Board to reconsider a Boulder Valley Comprehensive Plan map change for 0, 693, 695 Broadway (Table Mesa Shopping Center).

REQUESTING DEPARTMENT:
David Driskell, Executive Director, Planning, Housing + Sustainability (PH+S)
Susan Richstone, Deputy Director for Planning (PH+S)
Lesli Ellis, Comprehensive Planning Manager (PH+S)
Jay Sugnet, Senior Planner (PH+S)
Caitlin Zacharias, Planner I (PH+S)

Suggested Motion Language:
Staff requests Planning Board consideration of this matter and action in the form of the following motion:

Motion to approve a Boulder Valley Comprehensive Plan Land Use Map change to *Community Business* for 0, 693, 695 Broadway (Request #12) as shown and described in **Attachment A.**

The purpose of this item is for the Planning Board to reconsider a public request for a change to the Boulder Valley Comprehensive Plan (BVCP) Land Use map. This is part of a series of hearings and meetings scheduled for Aug. 30 through early 2017 that address Area I requested map changes (requires approval by the two city bodies) and Area II requested map changes (requires approval by City Council, Planning Board, Board of County Commissioners and Planning Commission).

On **Oct. 13**, City Council and Planning Board held a public hearing that focused on the four Area I requested map changes (i.e., Naropa, 385 Broadway, Mt. Calvary Church, and Table Mesa Shopping Center). After the public hearing was closed, Planning Board deliberated and voted to approve the staff recommendations on the four Area I requests. On **Nov. 1**, City Council deliberated and voted on the same requests. While Council voted to approve the staff recommendations for Naropa, 385 Broadway and Mt. Calvary Church, Council voted against the staff recommendation for the Table Mesa Shopping Center. Instead, Council voted to approve changing the land use designation for a portion of the shopping center from Medium Density Residential to Community Business.

Procedures approved at the start of the BVCP update process allow one of the approving bodies to request reconsideration of a decision by another approving body. Council is requesting the Planning Board to reconsider their decision from Oct. 13 regarding the Table Mesa Shopping Center. Because the public hearing was closed on Oct. 13, only written testimony will be provided at the hearing on Nov. 17 specific to the Table Mesa Shopping Center.
Attachment A is the City Council recommended map change for the Table Mesa Shopping Center. The

full staff memo for all the requested land use changes is available here[1].

Summary of Recommended Map Changes:

0, 693, 695 Broadway (Request #12)	**Change to Community Business** – City Council voted unanimously to grant the request from the property owner for the portion of the site currently designated Medium Density Residential.

City Council Action on Table Mesa Shopping Center

On Nov. 1, City Council approved the staff and Planning Board recommendations for Naropa, 385 Broadway, and Mt. Calvary Church. However, City Council voted 9-0 to approve the property owner's request to change the land use designation for a portion of the Table Mesa Shopping Center from Medium Density Residential to Community Business. Planning Board voted 6-2 in favor of keeping the existing Medium Density Residential designation. City Council's reasons for the vote are summarized below:

- The shopping center has existed since the early 1960s and will likely always exist as a shopping center;
- The land use designation and zoning should reflect the current uses;
- Potential impacts to the single-family homes to the south would be addressed through site planning if any redevelopment were to occur;
- Noise regulations are the same regardless of the zoning at the source of the noise; and
- The city should encourage vibrant commercial centers.

The BVCP, jointly adopted by the city and county and updated at least every five years, guides development and preservation in the Boulder Valley. The BVCP articulates a vision for the future and details policies that represent long-standing community values. The public map change request process is one track within the much larger BVCP update. Each phase entails extensive community dialogue and engagement. The webpage for the project, www.BoulderValleyCompPlan.net, includes the full project schedule and a link to the 2010 plan and maps.

Next Steps

The schedule for the Area II request for **Twin Lakes** is pending the outcome of the County Planning Commission reconsideration of the Twin Lakes decision. A city hearing is not likely occur until early 2017.

- Dec. 13 – **City Council deliberate and vote** on the Area II request for 3261 3rd St.
- Jan. 24 – **Joint Study Session of City Council and Planning Board** to review scenarios, analysis, community engagement results from fall, survey results, and CU South.
- Spring 2017 – **City Council Study Session** to review the Draft Plan and Focus Areas.

Approved By:

David Driskell, Executive Director
Department of Community Planning and Sustainability

ATTACHMENTS

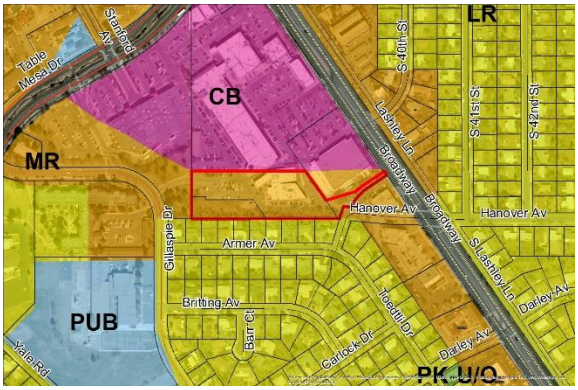
A. Table Mesa Shopping Center (Request #12) City Council Recommended Map Change

[1] https://bouldercolorado.gov/bvcp/bvcp-changes

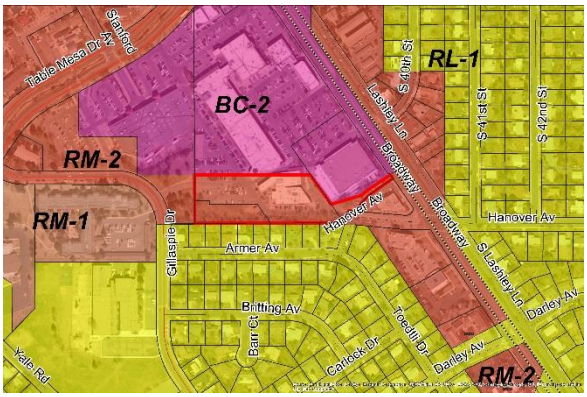
Request #12

0, 693, 695 Broadway
Table Mesa Shopping Center

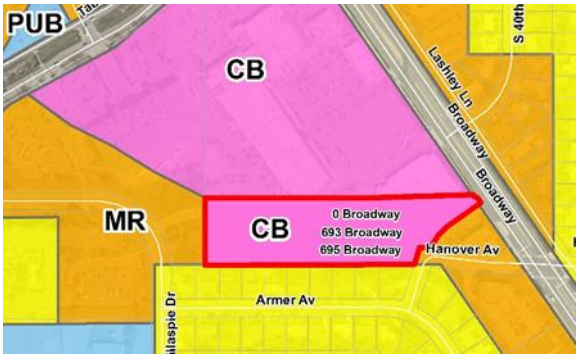
Existing BVCP Land Use Map



Existing Zoning Map



City Council Recommended Land Use Map



Request Summary

- Requester: Table Mesa Shopping Center LLC, owner
- Type of Request: Land use map change
- Brief Description of Request: Medium Density Residential (MR) to Community Business (CB)
- Approval Required: Two body

Existing Conditions

- BVCP Designation: Medium Density Residential (MR)
- Zoning: Residential Medium 2 (RM-2)
- Lot Size (BVCP boundaries do not follow parcel boundaries in this case):
  - Total area impacted by request: 3.5 acres
  - Total area of all properties impacted by request: 10.45 acres
- Existing Buildings: 187,940 sq. ft. of leasable area in Table Mesa Shopping Center

Jobs and Housing Assumptions

- Existing Estimated Dwelling Units: 25-57 with MR designation
- Existing Estimated Jobs: n/a
- Future Estimated Dwelling Units: 36-40 with CB designation
- Future Estimated Jobs: 200-220 with CB

Looking northwest near culinary school

C I T Y OF B O U L D E R
PLANNING BOARD AGENDA ITEM

MEETING DATE: November 17, 2016

AGENDA TITLE: Public Hearing and Recommendation to City Council for Acceptance of the Boulder Wastewater Collection System Master Plan (WWCSMP) and Action on the Proposed Amendments to the Comprehensive Plan (BVCP) Wastewater Utility Summary.

REQUESTING DEPARTMENT: PUBLIC WORKS
Maureen Rait, Executive Director of Public Works
David Driskell, Director, Planning, Housing & Sustainability
Susan Richstone, Deputy Director, Planning, Housing & Sustainability
Jeff Arthur, Director for Public Works for Utilities
Douglas Sullivan, Engineering Project Manager
Pieter Beyer, Civil Engineer II
Lesli Ellis, Comprehensive Planning Manager
Jean Gatza, Senior Planner
Phil Kleisler, Planner II

EXECUTIVE SUMMARY:
The core mission of the Boulder Public Works (PW) Department is to maintain and improve the quality of life in Boulder by planning for future needs, promoting environmental quality, building and maintaining municipal infrastructure, managing public investments, and protecting health and safety. Utilities staff are in the process of updating the 2009 Wastewater Collection System Master Plan (WWCSMP). The plan is being updated to better reflect current conditions and new regulatory requirements. The purpose of this agenda item is to review the Wastewater Collection System Master Plan (**Attachment A**) and provide a recommendation to City Council regarding acceptance of the plan and approval of the master plan summary for the Boulder Valley Comprehensive Plan (BVCP) document **(Attachment B)**.

Master plans provide a bridge between the BVCP, service delivery, future capital needs, and the Capital Improvements Program (CIP). The Planning Board's role in reviewing master plans is to look for consistency with BVCP goals and policies before the plans are accepted by City Council. Because of its role in reviewing the Capital Improvements Program (CIP), the Planning Board also reviews master plans to ensure that capital improvement needs and funding strategies have been identified to meet adopted service standards. The questions that are the focus of the Planning Board's review are:

1. Is the master plan consistent with the goals, policies, and growth projections of the BVCP?

2. Does the master plan outline the BVCP service standards and a plan to meet them in the future?
3. Does the plan describe and assess capital needs and a funding plan for them?

STAFF RECOMMENDATION:
Staff recommends that the Planning Board provide a recommendation to City Council for acceptance of the WWCSMP and approval of the BVCP Wastewater Utility Summary.

PUBLIC AND BOARD COMMENT AND PROCESS:
The master plan process has been led by a staff team with support from consulting firm HDR Engineering. The WWCSMP was presented in tandem with the 2016 Stormwater Master Plan. The Water Resources Board (WRAB) held three public hearings during the planning period to accept public testimony and provide direction to the project team. The WRAB unanimously recommended acceptance of the WWCSMP on April 18, 2016.

Like the Stormwater Master Plan process, the WWCSMP team used a combination of post-flood data and new analysis in the development of recommended capital improvements.

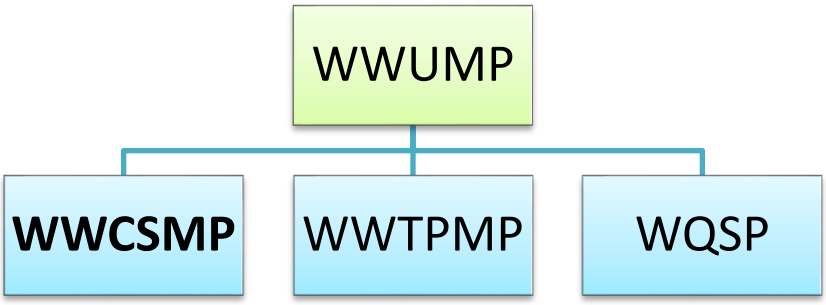
2013 Post-flood Survey
City staff conducted a survey asking residents that reported damage to FEMA to identify the source of flooding that caused damage. This data was used to identify any clusters of sewer-related flooding or backups, or any other trends that should be included in the 2016 WWCSMP. The results of this analysis can be found in section 2.2 of the proposed plan (page 10).

Table 1. Flood survey results by sewer basin by reported source.

Sewer Basin	Groundwater Seepage	Sewer Lateral Backup	Floor Drain Backup
Boulder Creek	219	55	78
Fourmile	64	11	27
Goose Creek	226	85	99
Gunbarrel	2	1	2
South Boulder Creek	221	91	84
Total	**732**	**243**	**290**

BACKGROUND AND PLAN OVERVIEW:
The Wastewater Utility Master Plan (WWUMP) is the overarching planning document that is intended to present key issues, projects and budgets for the collection system, wastewater treatment plan and water quality programs. As shown below in Figure 1, the WWUMP is supported by three subsequent city plans: Wastewater Treatment Plant Master Plan (WWTPMP), the Water Quality Strategic Plan (WQSP), and this Wastewater Collection System Master Plan (WWCSMP).

Figure 1. City of Boulder wastewater planning structure.



The primary goals of the WWCSMP are to identify capacity problems within the collection system and develop a prioritized list of recommended capital projects to resolve the capacity limitations. The 2016 WWCSMP will replace the 2009 plan and focus on the following tasks:

1. Revise the sanitary sewer system hydraulic model to include recently acquired flow monitoring data;
2. Incorporate inspection information of upstream collection systems;
3. Consider collection system performance during and since the 2013 flood; and
4. Develop a prioritized list of capital recommendations.

Factors Driving the Need for Change
Some key trends point to changing conditions in the community and provide the context for the WWCSMP update.

- **The need to update wastewater modeling to reflect current conditions.**
  During the 2013 flood event the city's wastewater collection system experienced an extremely high volume of storm water inflow and groundwater infiltration, leading to sewer overflows and backups throughout the city. City staff implemented an intensive flow-monitoring program from 2014 onwards in an effort to better understand the source of extraneous water entering the sanitary sewer system. The data gleaned from this effort was used to revise and calibrate the master plan's hydraulic model. The amount and quality of this data is also significantly higher than the data used in the 2009 WWCSMP, and as a result, the 2016 model used in the proposed master plan has a higher level of confidence and more adequately represents current conditions than previous models did.

  The proposed 2016 master plan update also allowed the city to review the practical and financial implications of raising the system's level of service standard to accommodate inflow and infiltration flows generated from a 25-year rainfall event. Raising the level of service would reduce the frequency and severity of sanitary sewer overflows and backups during extreme weather events.

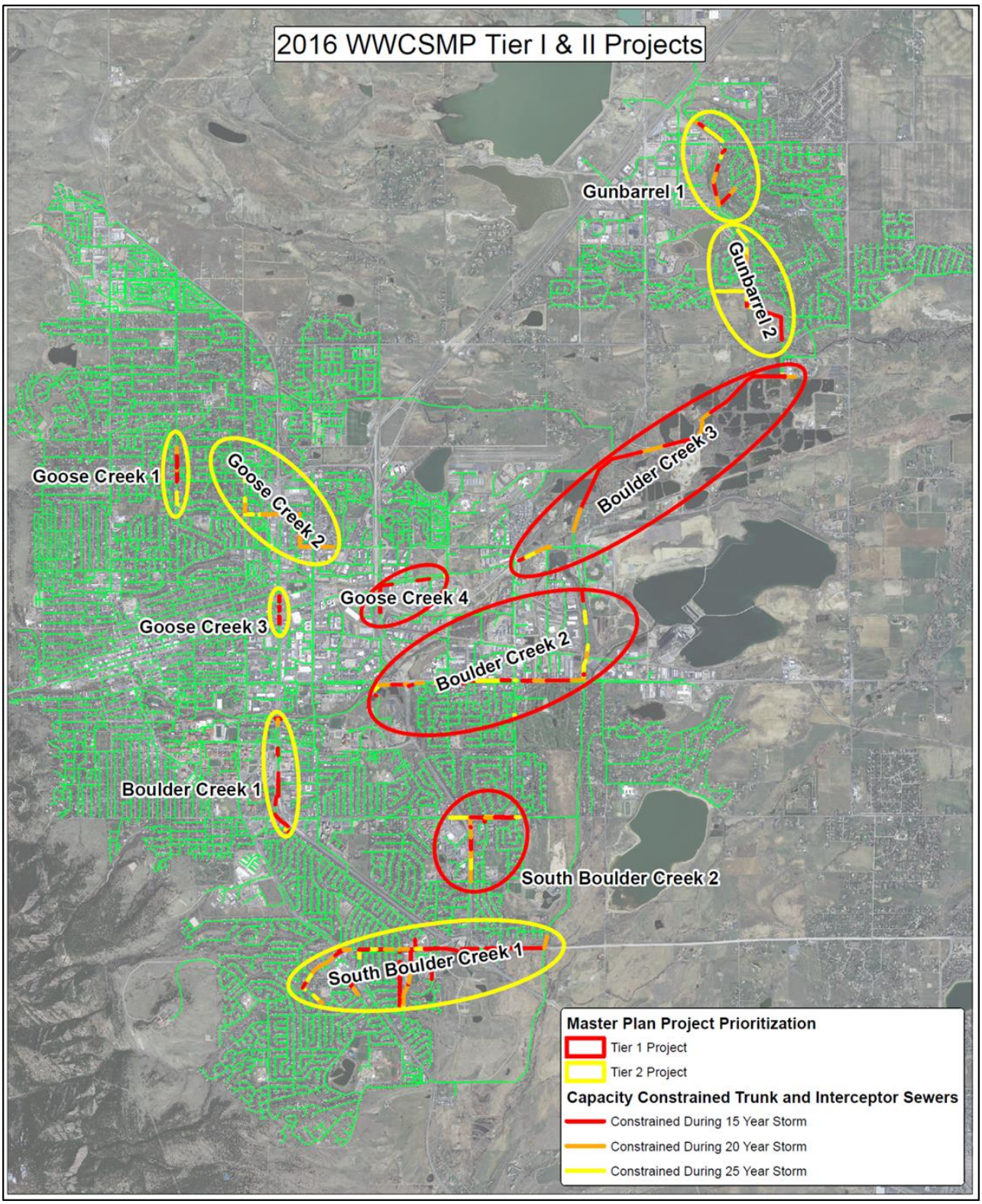
Additional Analysis
In 2014 the city performed an intensive system-wide flow monitoring study that utilized 60 temporary flow meters over four (4) months. The city has since installed nineteen permanent flow monitoring stations along main trunk sewers and performed inspections of numerous flow diversion structures. This information, coupled with the post-flood survey, helped inform the hydraulic model used for the 2016 WWCSMP.

The 2016 WWCSMP identifies four (4) high priority tier one projects and seven medium priority tier two requests. These projects are listed in Table 2, and shown in Figure 1 below.

Table 2. 2016 WWCSMP recommended project prioritization.

Problem Priority	Improvement ID	Improvement Location
Tier 1	Boulder Creek 3	Valmont Rd and 61st St to WWTP
Tier 1	South Boulder Creek 2	Foothills Pkwy, Baseline Rd
Tier 1	Boulder Creek 2	Arapahoe Ave and Foothills Pkwy to Old Tale Rd; South Boulder Creek corridor
Tier 1	Goose Creek 4	Foothills Pkwy and Pearl St
Tier 2	Goose Creek 1	19th Street from Kalmia Ave to Grape Ave
Tier 2	South Boulder Creek 1	Table Mesa Dr, South Boulder Rd, S 46th St
Tier 2	Boulder Creek 1	Colorado Ave and 28th St
Tier 2	Goose Creek 3	28th Street from Pine St to Walnut St
Tier 2	Goose Creek 2	Folsom St/Glenwood Dr/Valmont Rd
Tier 2	Gunbarrel 1	Boulder and Left Hand Ditch; Idylwild Tr/Boulder Country Club
Tier 2	Gunbarrel 2	Along Boulder Supply Canal north of Jay Rd

Figure 1 – 2016 WWCSMP Tier 1 and Tier 2 Project Recommendations



ANALYSIS:

1. **Is the master plan consistent with the goals, policies, and growth projections of the BVCP?**

Staff finds that the WWCSMP is consistent with the goals, policies and growth projections of the BVCP. The master plan is consistent with the following BVCP broad policies regarding delivery of services:

- **3.20 Flood Management**
  The city and county will protect the public and property from the impacts of flooding in a timely and cost-effective manner while balancing community interests with public safety needs. The city and county will manage the potential for floods by implementing the following guiding principles: a) Preserve floodplains ***b) Be prepared for floods*** *c) Help people protect themselves from flood hazards d) Prevent unwise uses and adverse impacts in the floodplain* ***e) Seek to accommodate floods, not control them****. The city seeks to manage flood recovery by protecting critical facilities in the 500-year floodplain and implementing multi hazard mitigation and flood response and recovery plans.*

  The proposed 2016 WWCSMP recommends actions to prepare and accommodate for future flood events. The plan identifies sewer overflows and basement backups during the 2013 flood as being largely caused by severe levels of inflow and infiltration in both the city-owned and private sewer system. The main source of sewer backups in some areas originated from overwhelmed floor drains as basements flooded from groundwater seepage and surface flooding. The locations of these backups were used in analyzing system capacity needs.

- **3.29 Wastewater**
  The city will pursue sustainable wastewater treatment processes to achieve water quality improvements with greater energy efficiency and minimal chemical use. Pollution prevention and proactive maintenance strategies will be incorporated in wastewater collection system management. The county will discourage the installation of private on-site wastewater systems where municipal collection systems are available or where a potential pollution or health hazard would be created.

  The proposed 2016 WWCSMP proactively identifies and prioritizes key projects to the city's sanitary sewer system. The recommended capital improvements will lead to fewer sewer backups and overflows, which have the potential to introduce pollutants into the system or contaminate properties.

  Growth Projections
  The 2010 BVCP projections for population, employment and future land uses were used to establish existing and future sanitary base flows and for the hydraulic model based on when this project began. The collection system's level of service is defined by the level of wet weather event that the system can sustain without causing sanitary sewer overflows or backups into buildings. The collection system's level of service is therefore directly related to the excess capacity in the collection system which is available to

convey rainfall dependent inflow and infiltration (RDII) flows. For this project, the 15-, 20-, and 25-year levels of service are examined, with the city's ultimate objective being that the collection system can serve the 25-year level of service under buildout conditions. The collection system pipes with identified capacity limitations, established from the model results, were examined to identify likely hydraulic issues under buildout conditions for the 15-, 20-, and 25-year levels of service flow scenarios and resulted in the recommended tier 1, 2 and 3 improvements based on priority.

2. Does the master plan outline BVCP service standards and a plan to meet them in the future?

The Public Works Department is currently meeting or exceeding BVCP urban service criteria for stormwater and floodplain management, as detailed in Chapter VI *Urban Service Criteria and Standards.*

3. Does the master plan describe and assess capital needs and a funding plan for them?

The WWCSMP, Chapter seven (7), includes detailed capital project recommendations, probable construction costs and an implementation plan.

The master plan recommendations include a total of 11 CIP projects – four high priority Tier 1 projects, and seven medium priority Tier 2 projects. These 11 projects will replace the recommended projects identified in the 2009 WWCSMP. These collection system projects have been incorporated into the Wastewater Utility Fund CIP planning. Key projects in the 2017-2022 CIP outlined in the plan include:

- The wastewater interceptor realignment project (14,000 ft. of sewer). ($20M)
- The lower Goose Creek sanitary trunk sewer replacement and rehabilitation project (7,500 ft. of sewer) ($4M in 2017)
- The Foothills & Baseline trunk sewer replacement ($3.5M in 2018)
- On-going funding for manhole and sewer rehabilitation (approx. $2M in 2017 and at least approx. $3M in on-going funding)

NEXT STEPS:
Staff will consider Planning Board's feedback and revise the Wastewater Collection System Master Plan if necessary. The revised plan will be presented to City Council as a public hearing item for review and acceptance in early 2017.

Approved By:

David Driskell, Executive Director
Department of Community Planning and Sustainability

ATTACHMENTS:

A – Draft Wastewater Collection System Master Plan

B – Revised BVCP Master Plan and Program Summary

ATTACHMENT A

City of Boulder

2016 Wastewater Collection System Master Plan

City of Boulder, Colorado
July 14, 2016

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Appendices

Appendix A – Cost Estimate Worksheets

Appendix B – Model Input Data Tables, Results Tables and Output

Glossary of Terms

Annual average dry weather flow (ADWF)	The yearly average daily wastewater flow comprised of population, employment and SIU contributions associated with non-rainfall periods. For this study, ADWF includes base infiltration associated with irrigation ditches and other groundwater influences. Generally used to represent the sanitary sewer system response to an average dry day of flow.
Base Infiltration (BI)	Groundwater that seeps into a collection system through defective pipes, pipe joints, and manhole structures. The rate of infiltration depends on the depth of groundwater above the defects, the size of the defects, and the percentage of the collection system that is submerged. Variation in groundwater levels and the associated infiltration is both seasonal and weather dependent.
Base Sanitary Flow (BSF)	Sanitary loading mostly from homes and businesses. Daily fluctuations in ADWF are mostly attributed to variations in BSF, such as domestic, industrial, and commercial wastewater contributions and how these contributions vary throughout a day.
Collector Sewer	A sewer that collects flows from the local and local collector sewers and conveys that flow to the interceptor sewers. Typical collector sewer diameters range from 12- to 24-inch.
Diurnal Pattern	A repeating pattern of factors which represents hourly changes over a day. In the context of a hydraulic model, the diurnal pattern represents hourly changes in flow contribution due to normal residential, commercial, and industrial behaviors.
Dry Weather Flow	The portion of the wastewater flow that is comprised of population, employment and SIU contributions with base infiltration from irrigation ditches and streams. The flow does not include rainfall dependent infiltration and inflow.
Groundwater Infiltration (GWI)	Measured during average dry weather flow period. The average of the low nighttime flows (midnight to 6 am) per day for the same time period, minus significant industrial or commercial nighttime flows
Force Main	A sewer that conveys pumped flow from a wet-well and pump station over a hydraulic obstacle where the flow cannot be conveyed by gravity such as a hill.
Hydraulic Model	A hydraulic network which attempts to best represent the actual collection system to evaluate and locate problems areas and to provide improvement recommendations for these areas. Hydraulic models mimic the actual operation of the system but do not match it exactly due to the many variables present between the system and model.
Hydrograph	A graph showing stage (the height of a water surface above an established datum plane), flow, velocity, or other property of water with respect to time.
Infiltration	Water that enters the collection system through cracks in the manholes and pipes and leaking pipe joints in aging pipes. The source of the infiltration can come from a number of sources including groundwater, irrigation ditches, streams, and rainfall seeping through the ground.
Inflow	Water that enters the collection system mainly through manhole lids and other surface entrances. The primary source of the inflow is from rainfall drainage that flows over the manhole lids but can also come from fire hydrant flushes and other liquid spills.
Interceptor Sewer	A sewer that collects flows from the local, local collector and collector sewers and conveys that flow to the wastewater treatment plant. Typical interceptor sewer diameters are greater than 24-inch.

Local Collector Sewer	A sewer that collects flows from the local sewers and conveys that flow to the collector and interceptor sewers. Since this system has steeper slopes and therefore longer reaches of smaller diameter of pipe, this definition of local collectors has been used to represent these collection pipes that link the local sewers to the collector sewers. Typical local collector sewer diameters can range from 8- to 12-inch.
Local Sewer	A sewer that collects flows from homes and business service connections and conveys that flow to the local collector, collector and interceptor sewers. Typical local sewer diameters are less than 10-inch.
Model Calibration	Calibration is a process of changing model variables in the attempt to more closely match the model results to actual system operation. Due to the many variables present, exact calibration between the two is very difficult; instead an understanding of the level of model calibration obtainable is important while analyzing the system using the model.
Peak Hour Wet Weather Flow (PHWWF)	The highest one hour flow during a significant rain event.
Peaking Factor	The ratio of peak hourly flow to average daily flow.
Rainfall Dependent Inflow and Infiltration (RDII)	The fraction of rainfall that enters the sanitary sewer system due to precipitation. Generally used to represent the sanitary sewer system response to rainfall.
Return Frequency	The reciprocal of the annual probability of exceedance of a specific flow value (also known as recurrence interval). For example, a return frequency of 10-year indicates that in any given year, there is a 1-in-10 (10 percent) chance of that flow or precipitation value occurring.
Sanitary Flow	The portion of the wastewater flow that is comprised solely of population, employment and SIU contributions with no infiltration and inflow.
Sanitary Sewer	A sewer that conveys liquid and waterborne wastes from residences, commercial and industrial buildings, and institutions together with minor quantities of groundwater and stormwater that are not admitted intentionally into the system.
Sanitary Sewer Overflow (SSO)	An event when wastewater flow spills out from a manhole due to a backed up sewer. Causes can range from blocked pipes to an overloaded system due to heavy rainfall. Sanitary sewer overflows are considered disadvantageous and even hazardous since the wastewater flow that escapes can contaminate.
Service Line	A pipe that conveys wastewater flow from a customer to a point where it joins the public sewer system.
Sewer Basin	An area of the collection system where the majority of flow in the area drains into a single interceptor pipe which conveys the flow downstream into another sewer basin or to the wastewater treatment plant.
Sewershed	An area defined using boundaries such as streets, property lines, streams, and topography as well as engineering judgment which creates a collection of manholes of which loading can be assigned.
Significant Industrial User (SIU)	An industrial user which contributes a large quantity and/or poor quality of wastewater where pretreatment and monitoring of flow are required. Significant industrial users contribute non-domestic flow that is accounted for separately during system loading.
Siphon	A designed pipeline segment that flows under pressure to go under a hydraulic obstacle such as a stream.

Thiessen Polygon	In the context of sewer collection systems, a polygon shape which bisects areas between manholes of which the contributing flow from that polygon can be assigned to a particular manhole.
Traffic Analysis Zones (TAZ)	Publicly available spatially-oriented data that provides population and employment projections for estimating growth and increased sanitary flow contributions.
Unit Flow Factors	Sanitary flow factors that are based on contribution from a single unit such as a person. Typically, unit flow factors are expressed in gallons per day per person or employee.
Wastewater Flow	The total wastewater stream comprised of all sanitary flow and infiltration and inflow.
Wet Weather Flow	The wastewater flow stream that is comprised of population, employment and SIU contributions with base infiltration from irrigation ditches and streams as well as rainfall dependent infiltration and inflow.
Wastewater Treatment Facility (WWTF)	The facility where all wastewater flow is conveyed to by the collection system and treated to all applicable permits and regulations. In this study, the WWTF refers to City of Boulder's 75th Street Wastewater Treatment Facility.

Acronyms and Abbreviations

2009 WWCSMP	2009 Wastewater Collection System Master Plan
2016 WWCSMP	2015 Wastewater Collection System Master Plan Update
ADWF	Annual average dry weather flow
BI	Base Infiltration
BSF	Base Sanitary Flow
BVCP	Boulder Valley Comprehensive Plan
CMOM	Capacity, Management, Operations, and Maintenance
CC	Centrifugally Cast
CCTV	Closed Circuit Television
CDPHE	Colorado Department of Public Health and Environment
CI	Cast Iron
CIP	Capital Improvement Project
city	City of Boulder
CMMS	Computerized Maintenance Management System
d/D	Modeled depth divided by the full flow depth
DRCOG	Denver Region Council of Government
DCS	Design and Construction Standards
DI	Ductile Iron
EPA	U.S. Environmental Protection Agency
FOG	Fats, Oils, and Grease
FSE	Food Service Establishments
gpd	Gallons per day
gpm	Gallons per minute
GRE	Grease Removal Equipment
GWI	Groundwater Infiltration
MWRD	Metropolitan Water Reclamation District
mgd	Million gallons per day
NASSCO	National Association of Sewer Service Companies
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
O&M	Operations and Maintenance
PHWWF	Peak Hour Wet Weather Flow
PF	Peaking Factor
PACP	Pipeline Assessment Certification Program
PVC	Polyvinyl Chloride
QC	Quality Control
RDII	Rainfall Dependent Inflow and Infiltration
RC	Reinforced Concrete
RPM	Reinforced Plastic Mortar
SSMP	Sewer System Management Plans
SIU	Significant Industrial User
SSO	Sanitary Sewer Overflow
TAZ	Traffic Analysis Zones
UMMS	Utility Maintenance Management System
VC	Vitrified Clay
WDR	Waste Discharge Requirements
WWCSMP	Wastewater Collection System Master Plan
WWTF	Wastewater Treatment Facility
WUSA	Wastewater Utility Service Area

Executive Summary

Existing Service Area and Collection System

The City of Boulder's (city) wastewater collection system and the 75th Street Wastewater Treatment Facility (WWTF) serve residences and businesses within the Wastewater Utility Service Area (WUSA). The WUSA is comprised of the Boulder Valley Comprehensive Plan (BVCP) Area I (within Boulder city limits) and Area II (areas adjacent to the city limits that may be subject to annexation in the future). Areas outside the WUSA boundary are served by other utility districts or septic systems. The resulting WUSA contains approximately 17,200 acres (27 sq. miles) and is shown on The wastewater collection system includes gravity sewers, diversion manholes, one inverted siphon and two lift station/force main systems that convey wastewater flow from the five sewer basins to the WWTF. Major features and gravity sewers by pipe size that compose the existing system are depicted in Figure ES-1 and summarized in Table ES-2.

Table ES-2. Existing Sewer System Summary – Modeled Elements

Collection System Feature / Sewer Basin	Modeled Gravity Sewer (miles)	Modeled Flow Split Manholes	Modeled Lift Stations	Modeled Force Mains	Modeled Inverted Siphons
Boulder Creek	120.5	14	0	0	0
Fourmile	48.0	1	0	0	0
Goose Creek	132.4	13	0	0	0
Gunbarrel	46.0	4	1 (City-owned)	1 (City-owned)	1
South Boulder Creek	31.0	8	1 (Private)	1 (Private)	0
Total	**377.9**	**40**	**2**	**2**	**1**

Source: City of Boulder GIS data.

Figure ES-1.

There are five sewer basins that contribute wastewater flow to the primary collector and interceptor system and ultimately to the WWTF (The wastewater collection system includes gravity sewers, diversion manholes, one inverted siphon and two lift station/force main systems that convey wastewater flow from the five sewer basins to the WWTF. Major features and gravity sewers by pipe size that compose the existing system are depicted in Figure ES-1 and summarized in Table ES-2.

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Fourmile	48.0	1	0	0	0
Goose Creek	132.4	13	0	0	0

Table ES-2. Existing Sewer System Summary – Modeled Elements

Collection System Feature / Sewer Basin	Modeled Gravity Sewer (miles)	Modeled Flow Split Manholes	Modeled Lift Stations	Modeled Force Mains	Modeled Inverted Siphons
Gunbarrel	46.0	4	1 (City-owned)	1 (City-owned)	1
South Boulder Creek	31.0	8	1 (Private)	1 (Private)	0
Total	**377.9**	**40**	**2**	**2**	**1**

Source: City of Boulder GIS data.

Figure ES-1).

Table ES-1. Sewer Basins

Sewer Basin	Area (acres)
Gunbarrel	3,000
Fourmile	2,220
Goose Creek	5,020
Boulder Creek	5,430
South Boulder Creek	1,530
Total	**17,200**

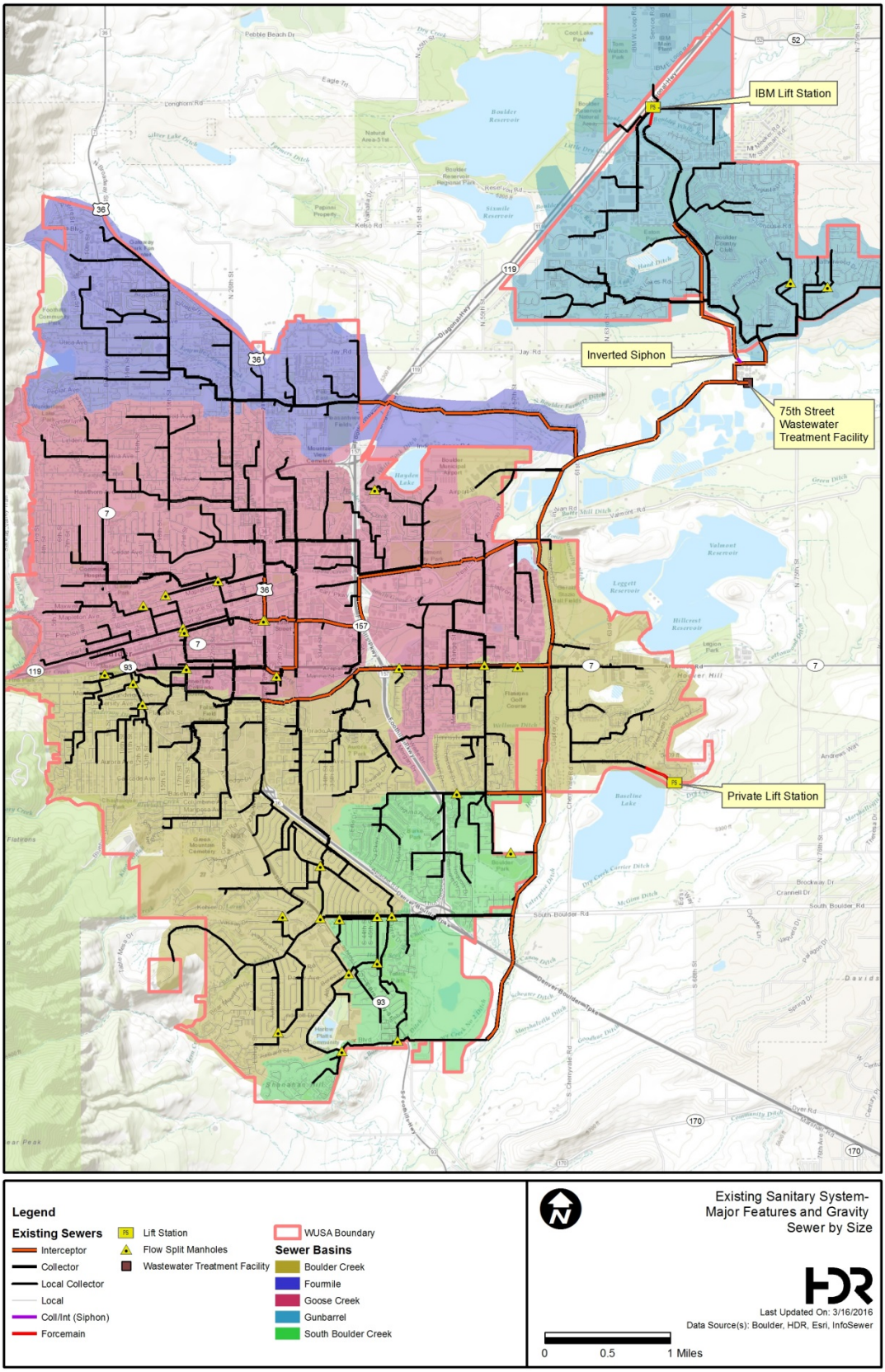
The wastewater collection system includes gravity sewers, diversion manholes, one inverted siphon and two lift station/force main systems that convey wastewater flow from the five sewer basins to the WWTF. Major features and gravity sewers by pipe size that compose the existing system are depicted in Figure ES-1 and summarized in Table ES-2.

Table ES-2. Existing Sewer System Summary – Modeled Elements

Collection System Feature / Sewer Basin	Modeled Gravity Sewer (miles)	Modeled Flow Split Manholes	Modeled Lift Stations	Modeled Force Mains	Modeled Inverted Siphons
Boulder Creek	120.5	14	0	0	0
Fourmile	48.0	1	0	0	0
Goose Creek	132.4	13	0	0	0
Gunbarrel	46.0	4	1 (City-owned)	1 (City-owned)	1
South Boulder Creek	31.0	8	1 (Private)	1 (Private)	0
Total	**377.9**	**40**	**2**	**2**	**1**

Source: City of Boulder GIS data.

Figure ES-1. Existing Sanitary System- Major Features and Gravity Sewer by Size



Flow Projections

The city provided existing (2014), 2035, and buildout data for city population and employment. This data, along with 2010 Census Data, was used to update city population and employment summaries for this 2016 Wastewater Collection System Master Plan (2016 WWCSMP). Growth projections are made to 2035 based on zoning capacity and growth rate assumptions. The 2010 BVCP has a planning timeframe of 15 years, but calls for growth projections to extend 20 years beyond the last update of the plan. The BVCP 20-year projections are based upon zoning capacity information supplemented by growth assumptions and input from DRCOG, the State Demographer's Office, and local and state economists. The WUSA is made up of the BVCP planning Areas I and II within these projections. Table ES-3 presents these city projections for the WUSA. The population projections summarized as part of the 2009 Wastewater Collection System Master Plan (2009 WWCSMP) were greater for the 2030 population (128,162) compared to this 2035 population projection (125,468), however, for employment the previous buildout projection (155,864) was less compared this projection (165,230).

Table ES-3. Population and Employment Projections for WUSA

Year	2010	2014	2035	Buildout
Population	109,200	114,200	125,468	125,468[1]
Employment	99,750	105,450	119,180	165,230

Source: City of Boulder Department of Community Planning and Sustainability, 1/20/2012; and 2014 Community Profile, 04/2014.

[1] Population was not separated between 2035 and buildout in the provided projections.

In the 2009 WWCSMP DRCOG TAZ polygons, with population and employment projections, were used to establish existing and future sanitary base flows. The TAZ polygons, however, have not been updated in several years, and the BVCP update process is just being initiated and will not be available to use for the 2016 WWCSMP. Therefore, 2014 use data from potable water meters and their GIS locations were used exclusively to spatially allocate the base sanitary loads to the hydraulic model.

The city's 2011 Wastewater Utility Master Plan (WUMP) water distribution model contains a detailed allocation of future water use and, therefore, represents the corresponding future sanitary load generation and how it is anticipated to be distributed across the city. By incorporating the city's 2011 WUMP future water use, future conditions modeling in the 2015 WWSMP Update is consistent with the water plan. The future water use allocation in the 2011 WUMP model, reduced by an appropriate winter (indoor) use factor of 0.65, is applied as future Base Sanitary Flow (BSF) loading for the 2016 WWCSMP. This future sanitary load allocation process aligns the future water use and sanitary sewer loads. Based on this process, it is estimated that Boulder's winter water demand will increase 2,395 gpm (3.45 mgd) by 2035. Of the 2,395 gpm (3.45 mgd) increase in 2035 winter water demand, 92 percent, or 2,208 additional gpm (3.18 mgd), is estimated to enter the WUSA.

Existing Dry Weather Flow

Existing potable water meter data from winter periods and Significant Industrial User (SIU) information were used to allocate BSF.

Monthly metered water use volumes from December 2013 through February 2014 were converted and averaged to a monthly rate of consumption. These averages were converted to a BSF of 8.9 million gallons per day [mgd] (6,158 gpm). This flow rate includes SIUs, which are owners who contribute high sanitary loadings.

The city provided updated average annual 2014 daily flows for the current SIUs. These flows were compared to the water meter data for those SIUs and the larger of the two values were used. In addition, a 70 percent reduction (30 percent flow through) was applied for the University of Colorado at Boulder's main campus based on the University's master plan. This process yields a total modeled SIU sanitary contribution of 816 gpm (1.17 mgd) or 13 percent of the total 8.9 mgd BSF to the WWTF for 2014.

BSF flows were allocated to the model by developing Thiessen polygons for the model manholes within each sewershed and spatially joining these sewersheds to the GIS water meter locations. The location of SIUs with respect to the Thiessen polygons was then reevaluated and, if necessary, flow allocations were adjusted so that they were loaded to the closest manhole to that SIU's outlet location, as provided by the city.

The total BSF for 2035 conditions is estimated be 8,366 gpm (12.0 mgd) by applying the additional 2035 flows estimated from the 2011 WUMP water distribution model. Future SIU flow is estimated to be approximately 10 percent of this 2035 BSF.

Base infiltration (BI) was developed from the city's permanent flow monitor data from August 26, 2015 by subtracting the contributing BSF from the average flow at the corresponding permanent flow monitor. BI was allocated to the model based on pipe diameter and pipe length and the BI loadings were calibrated to be within +10 percent of the annual average dry weather flow (ADWF) peak and daily volume for the permanent flow monitors.

Table ES-4 summarizes the modeled BSF, BI, and resulting ADWF for this 2016 WWCSMP.

Table ES-4. Existing and Buildout Dry Weather Flows

Model Flow Scenario	Existing (2015) (mgd)	Buildout (2035) (mgd)
Base Sanitary Flow (BSF)	8.9	12.1
Base Infiltration (BI)	6.0	6.0
Annual Average Dry Weather Flow (ADWF)	14.9	18.1

Wet Weather Flow

Wet weather flows are comprised of rainfall dependent inflow and infiltration (RDII) in addition to the ADWF. Wet weather infiltration is the additional infiltration that occurs due to rainfall-induced higher groundwater conditions and is typically seen in the hours or days following rain events. Inflow is rainfall related water that enters a collection system from sources such as private laterals, downspouts, manhole defects, foundation piping, and cross-connections with storm drains. RDII is directly influenced by the intensity and duration of a storm event as well as antecedent soil moisture conditions and is therefore variable from storm to storm.

The RDII flow response for the 2016 WWCSMP is based on the sanitary sewer system's response to the wet weather event that occurred on May 9, 2015 as seen at the permanent flow monitors and WWTF influent monitor. The model was calibrated to this event with the goal of having a slightly positive percent error and for modeled flows to be within +5% of the measured peak hour wet weather flow (PHWWF).

The collection system's level of service is defined by the level of wet weather event that the system can sustain without causing sanitary sewer overflows or backups into buildings. The collection system's level of service is therefore directly related to the excess capacity in the collection system which is available to convey RDII flows. The level of service can therefore be represented by the rainfall recurrence interval that results in the maximum conveyable RDII. For this project, the 15-, 20-, and 25-year levels of service are examined, with the city's ultimate objective being that the collection system can serve the 25-year level of service under buildout conditions.

15-, 20-, and 25-year levels of service were calculated based on rainfall/RDII relationship developed from WWTF influent flows in conjunction with available rainfall data. The calibrated wet weather flows were scaled to these 15-, 20-, and 25-year levels of service flows for collection system analysis. Table ES-5 summarizes these level of service flows used for the 2016 WWCSMP.

Table ES-5. PHWWF at the WWTF Influent for Existing and Buildout Condition Scenario Modeling

Model Condition	ADWF (mgd)	PHWWF 15-Year Level of Service (mgd)	PHWWF 20-Year Level of Service (mgd)	PHWWF 25-Year Level of Service (mgd)
Calibrated and Refined Existing Conditions	14.9	50.0	60.0	69.3
Buildout Conditions	18.1	53.2	63.2	72.5

Collection System Analysis

The primary source of data that was used for the collection system model development and analysis was the city's sanitary sewer GIS layers for manholes and sewer pipes. This database was provided to HDR in August 2014 and formed the basis of all subsequent work. Combined, the two GIS layers represent 9,952 manholes and 10,038 sewer main pipe segments, ranging in size from 4 inch to 60 inch in diameter.

Gravity sewers are typically classified as local, collector and interceptor sewers. Local sewers have diameters that are typically less than 10 inches and convey wastewater from relatively small service areas (20 acres +/- and less). Local sewers have numerous service line connections collecting wastewater from individual customers. Collector sewers have diameters that typically range between 12 and 24 inches. Collector sewers convey flow from multiple local sewers and also include individual service line connections, although not as many as local sewers. Interceptor sewers typically have very few, if any, individual service line connections and convey wastewater from connections with collector sewers to the WWTF.

Many of Boulder's local sewers provide service to relatively large areas with some local sewers serving areas up to 100 acres in size and/or highly developed areas. These small diameter local sewers are an integral part of the gravity sewer system. As a result, the local sewers that serve large areas have been termed "local collectors" for purposes of this study. The scope of this study was to analyze the hydraulic capacity of interceptor, collector and local collector sewers. Additional

collection system features included in the model and analysis are lift stations, force mains, diversion manholes, and inverted siphons. The modeled collection system is shown on The collection system pipes with identified capacity limitations, established from the model results, were examined to identify likely hydraulic issues under buildout conditions for the 15-, 20-, and 25-year levels of service flow scenarios. Table ES-6 summarizes pipes in the analyzed collection system with identified hydraulic limitations.

Table ES-6. Summary of Pipes with Modeled Hydraulic Limitations under Buildout Flow Projections in the Analyzed Collection System

Buildout Model Flow Scenario	Number of Pipes with Hydraulic Limitations	Total Length of Pipe with Hydraulic Limitations (miles)	Total Length of Pipe with Hydraulic Limitations (as a Percent of Total Analyzed System Length)	Number of Surcharged Manholes (Less than 1 foot of Freeboard)
15-Year Level of Service PHWWF	288	12.6	10%	41
20-Year Level of Service PHWWF	391	17.9	14%	99
25-Year Level of Service PHWWF	500	23.1	18%	176

The city's objective is that the collection system can serve the 25-year level of service under buildout conditions. The focus of problem identification was therefore examining the collection system's hydraulic criteria against this flow scenario. The resulting hydraulic problems were separated into three categories for characterization and prioritization: Type A, Type B, and Type C. These three categories are defined as follows:

- **Type A:** A series of under capacity pipes that are hydraulically connected to one another. For Type A hydraulic problems, the system wide hydraulic criteria is a modeled peak wet weather flow level exceeding 80 percent d/D and includes the interceptor, collector, local collector, and local systems.
- **Type B:** Isolated under capacity pipes that are not hydraulically connected to other problem locations. For Type B hydraulic problems, the system wide hydraulic criteria is a modeled peak wet weather flow level exceeding 80 percent d/D and includes the interceptor, collector, local collector, and local systems.
- **Type C:** Under capacity pipes that are part of the local collector and local systems that can be either isolated or hydraulically connected to other problem pipes. For Type C hydraulic problems, the modeled peak wet weather flow level hydraulic criteria is between 60 and 80 percent d/D and includes only the local collector and local systems.

Type C problems were placed in a separate category because they apply to local collector and local system pipes that are just above their hydraulic capacity criteria and, while modeling indicates they are hydraulically restricted, they do not have the same level of priority or risk as the Type A and Type B categories. In addition, the accuracy of the data that are used to identify these potential capacity restrictions may outweigh the precision provided by the hydraulic model. These Type C restrictions will likely require further assessment with flow monitoring and pipe invert validation.

Figure ES-2.

The collection system pipes with identified capacity limitations, established from the model results, were examined to identify likely hydraulic issues under buildout conditions for the 15-, 20-, and 25-year levels of service flow scenarios. Table ES-6 summarizes pipes in the analyzed collection system with identified hydraulic limitations.

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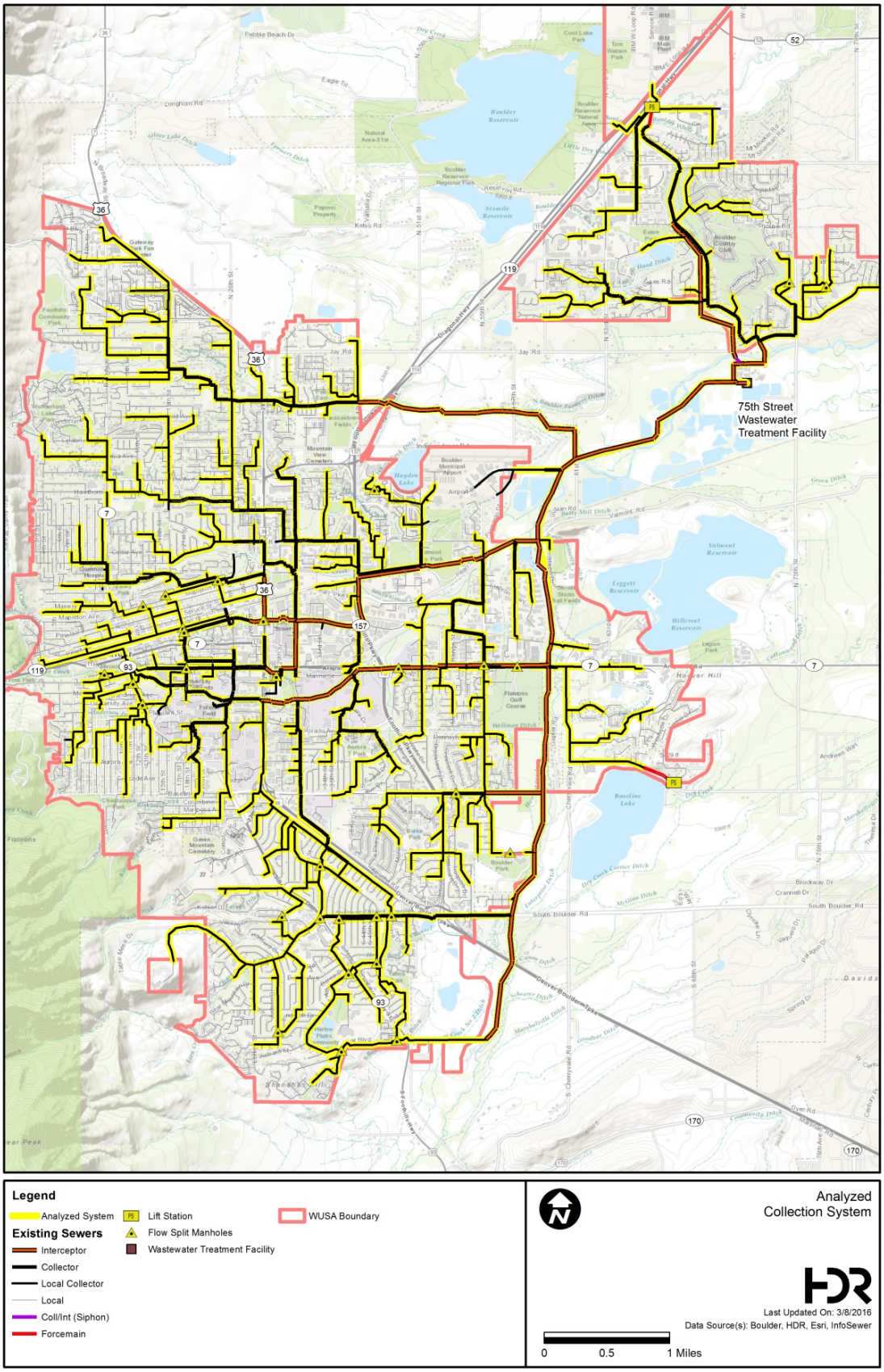
- **Type A:** A series of under capacity pipes that are hydraulically connected to one another. For Type A hydraulic problems, the system wide hydraulic criteria is a modeled peak wet weather flow level exceeding 80 percent d/D and includes the interceptor, collector, local collector, and local systems.
- **Type B:** Isolated under capacity pipes that are not hydraulically connected to other problem locations. For Type B hydraulic problems, the system wide hydraulic criteria is a modeled peak wet weather flow level exceeding 80 percent d/D and includes the interceptor, collector, local collector, and local systems.
- **Type C:** Under capacity pipes that are part of the local collector and local systems that can be either isolated or hydraulically connected to other problem pipes. For Type C hydraulic problems, the modeled peak wet weather flow level hydraulic criteria is between 60 and 80 percent d/D and includes only the local collector and local systems.

Type C problems were placed in a separate category because they apply to local collector and local system pipes that are just above their hydraulic capacity criteria and, while modeling indicates they are hydraulically restricted, they do not have the same level of priority or risk as the Type A and Type B categories. In addition, the accuracy of the data that are used to identify these potential capacity restrictions may outweigh the precision provided by the hydraulic model. These Type C restrictions will likely require further assessment with flow monitoring and pipe invert validation.

Figure ES-2. Analyzed Collection System



Type A problems account for 50 percent of the problem pipes or a total of 247 pipes with a cumulative length of approximately 12.8 miles (Figure ES-3). Type B problems account for 25 percent of the problem pipes or a total of 125 pipes with a cumulative length of approximately 3.9 miles (Figure ES-3). Type C problems account for the remaining 25 percent of problem pipes or a total of 128 pipes with a cumulative length of approximately 6.3 miles (Figure ES-4).

Recommended Collection System Improvements

The recommended system improvements that resolve the existing and future capacity issues are shown on Figure ES-5. This figure includes improvements that address both Type A and Type B problem categories. Type A problems consist of a series of problem pipes that are hydraulically connected to one another. Type B problems are isolated hydraulic restrictions that are not hydraulically connected to other problem locations or series of problem pipes.

The recommended improvements were grouped into three tiers to establish implementation priority:

- Tier 1 projects address Type A problems and have the highest priority.
- Tier 2 projects also address Type A problems but have lower priority compared to Tier 1.
- Tier 3 projects address Type B problems which have the lowest priority.

The improvement priorities were assigned based on a number of qualitative factors including discussions with the city, the flow conditions in which they occur (15-, 20-, or 25-year level of service), extent of the problem, potential for sanitary sewer overflows (SSOs) and service lateral backups, and relative benefit over other improvement projects. The relative benefit takes into account the amount of pipe replaced compared to the extent of the problem remedied. These factors are summarized in the problem characterization tables in Section 6 of this report. The resulting implementation priorities as developed in Section 7 and associated estimates of capital construction cost are shown in Table ES-7. Itemized capital cost estimate worksheets are included in Appendix A of this report.

Figure ES-3. Type A and Type B Problem Locations: Buildout Peak Hour Wet Weather Flows for 15, 20, and 25-Year Levels of Service

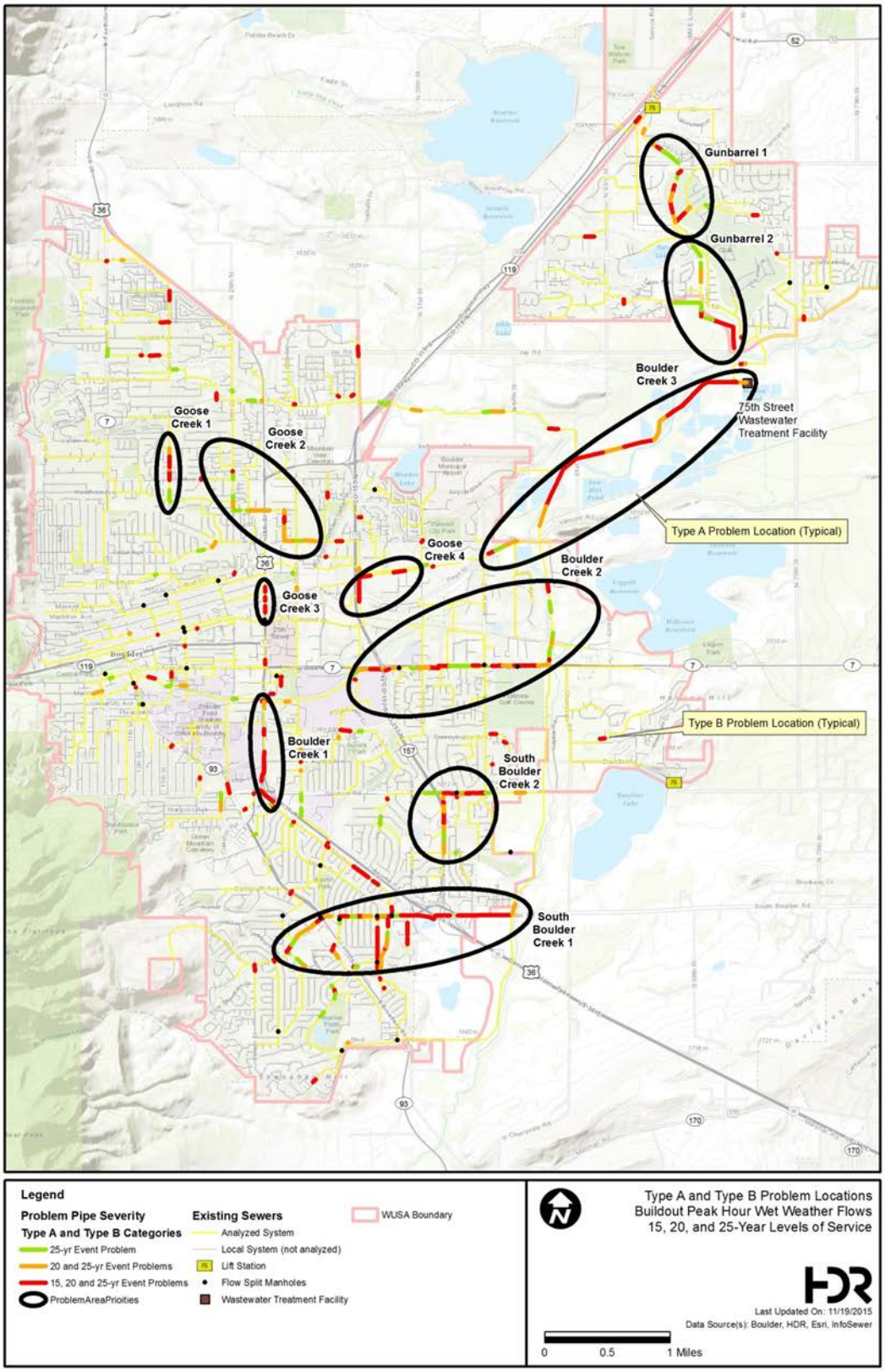


Figure ES-4. Type C Problem Locations: Buildout Peak Hour Wet Weather Flows for 15, 20, and 25-Year Levels of Service

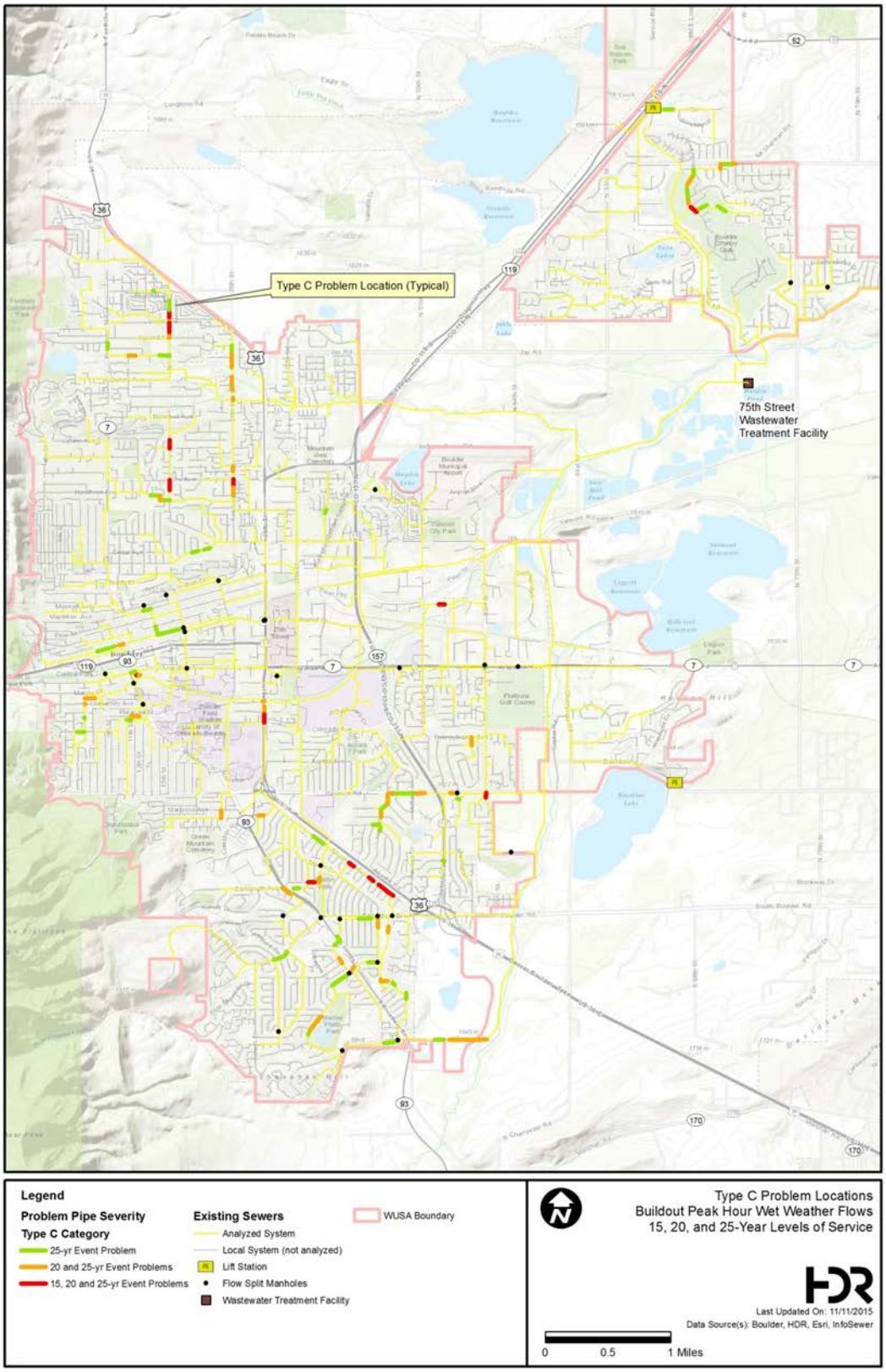
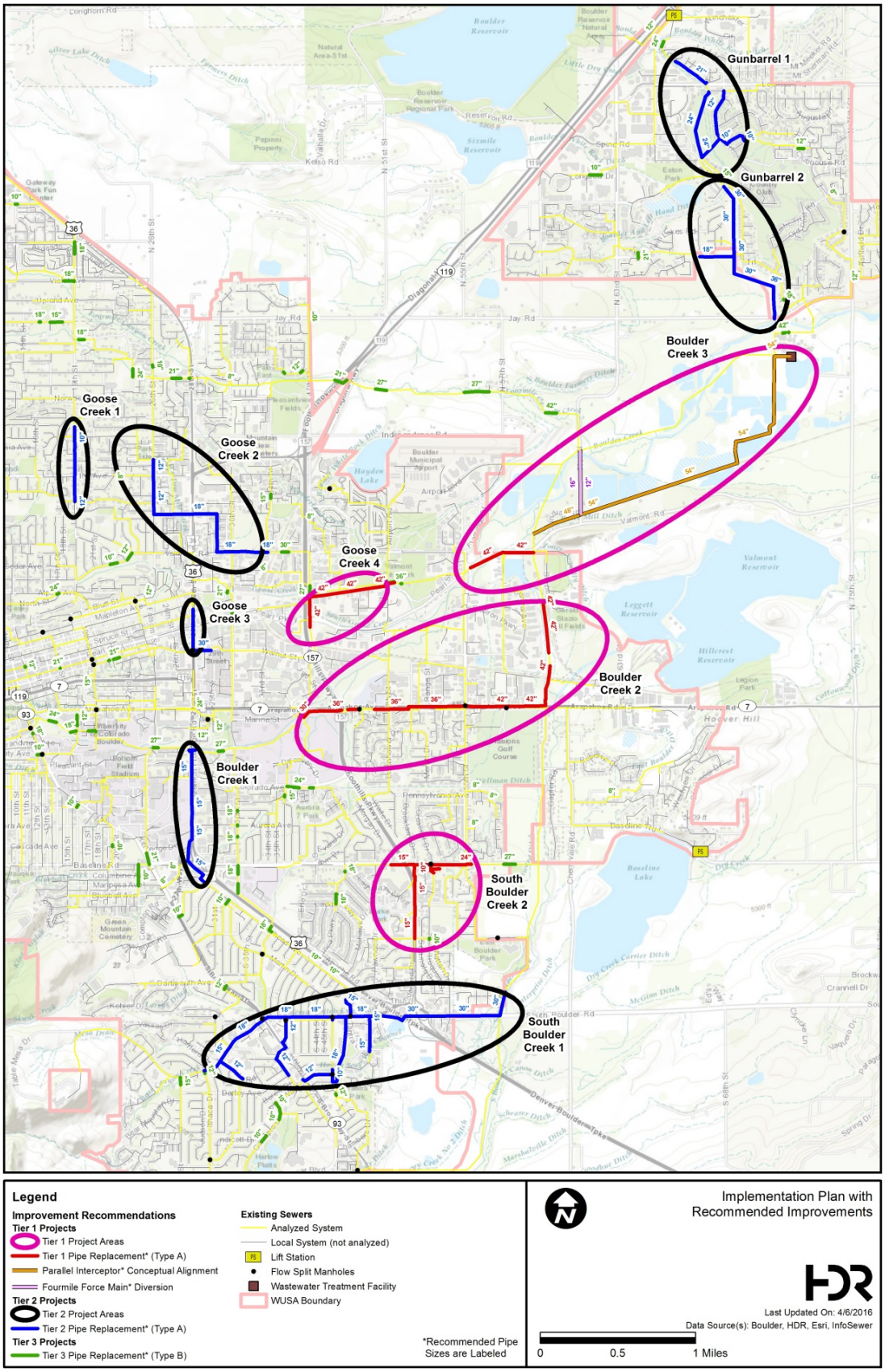


Table ES-7. Existing Sewer System Summary – Modeled Elements

Problem Priority	Improvement ID	Improvement Location	Improvement Size (inches)	Total Improvement Length (feet)	Capital Cost
Tier 1	Boulder Creek 3	Valmont Rd and 61st St to WWTP	12,16,42, 48, 54	19,174	$26,040,000
Tier 1	South Boulder Creek 2	Foothills Pkwy, Baseline Rd	10, 12, 15, 18, 21, 24, 30	5,880	$3,497,000
Tier 1	Boulder Creek 2	Arapahoe Ave and Foothills Pkwy to Old Tale Rd; South Boulder Creek corridor	30, 36, 42	10,810	$12,605,000
Tier 1	Goose Creek 4	Foothills Pkwy and Pearl St	42	4,016	$8,320,000
				TIER 1 TOTAL	**$50,462,000**
Tier 2	Goose Creek 1	19th Street from Kalmia Ave to Grape Ave	10, 12	2,539	$1,292,000
Tier 2	South Boulder Creek 1	Table Mesa Dr, South Boulder Rd, S 46th St	10, 12, 15, 18, 21, 24, 30	21,478	$17,370,000
Tier 2	Boulder Creek 1	Colorado Ave and 28th St	12, 15, 24	5,118	$4,298,000
Tier 2	Goose Creek 3	28th Street from Pine St to Walnut St	24, 30	1,945	$1,250,000
Tier 2	Goose Creek 2	Folsom St/Glenwood Dr/Valmont Rd	12, 18	7,063	$4,004,000
Tier 2	Gunbarrel 1	Boulder and Left Hand Ditch; Idylwild Tr/Boulder Country Club	8, 10, 12, 15, 21, 24	7,395	$4,388,000
Tier 2	Gunbarrel 2	Boulder Supply Canal north of Jay Rd	18, 30, 36,	6,786	$5,467,000
				TIER 2 TOTAL	**$38,069,000**
				TIER 3 TOTAL1	**$18,299,000**
				TOTAL ALL PROJECTS TOTAL	**$106,830,000**

[1]Tier 3 cost reflect Type B improvements

Figure ES-5. Implementation Plan with Recommended Improvements



O&M Review and Recommendations

The review and recommendations for the collection system operations and maintenance (O&M) procedures from the 2009 WWCSMP were not revised for this 2016 WWCSMP. This section therefore remains as previously published.

The 2009 WWCSMP project team reviewed the collection system operations and maintenance (O&M) procedures. The purpose of this O&M procedure was to review the current state of collection system O&M practices and evaluate potential increases in service levels due to trends in the regulatory environment in the western United States. In addition, the 2008 QualServe peer review program and self assessment survey evaluated the Utility's overall performance, efficiency and customer service as well as maintaining industry best management practices.

Both the QualServ program and the WWCSMP O&M review found that the Gravity System's Maintenance group operates and maintains the collection system such that it continues to provide a high level of service to its existing customers.

Boulder developed a methodology for determining the mileage and cost of the 20-year CIP for rehabilitating wastewater pipes and manholes. This methodology was based on spreadsheet model that characterized pipe failure as a function of time to assist in forecasting long-term budgetary needs for rehabilitation of sanitary sewer pipe. This analysis resulted in a recommendation for an annual manhole and sewer pipe rehabilitation budget of $850,000. This methodology was given an independent review which recommended that an annual sewer rehabilitation budget of $500,000 would be adequate for the 20-year planning period.

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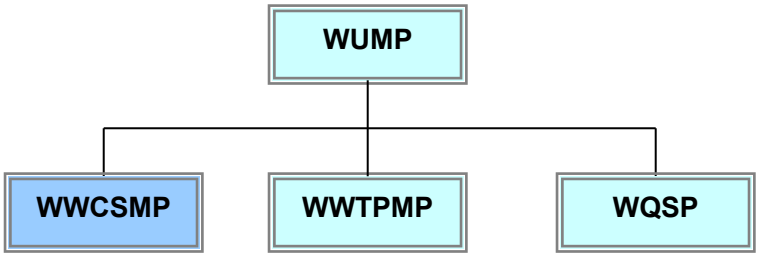
1 Introduction

The Wastewater Utility Master Plan (WUMP) is the overarching planning document that is intended to present key issues, projects and budgets for the collection system, wastewater treatment plan and, water quality programs. The WUMP is supported by the Wastewater Treatment Plant Master Plan (WWTPMP), the Water Quality Strategic Plan (WQSP), and this Wastewater Collection System Master Plan (WWCSMP). This document is the WWCSMP and it addresses the wastewater collection system through development of a master plan that addresses issues associated with the capacity of the collection system capacity issues and collection system operations and maintenance programs.



The primary goals of the WWCSMP are to identify capacity problems within the collection system and develop a prioritized list of recommended capital projects to resolve the capacity limitations. These goals were met through the following tasks:

- Develop a computer model of the sewer collection system based on the city's GIS data.
- Analyze the existing collection system under existing and future land use conditions.
- Identify capacity problems within the collection system under future conditions.
- Develop improvement alternatives and identify recommended improvement projects.
- Prioritize the recommended improvements and develop planning level estimates of capital construction cost.

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2 Data Review and Assessment

This section inventories the data collected and reviewed for the City of Boulder (city) 2016 WWCSMP. The purpose of the data review and assessment is to compare the dataset used for the 2009 WWCSMP with the recently available dataset for the 2016 WWCSMP. The recently collected data from Boulder forms the basis for the hydraulic model and plan update. This data set contains more complete information than available for the 2009 WWCSMP. Updates include the latest collection system GIS data with details for modeling Boulder's flow split manholes. Existing and future flow allocation is improved with flow monitoring and water use data from 2014 and water use projections from the 2011 Water Utility Master Plan (2011 WUMP). In addition, this section provides an assessment and summary of the data related to the 2013 post-flood sewer conditions and the *2014 Flow Monitoring Program* report (Stantec, 2014).

2.1 Data Collection and Review

The following sections list and describe the data collected and reviewed to date related to the 2016 WWCSMP.

2.1.1 Data Inventory

Table 2-1 presents an inventory of the data provided by Boulder for this project (October 2014 through January, 2015).

Table 2-1. Data Inventory

Item[1]	Description	Type
2014 Flow Monitoring Program	Flow monitoring study by Stantec	pdf
2014 Flow Monitoring Program Rainfall Data	Appendix IV of the 2014 Flow Monitoring Report by Stantec	txt
2014 Flow Monitoring RDII Calculations	Appendix V I-I of the 2014 Flow Monitoring Report	xlsx
2009-2015 WWTF Influent Flow Data	Influent flow data from Boulder's WWTF from June 2009 through May 2015	xlsx
2013 Hot Spot Maps	Maps showing the ongoing Hot Spot Cleaning program focusing on problem areas of the sewer system	pdfs
2013-14 Winter Water Meter Data	Table and points containing winter water demand records	gdb
2011 Water Utility Master Plan	Planning document containing information relating the water system and future demand projections	pdf
Recent Sewer Replacement Data	Layer indicating recent sewer main repairs (included in Sanitary Sewer gdb)	Feature class
2009 Boulder Wastewater System Master Plan	Planning document containing information relating to the wastewater collection system	pdf

Table 2-1. Data Inventory

Item[1]	Description	Type
Groundwater shapefiles	Contains groundwater elevation data for the project area	shapefiles
Basemap.gdb	Background Boulder layers	gdb
Boulder_2013FloodData.gdb	Table and spatial containing results of survey done following the 2013 flood event	gdb
FEMA DFIRM.gdb	DFIRM geodatabase	gdb
FloodManagement.gdb	Boulder of Boulder flood management layers	gdb
Planning.gdb	Landuse, zoning, planning layers	gdb
SanitarySewer.gdb	Most recently updated GIS information	gdb
StormDrainage.gdb	Stormwater collection system	gdb
Transportation.gdb	Transportation layers	gdb
WaterDistribution.gdb	Water distribution system	gdb
TAZ Update shapefiles	Traffic analysis zone layers	shapefiles
Telecom shapefiles	Communications-related line layers	shapefiles
I&I Study shapefiles	Flow monitor and rain gauge locations	shapefiles

[1] gdb is the file type for geodatabase which contains multiple GIS feature classes (layers).

2.1.2 Recent Sanitary Sewer GIS

The most up-to-date GIS files of Boulder's wastewater collection system were provided in geodatabase format and included the four feature classes shown in **Table 2-2**.

Table 2-2. GIS Feature Classes Provided

Feature Class	Geometry Type	Description	Date Received
ssCasing	Polyline	Pipe Casing	8/14/2014
ssMain	Polyline	Wastewater Collection System Mains	1/7/2014
ssManhole	Point	Manholes	1/7/2014
ssService	Polyline	Service Laterals	8/14/2014

The ssMain and ssManhole feature classes, the only two layers included in the model, were compared to the 2009 WWCSMP InfoSewer model. Based on a match of unique identification fields in the GIS files and the model, it was determined that the model could be updated using the Table 2-2 GIS files. Based on the recent GIS files, an estimated 324 manholes need to be updated in the model (approximately three percent of the system's manholes) and an estimated 520 pipes equaling approximately 89,700 feet (ft) in length need to be updated in the model (approximately four percent of the system's pipes by length). Figure 2-1 shows manholes and sewer mains that need to be updated in the model.

In addition, the GIS attributes for the ssMain and ssManhole feature classes were reviewed for completeness. Invert values are missing from 1,773 of 10,133 pipes in the GIS. In the collector and interceptor systems (12 inches and greater), the inverts will be filled in using interpolation from upstream and downstream known values. Ninety percent of pipes missing inverts are less than or equal to 8 inches in diameter are missing invert elevations. For the purposes of this 2016 WWCSMP, missing elevations will be interpolated only for pipes that are larger than 8 inches in diameter. Pipes less than 8 inches in diameter without inverts will not be analyzed for capacity.

Diameter values are missing from 95 of 10,133 pipes in the GIS. These missing diameters will be filled in using upstream and downstream known values. These data gaps should be field collected and populated in the GIS prior to the next model update to enable a complete system analysis. The REHABTYPE and REHABDATE fields in the ssMain feature class will be used to identify pipes that were recently rehabilitated with cured-in-place pipe (CIPP) liners or other methods of rehabilitation.

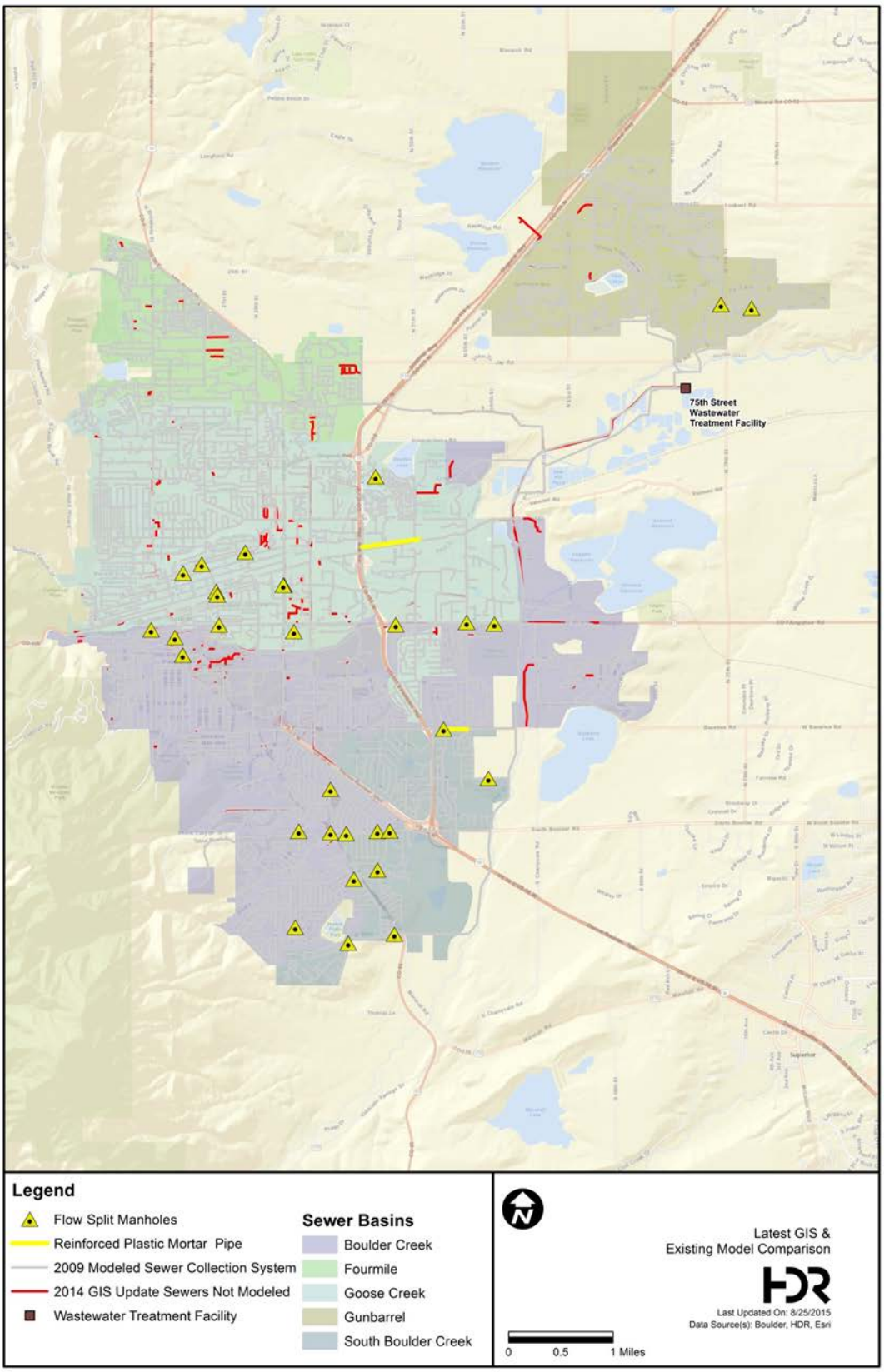
A review of the GIS data indicates that some pipes within the system are reinforced plastic mortar (RPM) pipe. The product name of RPM is Flextran and the material is a thin-walled fiberglass-based pipe that was installed in the early to mid 1970s. Flextran RPM pipes have been known to experience deterioration and/or be susceptible to structural failure over time in collection systems around the country. Boulder knows that these pipes need to be lined with a structural liner or replaced. According to the GIS data, 13 pipes within the system, for a total length of 4,117 feet, are comprised of RPM pipe. Existing RPM pipes within Boulder's collection system are highlighted in Figure 2-1.

2.1.3 2013 Post-flood Survey Data

The 2013 post-flood survey data provided by Boulder includes the Flood Survey layer and the Flood Call Log. The Flood Survey layer was the outcome of a survey conducted by Boulder and is the key data set. The flood survey's goal was to capture data on the origin of residential damages during the flood. This data can be used to determine if damages were caused by surface water flooding, sanitary sewer surcharges, or creek flows. The Flood Call Log is a compilation of 911 and Public Works call center calls. The notes in this dataset are based on the caller's interpretation of events. This data was used to initiate the Hot Spot Cleaning program in early 2014.

Sewer overflows and basement backups during the 2013 flood event were found to be largely the result of severe levels of inflow and infiltration in both the City owned and private sewer systems. In some areas of the system the main source of sewer backups was found to be excessive flow from floor drains which overwhelmed the local sewer system as basements flooded from groundwater seepage and surface flooding.

Figure 2-1. Latest GIS & Existing Model Comparison



The location of these backups and surcharges will be used in the 2016 WWCSMP to analyze potential capacity issues using the hydraulic model and to make improvement recommendations in specific areas that experienced substantial localized issues during the 2013 flood event.

2.1.4 Sanitary Sewer Cleaning and Hot Spots

Following the 2013 flooding event, Boulder began conducting sewer cleaning and field inspections of reported backups. These priority inspections have been completed and no blockages were found. Boulder provided maps showing priority areas of the system and scheduled cleaning. The entire collection system is planned to be inspected with closed-circuit television (CCTV) within the next 2 years. Infiltration and inflow (I&I) has been observed at pipe joints in local sewers. I&I at service connections is a known issue that will be addressed over time. Inflow into manholes is also being looked into by Boulder.

2.1.5 Population and Employment Data

Boulder provided existing (2014) and buildout (2035) data for Boulder population and employment. This information along with 2010 Census Data will be used to update Boulder-wide population and employment summaries in their corresponding WWCSMP sections. In the 2009 WWCSMP, TAZ from the DRCOG with population and employment projections were used for establishing existing and future sanitary base flows. However, the TAZ polygons haven't been updated in several years. In addition, the BVCP update process is just being initiated and will not be available in time to use during this project. Therefore, 2014 use data from water meters and their GIS locations will be used to spatially allocate the base sanitary loads to the hydraulic model.

2.1.6 Wastewater Treatment Facility Influent Flow

Recent influent flow data for the city's 75th Street WWTF were received and analyzed to determine average, maximum, and minimum flows as summarized in Table 2-3. According to the data, the maximum average daily influent to the WWTF occurred on September 13, 2013 at 51.7 million gallons per day (mgd) during the 2013 flood event. Minimum average daily influent flow occurred on December 19, 2012 at 7.3 mgd. Average influent flow for the entire study period was 13.4 mgd.

Table 2-3. 75th Street Wastewater Treatment Facility Influent Flow (mgd)

		2009[1]	2010	2011	2012	2013	2014[2]	Entire Period [3]
Hourly	Average	13.36	13.93	12.63	11.89	15.07	14.16	13.43
	Max	20.48	39.03	31.52	50.00	53.63	57.70	57.70
	Min	5.91	0.56	-	0.78	0.00	6.68	-
Daily	Max	15.94	24.39	23.60	16.12	51.69	16.96	51.69
	Min	9.42	7.88	8.77	7.25	8.56	11.20	7.25
	Max Day	7/30/2009	4/23/2010	5/19/2011	7/9/2012	9/13/2013	4/15/2014	9/13/2013
	Min Day	12/25/2009	12/25/2010	1/1/2011	12/19/2012	1/1/2013	1/1/2014	12/19/2012

[1] Data from June 25, 2009
[2] Data through April 29, 2014
[3] Data from June 25, 2009 through April 29, 2014

2.1.7 *2014 Flow Monitoring Program* Report

Stantec performed flow monitoring throughout the wastewater collection system at 60 manholes between April and July, 2014. The *2014 Flow Monitoring Program* report (Stantec, 2014) presents an I&I analysis based on the data collected during this period. Stantec provided flow monitoring data and I&I analysis results to Boulder that can be viewed using their software. The data from this report will be used in the model update including base infiltration allocation for dry-weather conditions and rainfall dependent infiltration and inflow (RDII) allocation for wet-weather conditions. In addition, the data will be used for dry- and wet-weather model calibration.

2.1.8 Water Demands

Existing water use data and water demand projections will be used to allocate base sanitary loads. Water use data from meters provides an enhanced spatial preciseness of load allocation in the model based on having actual, instead of estimated, use data. Using detailed water use data is improved over the approach used in the 2009 WWCSMP which was based on TAZ-based population and employment projections and applied equal unit flows across Boulder. Water meter data better represents the local base sanitary flow generation because of its generally accepted increased data accuracy and reliability. This will improve the ability to calibrate the model at a more local level than in the 2009 WWCSMP.

2.1.8.1 Existing Meters

Water meter use data for winter, 2013 through spring, 2014 were provided by Boulder, including GIS points of the account locations. This data will be used to calculate base sanitary loads for existing conditions. These loads will then be allocated to the model as the basis for the existing scenario flows along with the 2014 I&I data from the 2014 Flow Monitoring Program.

2.1.8.1 Future Demand Projections from Water Utility Master Plan

The 2011 WUMP provides future demand projections for Boulder's water distribution system in five year increments from 2010 through buildout (2035). These water demands will serve as the basis for buildout base sanitary loads in the 2015 WWCSMP model along with the 2014 I&I data. These demand projections will be applied to the WWCSMP model update directly from the final 2011 WUMP model provided to Boulder for the winter month 2035 scenario.

2.1.9 Significant Industrial Users

A spreadsheet listing fifteen SIUs was provided by Boulder. The spreadsheet includes 2013 average discharge flows for each of these SIU. This spreadsheet will be used to update the model with average dry-weather flow contributions from these users.

2.1.10 Flow Split Manholes

Boulder completed the process of collecting data on flow split manholes throughout the collection system. There are 40 structures with flow split-related information in GIS including:

- 4 with weir overflows.
- 1 shared manhole.
- 8 splits that are plugged.
- 7 that are invert overflows.
- 2 with abandoned gate structures.
- 15 percentage flow splits.
- 3 apex manholes.

These flow split manholes will be incorporated accordingly in the hydraulic model. Analysis will be completed during the 2016 WWCSMP using the updated model to determine whether some of these flow split manholes can be plugged to allow for more straightforward system operations.

2.1.11 Recent Sewer Replacement

Boulder provided a GIS feature class of Sewer Main Repairs in the sanitary sewer collection system indicating approximately 4.8 miles of sewer main was repaired between 2002 and 2013. Additionally, Boulder is embarking on an R&R/lining program that will address the vast majority of the system in the next 20 years.

2.1.12 Lift Station Changes

No lift station changes have occurred since the 2009 WWCSMP; however improvements to the IBM Lift Station are planned in the near future. Boulder is in the process of designing improvements to both the overall pumping capacity and wet-well volume to reduce the risk of overflows due to limited on-site storage and better manage flow through the lift station and downstream force main. One additional pump of similar capacity to the existing three will be added to increase total and firm lift station capacities by approximately 33 percent and 50 percent, respectively. Additional wet-well volume for handling overflows during wet-weather events is being designed for the lift station.

2.2 2013 Post-Flood Survey Data

Boulder's post-flood survey asked residents that reported damage to FEMA to identify the source of the flooding that caused the damage as originating from surface flooding, groundwater seepage through foundations, sewer lateral backups, floor drain backups or a combination of the above.

Although the survey distinguished between sewer lateral backups and floor drain backups, Boulder's building codes require floor drains to be plumbed to the sanitary sewer meaning that floor drain backups should also be considered a sewer lateral backup. The difference between these two survey responses could therefore be interpreted as the severity of the surcharge which caused the backup. A low-level surcharge may cause a backup from floor drains but may not be severe enough to reach the level of higher plumbing fixtures such as toilets or sinks which would cause a resident to clearly identify it as a sewer backup. Residents that do not have bathrooms in their basements would also only experience sanitary sewer backups though the basement floor drains.

The post-flood survey data was reviewed to identify any clusters of sewer-related flooding or backups or any other trends in the data that should be considered in the 2016 WWCSMP. The review showed that groundwater seepage contributed to the most cases of flooding with 732 total reported instances. Floor drains and sewer laterals contributed to 290 and 243 instances of flooding, respectively. Table 2-4 shows the reported sources of flooding by sewer collection system basin.

Table 2-4. Flood Survey Results by Sewer Basin: Instances of Flooding by Reported Source

Sewer Basin	Groundwater Seepage	Sewer Lateral Backup	Floor Drain Backup
Boulder Creek	219	55	78
Fourmile	64	11	27
Goose Creek	226	85	99
Gunbarrel	2	1	2
South Boulder Creek	221	91	84
Total	**732**	**243**	**290**

Some survey respondents indicated that there was more than one source of flooding so the data was further analyzed to evaluate if there were any trends between different combinations of sources. The results of this exercise, shown in Table 2-5, indicate that the individual source of groundwater seepage still constituted the majority of flooding instances, and that the combination of groundwater seepage and floor drain backups was the second largest contributor. It makes sense that groundwater seepage would be found frequently in combination with sewer backups through floor drains since areas with high rates of groundwater seepage likely also had overwhelmed local sanitary sewers due to the groundwater seepage discharging to the sanitary sewers via floor drains.

Table 2-5. 75th Street Wastewater Treatment Facility Influent Flow (mgd)

Basin	Ground-water Seepage Only	Sewer Lateral Backup	Floor Drain Backup Only	Ground-water and Sewer Lateral	Ground-water and Floor Drain	Sewer Lateral and Floor Drain	All Three	Total Instances
Boulder Creek	160	20	19	10	34	10	15	268
Fourmile	44	2	8	3	13	2	4	76
Goose Creek	160	43	37	15	35	11	16	317
Gunbarrel	1	1	1	0	1	0	0	4
South Boulder Creek	145	42	16	20	39	12	17	291
Total	**510**	**108**	**81**	**48**	**122**	**35**	**52**	**956**

There were 290 instances of floor drain backups, 261 of which were in the Goose Creek, South Boulder Creek, and Boulder Creek basins. Thirty-five of these instances coincided with sewer laterals backups in the same residence. One hundred twenty-two (42 percent) of residences experiencing floor drain backups also reported flooding from groundwater seepage.

The survey data was further analyzed to investigate the flooding causes in each flow monitoring sub-basin. The flow monitoring sub-basins were established during the *2014 Flow Monitoring Program*. Table 2-6 and

Table 2-7. Flood Survey Results by Flow Monitoring Sub-Basin: Instances of Flooding by Reported Source

present the data by the sources of flooding within the basins.

Table 2-6. Flood Survey Results by Flow Monitoring Sub-Basin: Instances of Flooding by Reported Source

Basin	Flow Monitoring	Basin	Flow Monitoring
Boulder Creek	S-51	99	34
Fourmile	S-31	64	11
South Boulder Creek	S-34	44	32
South Boulder Creek	S-52	36	31
Goose Creek	S-49	40	19
Goose Creek	S-24	48	1
Goose Creek	S-28	34	31
Boulder Creek	S-25	34	10
Goose Creek	S-54	27	15
South Boulder Creek	S-05	64	12
Goose Creek	S-47	25	17
South Boulder Creek	S-01	23	0
Boulder Creek	S-58	14	0
Boulder Creek	S-27	43	8
Goose Creek	S-29	29	0
Goose Creek	S-22	12	2
South Boulder Creek	S-14	12	6
South Boulder Creek	S-36	20	1
Gunbarrel	S-45	1	0
South Boulder Creek	S-03	7	0
Boulder Creek	S-10	6	0
Boulder Creek	S-11	6	1
South Boulder Creek	S-13	0	1
South Boulder Creek	S-15	8	7
South Boulder Creek	S-16	2	0
Boulder Creek	S-19	6	1
Boulder Creek	S-26	7	1
Goose Creek	S-48	4	0
South Boulder Creek	S-12	2	0
Boulder Creek	S-18	1	0

Table 2-6. Flood Survey Results by Flow Monitoring Sub-Basin: Instances of Flooding by Reported Source

Basin	Flow Monitoring	Basin	Flow Monitoring
Goose Creek	S-32	7	0
South Boulder Creek	S-35	3	1
Gunbarrel	S-37	0	1
Boulder Creek	S-44	3	0
Gunbarrel	S-46	1	0
Total		**732**	**243**

Table 2-7. Flood Survey Results by Flow Monitoring Sub-Basin: Instances of Flooding by Reported Source

Basin	Flow Monitoring Sub-Basin	Ground-water Seepage Only	Sewer Lateral Backup Only	Floor Drain Backup Only	Ground-water and Sewer Lateral	Ground-water and Floor Drain	Sewer Lateral and Floor Drain	All Three	Total
Boulder Creek	S-51	62	9	12	8	17	5	12	125
Fourmile	S-31	44	2	8	3	13	2	4	76
South Boulder Creek	S-05	53	4	2	1	5	2	5	72
South Boulder Creek	S-34	20	12	7	9	7	3	8	66
Goose Creek	S-28	21	20	9	7	3	1	3	64
South Boulder Creek	S-52	17	18	4	5	11	5	3	63
Goose Creek	S-24	38	1	10	0	10	0	0	59
Goose Creek	S-49	25	2	5	4	4	6	7	53
Boulder Creek	S-27	40	6	1	0	3	2	0	52
Goose Creek	S-54	18	10	5	1	6	2	2	44
Boulder Creek	S-25	22	4	2	1	8	2	3	42
Goose Creek	S-47	15	10	5	3	5	2	2	42
Goose Creek	S-29	25	0	2	0	4	0	0	31
South Boulder Creek	S-01	15	0	3	0	8	0	0	26
South Boulder Creek	S-36	16	0	0	1	3	0	0	20
Boulder Creek	S-58	9	0	2	0	5	0	0	16
South Boulder Creek	S-14	6	3	0	2	3	0	1	15
South Boulder Creek	S-15	6	4	0	2	0	1	0	13
Goose Creek	S-22	8	0	1	0	2	0	2	13
Boulder Creek	S-11	6	1	1	0	0	0	0	8
Boulder Creek	S-26	7	0	0	0	0	1	0	8
South Boulder Creek	S-03	6	0	0	0	1	0	0	7
Boulder Creek	S-10	6	0	1	0	0	0	0	7
Goose Creek	S-32	7	0	0	0	0	0	0	7
Boulder Creek	S-19	4	0	0	1	1	0	0	6
South Boulder Creek	S-35	3	1	0	0	0	0	0	4

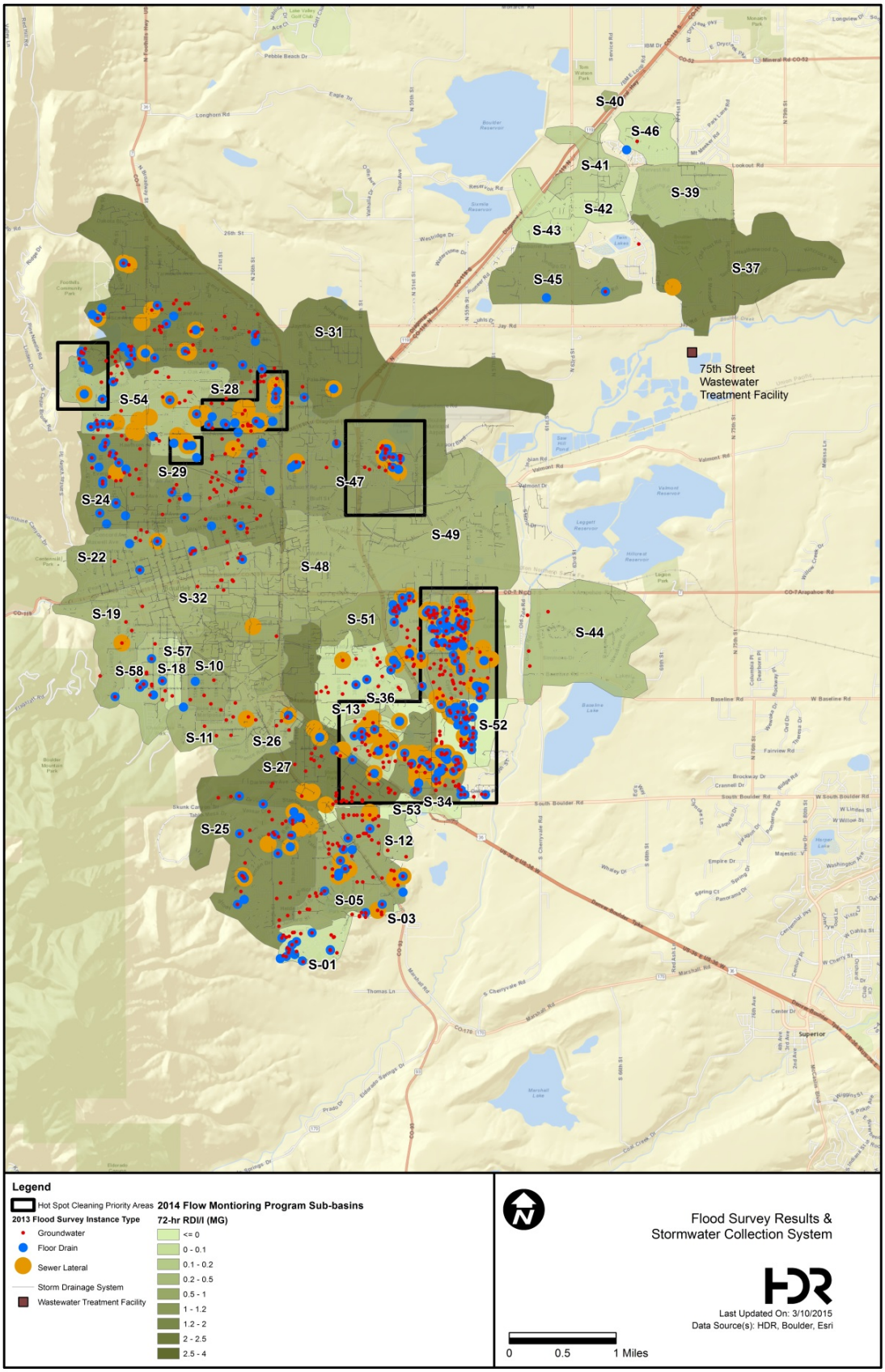
Table 2-7. Flood Survey Results by Flow Monitoring Sub-Basin: Instances of Flooding by Reported Source

Basin	Flow Monitoring Sub-Basin	Ground-water Seepage Only	Sewer Lateral Backup Only	Floor Drain Backup Only	Ground-water and Sewer Lateral	Ground-water and Floor Drain	Sewer Lateral and Floor Drain	All Three	Total
Goose Creek	S-48	3	0	0	0	1	0	0	4
Boulder Creek	S-44	3	0	0	0	0	0	0	3
South Boulder Creek	S-12	2	0	0	0	0	0	0	2
South Boulder Creek	S-16	1	0	0	0	1	0	0	2
Gunbarrel	S-45	0	0	1	0	1	0	0	2
South Boulder Creek	S-13	0	0	0	0	0	1	0	1
Boulder Creek	S-18	1	0	0	0	0	0	0	1
Gunbarrel	S-37	0	1	0	0	0	0	0	1
Gunbarrel	S-46	1	0	0	0	0	0	0	1
Total		**510**	**108**	**81**	**48**	**122**	**35**	**52**	**956**

A map of the post-flood survey data is provided as Figure 2-2. This figure shows the location of the reported instances of groundwater seepage, floor drain backups, and sewer lateral backups. The figure also includes the sewer collection system flow monitoring sub-basins and their RDII results from the *2014 Flow Monitoring Program* report (Stantec, 2014) for reference.

The Flood Survey Results by Flow Monitoring Sub-basin table values along with Figure 2-2 show the areas of the system with higher density of reported instances of groundwater seepage, floor drain backups, and sewer lateral backups. The reported instances generally appear within sub-basins with higher RDII rates. The data from the 2013 post-flood survey will be used to help prioritize capital improvement projects in this WWCSMP Update.

Figure 2-2. 2013 Flood Survey Results & Stormwater Collection System



2.3 2014 Flow Monitoring Program

The *2014 Flow Monitoring Program* report (Stantec, 2014) was reviewed and assessed for use during the 2016 WWCSMP including the model update. This section does not include any additional analysis but only summarizes the findings of the *2014 Flow Monitoring Program* report (Stantec, 2014). Table 2-8 shows the temporary meters correlated to model sub-basins including upstream, downstream, crossing, and internal meters. Figure 2-3 shows the schematic of the temporary flow monitoring locations and basins while Figure 2-4 shows the actual locations of the temporary flow monitors and basins within Boulder. When using this data in the 2015 WWCSMP the data quality presented in the *2014 Flow Monitoring Program* report (Stantec, 2014) will be used to determine the confidence in the data to be used for flow allocation and calibration.

Table 2-8. Temporary Flow Monitoring Locations and Corresponding Flow Monitoring Sub-basins

Sewer Basin	Flow Monitoring Sub-basin	Assigned Rain Gauge	Downstream Meters	Upstream Meters	Crossing Meters	Internal Meters
South Boulder Creek	S-01	RG-5	FM-01, 02			
South Boulder Creek	S-03	RG-5	FM-03	FM-01	FM-04	
South Boulder Creek	S-05	RG-5	FM-05, 06, 08	FM-02, 07	FM-04	
Boulder Creek	S-10	RG-1	FM-10			
Boulder Creek	S-11	RG-1	FM-11			
South Boulder Creek	S-12	RG-5	FM-12			
South Boulder Creek	S-13	RG-5	FM-13	FM-35		
South Boulder Creek	S-14	RG-5	FM-14			
South Boulder Creek	S-15	RG-5	FM-15			
South Boulder Creek	S-16	RG-5	FM-16			
Boulder Creek	S-18	RG-1	FM-18			
Boulder Creek	S-19	RG-1	FM-19	FM-18, 57, 58	FM-17	
Goose Creek	S-22	RG-4	FM-21, 22, 23			
Goose Creek	S-24	RG-4	FM-24			
Boulder Creek	S-25	RG-5	FM-25		FM-09	
Boulder Creek	S-26	RG-1	FM-26		FM-55, 56	
Boulder Creek	S-27	RG-1	FM-27		FM-09, 55, 56	
Goose Creek	S-28	RG-4	FM-28	FM-54		
Goose Creek	S-29	RG-4	FM-29	FM-30		
Fourmile	S-31	RG-2	FM-31			
Goose Creek	S-32	RG-1	FM-20, 32	FM-21	FM-17	

Table 2-8. Temporary Flow Monitoring Locations and Corresponding Flow Monitoring Sub-basins

Sewer Basin	Flow Monitoring Sub-basin	Assigned Rain Gauge	Downstream Meters	Upstream Meters	Crossing Meters	Internal Meters
South Boulder Creek	S-34	RG-5	FM-34			
South Boulder Creek	S-35	RG-5	FM-35	FM-14, 15, 16		
South Boulder Creek	S-36	RG-1	FM-36			
Gunbarrel	S-37	RG-3	FM-37		FM-38	
Gunbarrel	S-39	RG-3	FM-39			
Gunbarrel	S-40	RG-3	FM-40			
Gunbarrel	S-41	RG-3	FM-41	FM-42		
Gunbarrel	S-42	RG-3	FM-42	FM-43		
Gunbarrel	S-43	RG-3	FM-43			
Boulder Creek	S-44	RG-2	FM-44			
Gunbarrel	S-45	RG-3	FM-45			
Gunbarrel	S-46	RG-3	FM-46			
Goose Creek	S-47	RG-2	FM-47	FM-28		
Goose Creek	S-48	RG-2	FM-48	FM-22, 23, 24, 32, 29		
Goose Creek	S-49	RG-2	FM-49	FM-47, 48	FM-50	
Boulder Creek	S-51	RG-2	FM-51	FM-10, 11, 19, 20, 26, 27, 36	FM-50	
South Boulder Creek	S-52	RG-5	FM-52	FM-13, 34		FM-33
South Boulder Creek	S-53	RG-5	FM-53, 07	FM-05, 06, 08, 12, 25		
Goose Creek	S-54	RG-4	FM-30, 54			
Boulder Creek	S-57	RG-1	FM-57			
Boulder Creek	S-58	RG-1	FM-58			

Figure 2-3. Temporary 2014 Flow Monitoring Schematic (Stantec, *2014 Flow Monitoring Program* Report – Figure 1.2)

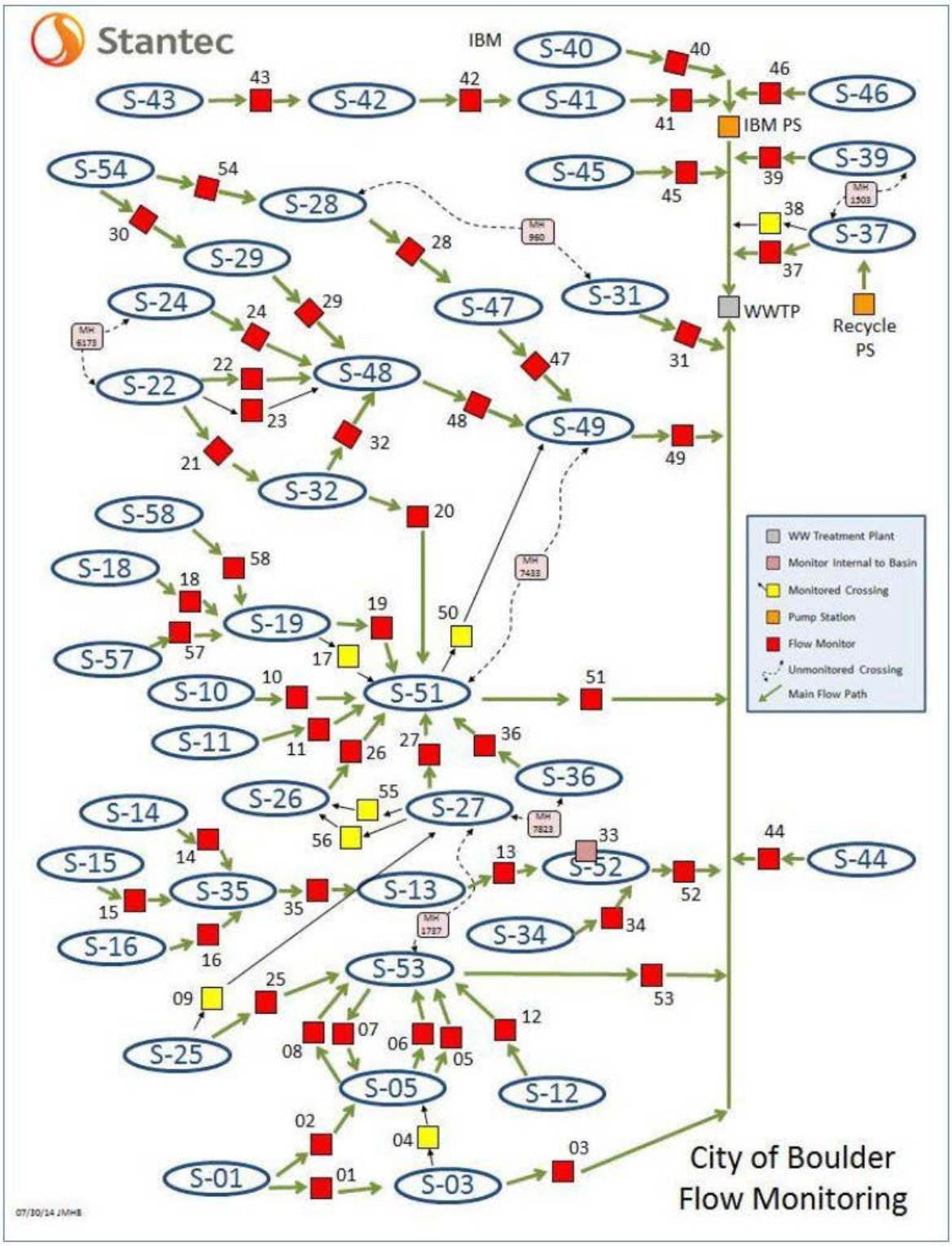
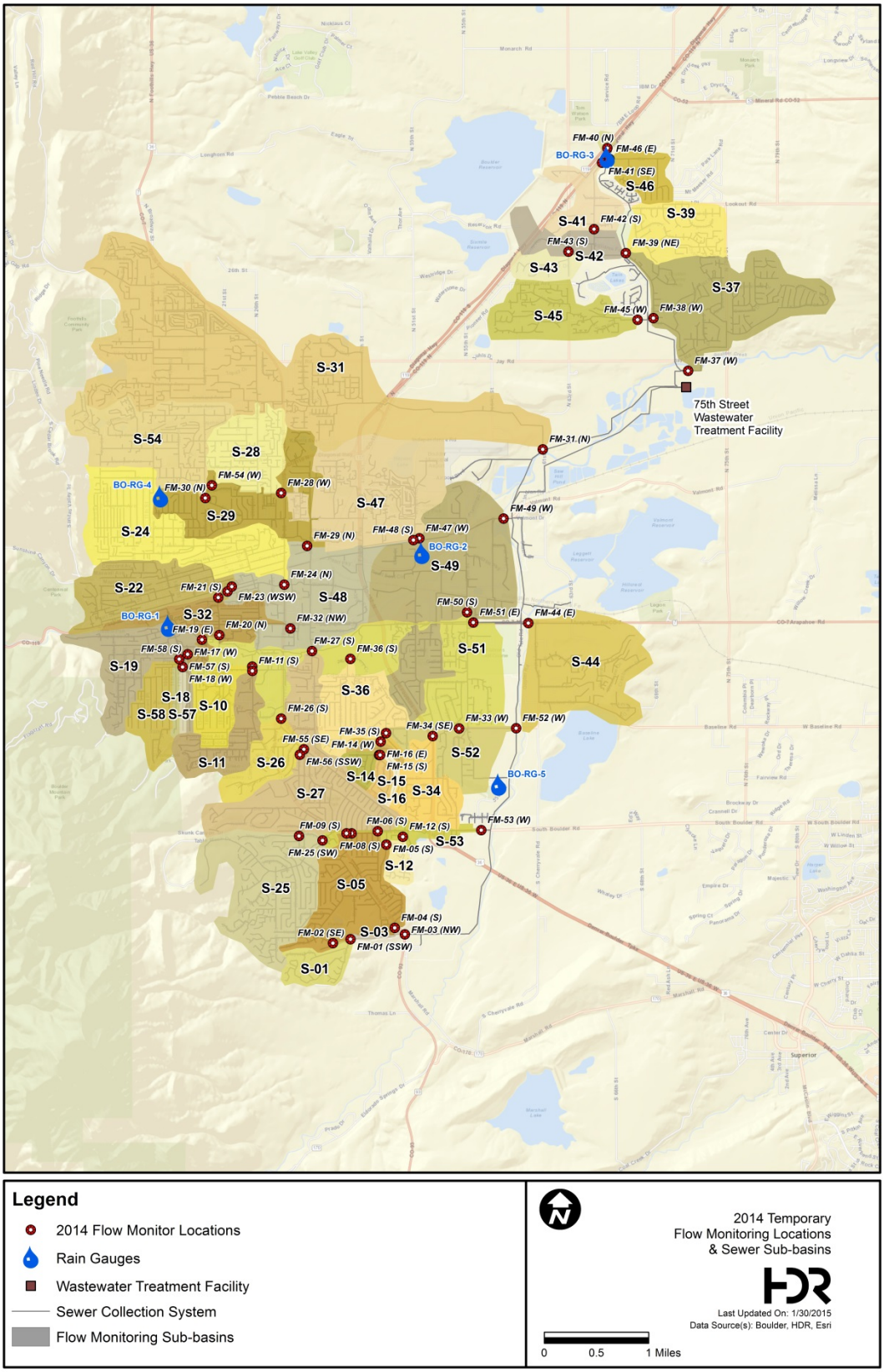


Figure 2-4. 2014 Temporary Flow Monitoring Locations & Sewer Sub-basins



Precipitation records for the five rain gauges were used in the *2014 Flow Monitoring Program* (Stantec, 2014) to calculate I&I volumes. These records contain rainfall data for three storm events used for the RDII analysis including May 11th, May 30th, and June 8th, 2014. Other storms that occurred during the flow monitoring period were not consistent enough across the City to use in the RDII analysis. Table 2-9 summarizes these three observed rainfall events for in the analysis.

Table 2-9. *2014 Flow Monitoring Program* Rainfall Event Summary

Storm Event Date	Total Rainfall Depth (inches)[2]	Total Duration (hours)[2]	Estimated Reoccurrence Interval (years)
May 11th, 2014[1]	1.78-2.01	38	2
May 30th, 2014	0.23-0.33	1-2	Less than 1
June 8th, 2014	0.47-0.5	7-8	Less than 1

[1] The May 11th event was rainfall on top of snow and could result in skewed flow monitoring results as rain melts the snow which results in additional I&I volumes at a different rate than only rainfall would.

[2] Rainfall depth and durations are the range of values for all five rain gauges.

Figure 2-5 shows a comparison of rainfall intensity between rain gauges for the period of the 2015 Flow Monitoring Program. These records will be used with corresponding monitor results at peak flow periods in re-assessing system I&I and capacity responses to rainfall. When using the May 11th storm data, it should used with the understanding that the event was a rain on snow event. Although the rainfall volume was lesser, the May 30th storm had no snowfall and included intense periods of rainfall that are spatially consistent across the City. Therefore, this storm event will be used as the existing wet-weather model calibration scenario.

None of the storms during the flow monitoring program used for analysis were large enough to be used as a capacity evaluation event so the calibrated model scenario's I&I factors for each flow monitoring sub-basin will be increased using the precipitation event versus peak wet weather flow equation developed in the 2009 WWCSMP report (HDR, 2009 WWCSMP, Figure 3-3). The desired evaluation event for Boulder's collection system is the 25-year reoccurrence interval storm.

Figure 2-5. Comparison of Rainfall Data between the Five Rain Gauges (inches) (Stantec, *2014 Flow Monitoring Program* Report - Appendix IV)

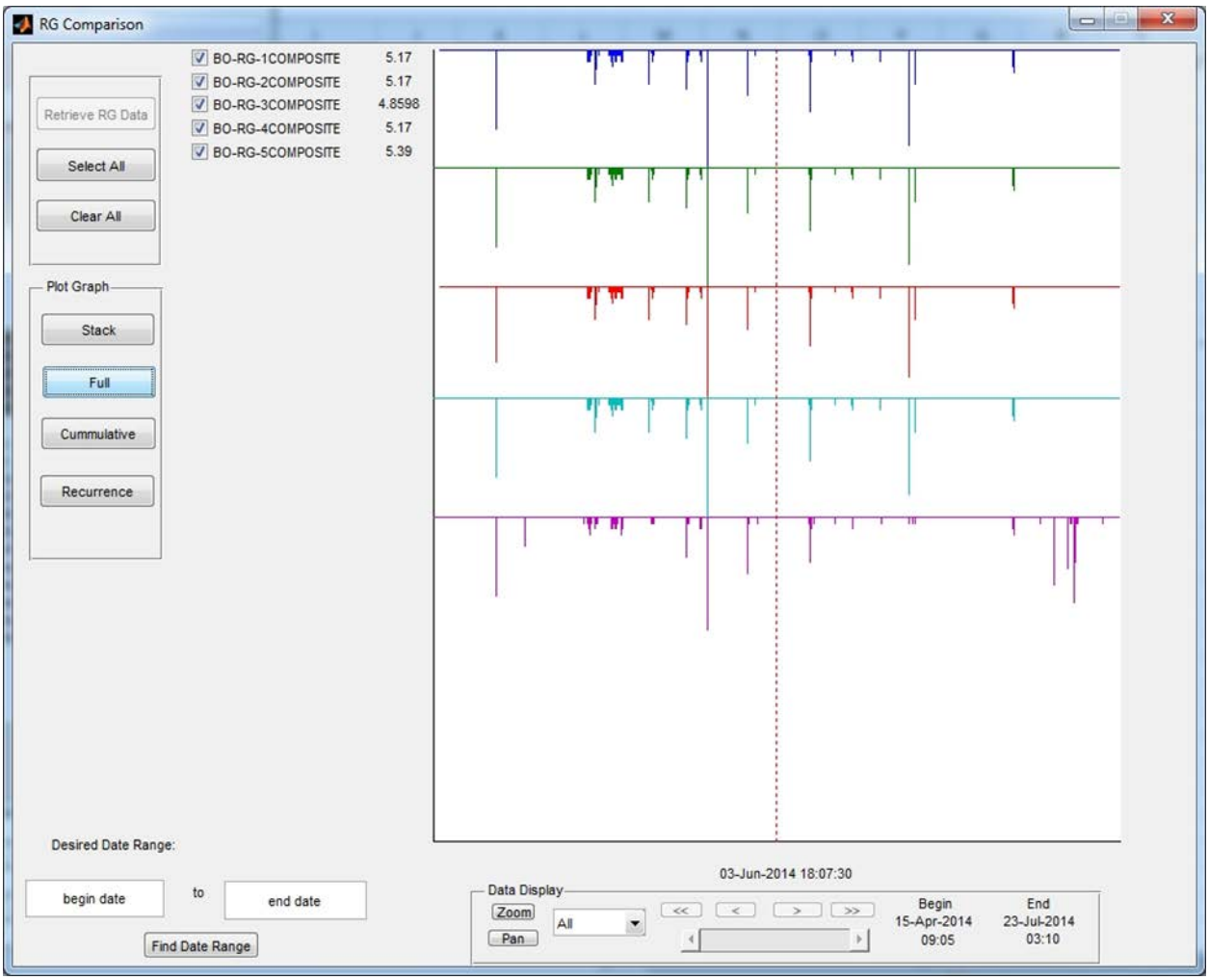


Table 2-10 shows values of average day sanitary flow rate (ADSF) and spring seasonal low groundwater infiltration rate (GWI) in gpm. Boulder commented that although the IBM Campus was reported as a critical infiltration area in the *2014 Flow Monitoring Program* report (Stantec, 2014), there was a reported significant industrial discharge that could have skewed the results in the Gunbarrel sewer basin (S-40).

Table 2-10. Flood Survey Results by Flow Monitoring Sub-Basin: Instances of Flooding by Reported Source

Sewer Basin	Flow Monitoring Sub-basin	ADSF (gpm)[1]	Seasonal Low GWI (gpm)[1]
South Boulder Creek	S-01	47	15
South Boulder Creek	S-03	(7)	(15)
South Boulder Creek	S-05	152	83
Boulder Creek	S-10	171	97
Boulder Creek	S-11	85	81
South Boulder Creek	S-12	39	21
South Boulder Creek	S-13	14	43
South Boulder Creek	S-14	14	9
South Boulder Creek	S-15	9	6
South Boulder Creek	S-16	5	1
Boulder Creek	S-18	19	2
Boulder Creek	S-19	161	120
Goose Creek	S-22	298	131
Goose Creek	S-24	472	196
Boulder Creek	S-25	323	40
Boulder Creek	S-26	74	80
Boulder Creek	S-27	607	192
Goose Creek	S-28	238	197
Goose Creek	S-29	302	151
Fourmile	S-31	696	353
Goose Creek	S-32	388	83
South Boulder Creek	S-34	156	84
South Boulder Creek	S-35	15	1
South Boulder Creek	S-36	147	53
Gunbarrel	S-37	297	506
Gunbarrel	S-39	87	13
Gunbarrel	S-40	97	68
Gunbarrel	S-41	73	55
Gunbarrel	S-42	19	14
Gunbarrel	S-43	12	9
Boulder Creek	S-44	89	17
Gunbarrel	S-45	215	240
Gunbarrel	S-46	54	1

Table 2-10. Flood Survey Results by Flow Monitoring Sub-Basin: Instances of Flooding by Reported Source

Sewer Basin	Flow Monitoring Sub-basin	ADSF (gpm)[1]	Seasonal Low GWI (gpm)[1]
Goose Creek	S-47	362	117
Goose Creek	S-48	462	627
Goose Creek	S-49	997	(159)
Boulder Creek	S-51	220	(114)
South Boulder Creek	S-52	(156)	(75)
South Boulder Creek	S-53	(62)	5
Goose Creek	S-54	106	23
Boulder Creek	S-57	13	1
Boulder Creek	S-58	108	18

[1] ADSF and Seasonal Low GWI values with parenthesis indicate negative values which with flow monitoring basins are flow subtraction issues between upstream and downstream meters whose flows do not add up. These meters and their data should not be relied on for hydraulic modeling.

Table 2-11 shows the RDII for each monitored sub-basin in the system. Inflow values were based on the maximum values for the three storm events that occurred during the flow monitoring period. Infiltration values were based on the May 11th storm except for S-11 which was based on the June 6th storm. Based on these calculations, the maximum total RDII for the system is approximately 32 million gallons over the storm event. Boulder commented that Southeast Boulder is known as an area of the collection system with high I&I contributions which can be seen on Figure 2-2 and in the data below in the Boulder Creek and South Boulder Creek sewer basins.

Table 2-11. Rainfall Derived Inflow and Infiltration per Sub-basin

Sewer Basin	Flow Monitoring Sub-basin	Rainfall Derived Infiltration – (Total 72-hr Infiltration per length of Pipe, Gal/ft)	Rainfall Derived Inflow (4-hr RDII per length of Pipe, Gal/ft)	Rainfall Derived Infiltration (Million Gallons)	Rainfall Derived Inflow (Million Gallons)	Total RDII (Million Gallons)
Fourmile	S-31	15.2	0.5	3.75	0.11	3.86
Gunbarrel	S-37	33.9	0.7	2.85	0.06	2.91
Boulder Creek	S-27	26.6	0.8	2.65	0.08	2.73
Goose Creek	S-24	18	1.8	2.11	0.21	2.32
Boulder Creek	S-25	21.5	0.9	1.95	0.08	2.03
Gunbarrel	S-45	36.8	0.9	1.56	0.04	1.60
Goose Creek	S-28	26.9	0.9	1.49	0.05	1.54
Goose Creek	S-29	20.5	0.7	1.42	0.05	1.46
Goose Creek	S-47	14.8	0.5	1.35	0.05	1.40
South Boulder Creek	S-34	41.3	1.9	1.28	0.06	1.34
South Boulder Creek	S-05	16.3	0.7	1.11	0.05	1.16
Boulder Creek	S-51	11.3	0.7	1.06	0.07	1.13
Goose Creek	S-22	15.4	1.4	0.99	0.09	1.08
Boulder Creek	S-10	33.3	2.5	0.99	0.08	1.06
Goose Creek	S-49	10.2	0.8	0.90	0.07	0.96
Goose Creek	S-48	10.2	0.8	0.72	0.05	0.77
Boulder Creek	S-19	13	0.7	0.72	0.04	0.76
Boulder Creek	S-26	28.4	2.1	0.67	0.05	0.72
Goose Creek	S-32	13.5	0.7	0.61	0.03	0.64
Gunbarrel	S-40	85.2	3.8	0.54	0.02	0.57
Boulder Creek	S-11	16.8	0.2	0.52	0.01	0.52
Gunbarrel	S-39	10.7	0.9	0.43	0.04	0.47
South Boulder Creek	S-12	56.4	2.8	0.42	0.02	0.44
South Boulder Creek	S-13	140.7	4.3	0.42	0.01	0.44
Boulder Creek	S-58	11.4	1.1	0.30	0.03	0.33
Boulder Creek	S-44	5.8	0.3	0.31	0.02	0.33
South Boulder Creek	S-14	44.8	2.3	0.27	0.01	0.29
Goose Creek	S-54	2.8	0.2	0.23	0.02	0.25
South Boulder Creek	S-15	21	1.1	0.13	0.01	0.14
Gunbarrel	S-41	7.1	1	0.11	0.02	0.13
Gunbarrel	S-46	6.4	0.6	0.09	0.01	0.09

Table 2-11. Rainfall Derived Inflow and Infiltration per Sub-basin

Sewer Basin	Flow Monitoring Sub-basin	Rainfall Derived Infiltration – (Total 72-hr Infiltration per length of Pipe, Gal/ft)	Rainfall Derived Inflow (4-hr RDII per length of Pipe, Gal/ft)	Rainfall Derived Infiltration (Million Gallons)	Rainfall Derived Inflow (Million Gallons)	Total RDII (Million Gallons)
Boulder Creek	S-18	20.5	2.9	0.08	0.01	0.09
South Boulder Creek	S-16	23.6	1.8	0.08	0.01	0.08
South Boulder Creek	S-01	2.8	1.4	0.05	0.02	0.07
South Boulder Creek	S-35	23.2	0.5	0.07	0.00	0.07
Gunbarrel	S-42	6.1	0.5	0.06	0.00	0.07
Boulder Creek	S-57	17.6	2	0.06	0.01	0.06
Gunbarrel	S-43	3.7	0.3	0.02	0.00	0.03
South Boulder Creek	S-36	-	0.2			
South Boulder Creek	S-53	-38.5	-1.2	-0.57	-0.02	-0.59
South Boulder Creek	S-52	-58.3	-0.6	-1.62	-0.02	-1.64
South Boulder Creek	S-03	-	-	-	-	-
Total		**-**	**-**	**30.19**	**1.56**	**31.75**

Table 2-12 shows the RDII for each monitored basin in the system. Overall, the Goose Creek and Boulder Creek sewer basins have more RDII than the other basins.

Table 2-12. Rainfall Derived Inflow and Infiltration per Basin

Basin	Rainfall Derived Infiltration (Million Gallons)	Rainfall Derived Inflow (Million Gallons)	Total RDII (Million Gallons)
Goose Creek	9.83	0.62	10.45
Boulder Creek	9.30	0.47	9.77
Gunbarrel	5.67	0.19	5.86
Fourmile	3.75	0.11	3.86
South Boulder Creek	1.64	0.17	1.81
Total	**30.19**	**1.56**	**31.75**

2.3.1 Permanent Flow Monitoring Locations

Boulder would like to install permanent flow monitors at select locations within the collection system to capture dry- and wet-weather flows for future capacity analysis and model calibration. The chance of monitoring peak flows during significant storm events increase with permanent flow monitoring. Having permanent flow monitoring locations spread out across the system allows for continual system performance allowance as system-wide rehabilitation and other improvements that reduce I&I and expand capacity continue. Figure 2-6 shows the recommended permanent flow monitoring

locations within the collection system. These nine recommended sites break up the overall system into reasonable basins for future flow monitoring purposes. Along with the permanent flow monitoring locations, permanent rain gauges should be considered to provide good coverage for rainfall monitoring across the system. At least three permanent rain gauges are recommended but with the variability of rainfall in this area, up to five would be appropriate.

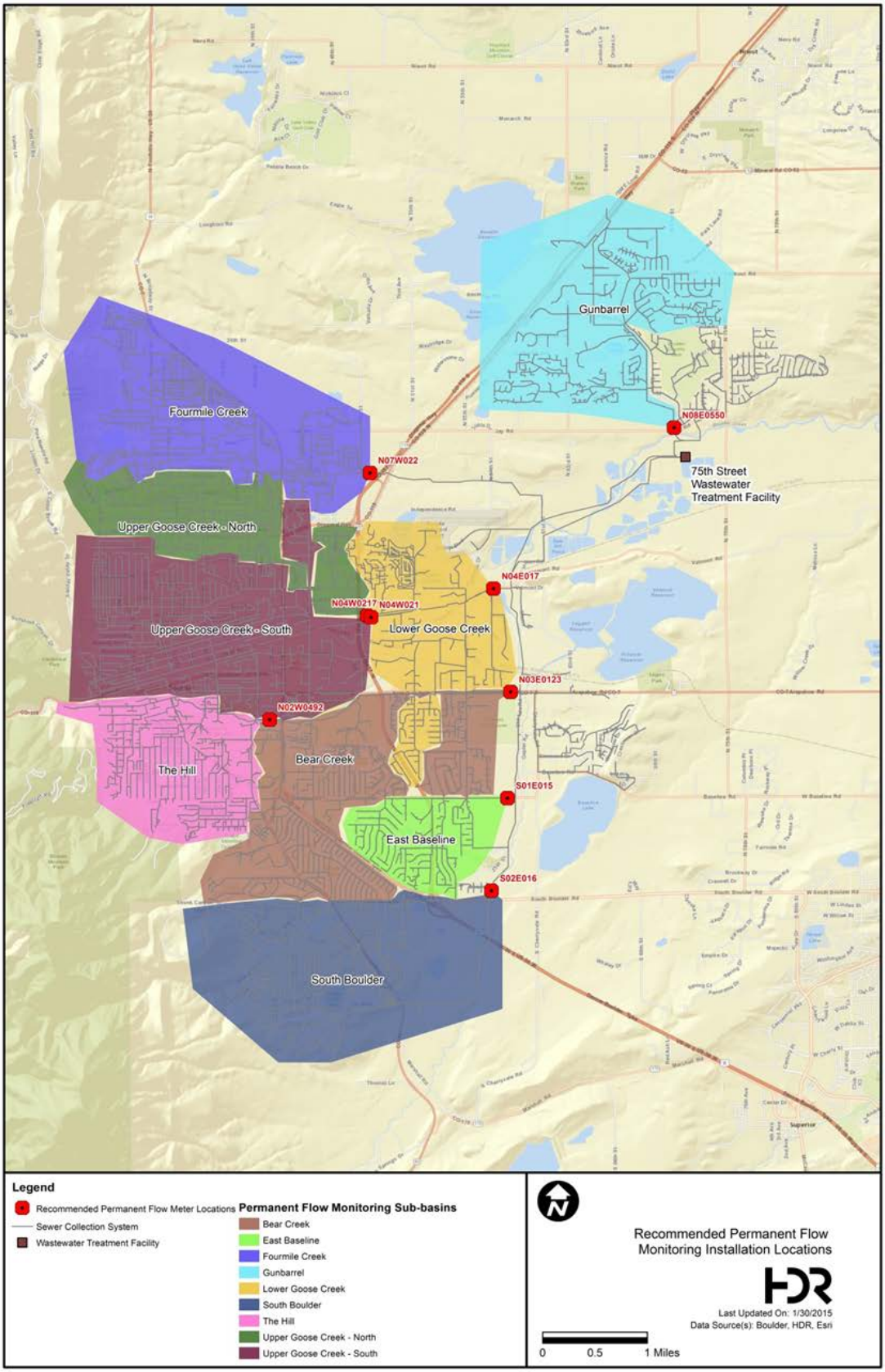
2.4 Summary

Based on the review and assessment of the data, there is sufficient detail in the data to provide an enhanced update to the collection system hydraulic model and WWCSMP analyses. The 2013 post-flood survey data related to the collection system including sewer lateral backups, floor drain backups, and groundwater seepage can be used to help prioritize capital improvement projects in the 2016 WWCSMP. The 2009 WWSCMP model can be efficiently updated using the latest GIS data and flow split manhole information.

Using the 2014 water use data, water meter locations, 2011 WUMP model demand projections, and updated SIU flows, a more accurate allocation of base sanitary flow in the model is possible for existing and buildout (2035) conditions. Applying the data and results of the *2014 Flow Monitoring Program* (Stantec, 2014), GWI and RDII flow allocation can be accounted for in the WWCSMP model at a more detailed level by flow monitoring basin. The May 30th, 2014 storm event captured by the *2014 Flow Monitoring Program* will be used as the existing wet-weather model calibration scenario. Overall, the increased detail and apparent accuracy of data available will improve the level of model calibration and related analysis.

In addition, this updated WWCSMP will be coordinated at a higher level than before with the parallel Stormwater Master Plan Update project. Areas that do not have existing stormwater infrastructure will be evaluated based on their existing and future wastewater capacity limitations. Capital improvement extents and prioritization will be coordinated to schedule construction for reduced public disturbances and increased cost savings by working at the same time in the same area of Boulder.

Figure 2-6. Recommended Permanent Flow Monitoring Installation Locations



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3 Dry Weather Model Update and Calibration

This section documents the process and results of the dry weather model update and calibration for the City of Boulder (city) 2016 WWCSMP. It documents updates to the model network, BSF, and BI allowances for existing conditions dry weather model development and calibration. It also documents development of buildout dry weather BSF projections.

This section discusses the following:

- System infrastructure summary and model update based on the current (2014) GIS information.
- Existing BSF loadings from 2014 water use data.
- BI allocations from 2015 permanent flow monitoring data.
- Dry weather model calibration process and results.
- Water use projections from the 2011 WUMP for future BSF loading.

Solid model development and calibration are important for the confidence level associated with its results.

3.1 Wastewater Utility Service Area

The WUSA contains approximately 16,610 acres (25.9 square miles) that are served by 386 miles of sanitary sewers located within 5 major sewer basins. The sewer collection system includes gravity sewers, diversion manholes, one inverted siphon, and two lift station/force main systems that convey wastewater flow to the 75th Street WWTF. Major features and gravity sewer, by pipe size, that make up the existing system are depicted in Figure 3-1. Table 3-1 summarizes, by sewer basin, the major features found in the sanitary sewer collection system contained in the WUSA that were included in the model update.

Figure 3-1. Existing Sanitary System - Major Features and Gravity Sewer by Size

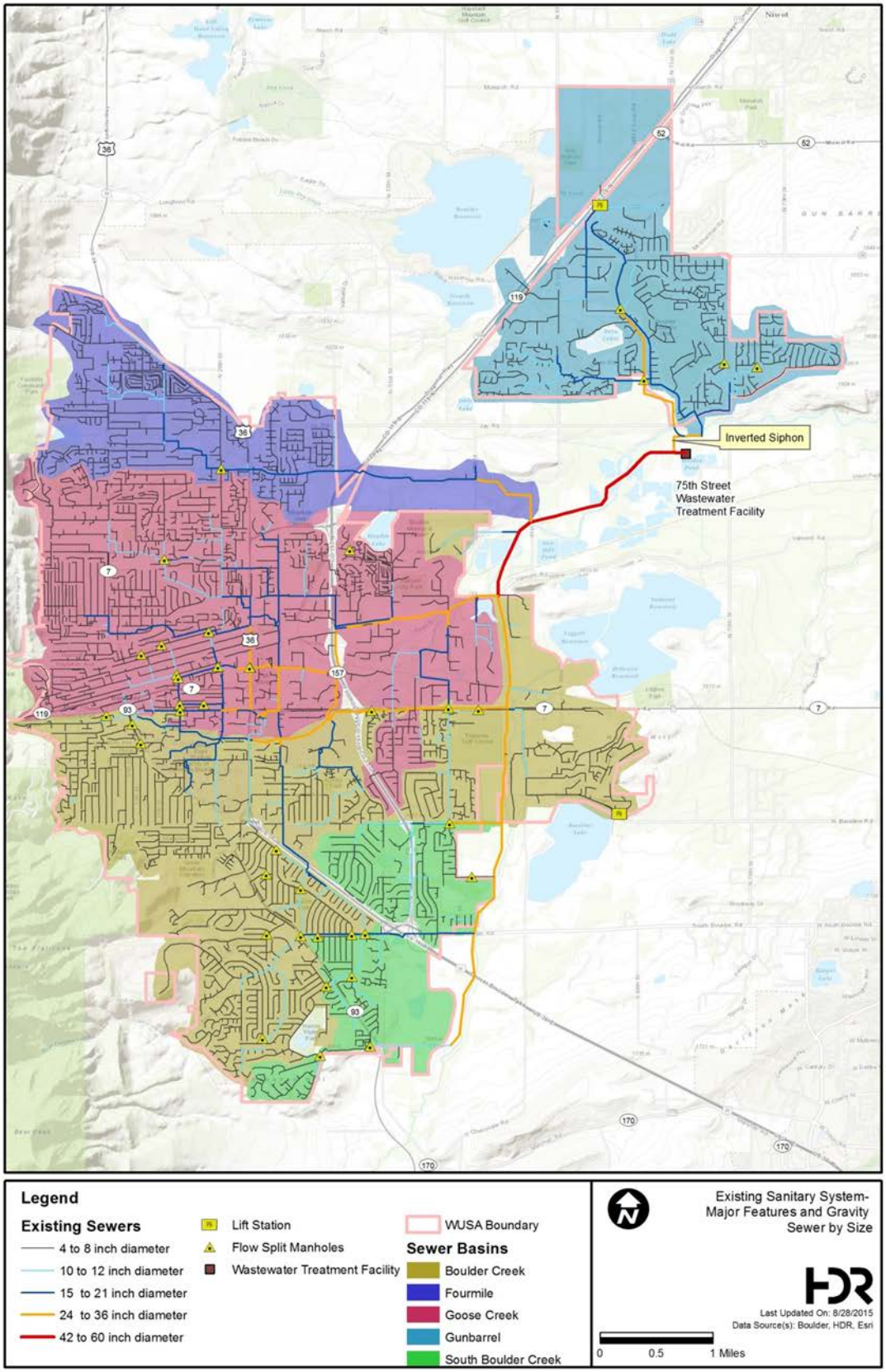


Table 3-1. Existing Sewer System Summary – Modeled Elements

Collection System Feature / Sewer Basin	Modeled Gravity Sewer (miles)	Modeled Flow Split Manholes	Modeled Lift Stations	Modeled Force Mains	Modeled Inverted Siphons
Boulder Creek	120.5	14	0	0	0
Fourmile	48.0	1	0	0	0
Goose Creek	132.4	13	0	0	0
Gunbarrel	46.0	4	1 (City-owned)	1 (City-owned)	1
South Boulder Creek	31.0	8	1 (Private)	1 (Private)	0
Total	**377.9**	**40**	**2**	**2**	**1**

Source: City of Boulder GIS data.

3.2 System Infrastructure Model Update

The first step in the process was to update the 2009 WWCSMP InfoSewer model with the city's current GIS sewer network data from August 2014. InfoSewer Version 7.6 Service Pack 1 Update 2 by Innovyze was used to update the model.

3.2.1 GIS Pipe and Manhole Data

With the city's 2014 GIS data, existing pipe and manhole diameters, materials, elevations, and inverts were updated. New developments and infrastructure improvements that have occurred since the 2009 WWCSMP and are reflected in the city's GIS were added to the model. The updated model elements were snapped to the GIS data, creating a near 1:1 relationship between the two datasets (as of August 2014).

The modeled system for the 2016 WWCSMP is made up of pipes greater than 8 inches. Linear interpolation was used to estimate missing pipe inverts or to correct negative slopes within the analyzed system. Pipe connectivity and direction issues in the GIS data were resolved in the model prior to completing flow loading and scenario modeling.

3.2.2 Flow Split and Diversion Manholes

Since the 2009 WWCSMP, the city has obtained better information on their diversion manholes. City staff has visited all of the known diversion manholes contained in the GIS and documented the relative flow split between downstream pipes. This effort also revealed that some of the flow splits contained in the GIS were no longer active due to one or more of the downstream pipes having been abandoned using concrete plugs. There are 40 manholes with information related to flow splits in city's GIS, including:

- 15 flow split manholes where effluent sewers share similar invert elevations and flow is split at all times.
- 4 manholes with weir walls that split flows during high-flow events.
- 7 manholes that have elevated secondary effluent sewers that activate during surcharges.

- 1 manhole shared by two parallel sewers.
- 8 splits that have been plugged.
- 2 with abandoned (closed) gate structures.
- 3 apex manholes at topographic high points that serve as common access points between two lines flowing to different sewersheds.

The flow splits at these manholes are now reflected in the current model. When flow splits are not specifically defined as a percentage split, the modeling software automatically splits the flow based on the downstream invert elevations and hydraulic grade lines. Incorporating the flow splits in the model results in a better downstream representation of the modeled flow and capacity analysis. An analysis will be completed during a later phase of the 2016 WWCSMP to determine whether some of these flow splits can be plugged to facilitate more straightforward system operations.

3.2.3 Network Validation

Additional steps were taken to validate the city's collection system network and, as necessary, changes were made to the model. Network validation included:

- Pipe slopes that were negative or excessively positive (greater than 15 percent) were identified and the pipe inverts were adjusted to correct the slope, if they were found to be erroneous.
- Manhole rim elevations were checked for irregularities, such as elevations causing excessively deep or negative pipe cover at manholes, and fixed as necessary.
- Pipe cover was checked for shallow pipes with less than 3 feet of cover at manholes and adjusted as necessary.
- Interceptor profiles within the model environment were checked for irregularities, such as negative slopes, and corrected as necessary.

3.2.4 Steady-State Modeling

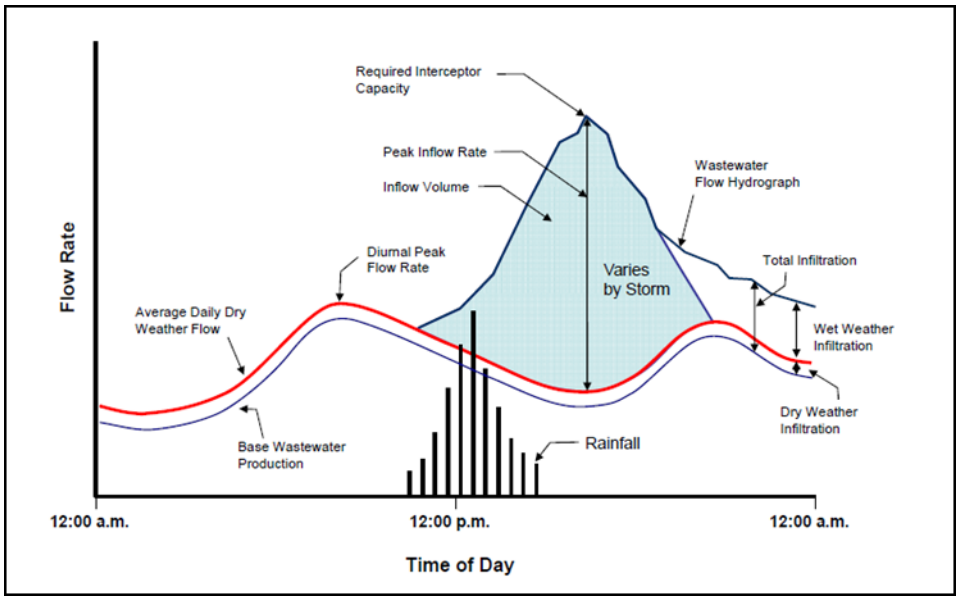
Steady-state modeling was selected for the 2016 WWCSMP. This method is common in drier climate areas of the United States without frequent sanitary sewer overflows for master planning-level models to determine system capacity deficiencies and develop capacity improvements. The modeled average day and peak hour flows for this 2005 WWCSMP Update represent a snapshot in time. Peak hour flows drive the capacity analysis.

Unsteady-state scenarios, also known as extended period simulation (EPS) modeling, can more accurately account for detention and flow attenuation. However, the city does not have a lot of collection system storage, other than at two lift station wet wells and one siphon which are a small volume as compared to the system volume. Also, flow diversions are also relatively straightforward and pipe slopes are relatively steep compared to most collection systems. Therefore, there is little opportunity for detention and flow attenuation in the system that would make unsteady-state modeling beneficial. Finally, since InfoSewer (the software used to update the model) is based only on Manning's equation and does not use the dynamic Saint Venant equation to calculate flow attenuation through the system, there is little hydraulic calculation advantage to using EPS (unsteady) scenarios.

3.3 Dry Weather Analysis

Dry weather flow represents the flow in the sanitary sewer system outside of the influence of individual rainfall events. ADWF is the flow that it is in a sanitary sewer system on a normal dry day and represents the average daily loading to the WWTF. ADWF is comprised of BSF and BI. Figure 3-2 shows the typical flow components for dry and wet weather conditions over the course of a day.

Figure 3-2. Typical Collection System Flow Components



BSF is the sanitary loading mostly from homes and businesses and BI is mostly groundwater that seeps into a collection system through defective pipes, pipe joints, and manhole structures. The rate of infiltration depends on the depth of groundwater above the defects, the size of the defects, and the percentage of the collection system that is submerged. Variation in groundwater levels and the associated infiltration is both seasonal and weather dependent.

ADWF is the expected wastewater flow on a day with no precipitation events and no residual influence of previous precipitation events. ADWF can vary seasonally as groundwater levels change and cause fluctuations in the base infiltration. Daily fluctuations in ADWF are mostly attributed to variations in BSF, such as domestic, industrial, and commercial wastewater contributions and how these contributions vary throughout a day. These daily fluctuations in wastewater flows over the course of the day are represented by diurnal patterns.

The 2009 WWCSMP used the best available data at the time, including potable water meter data, to develop BSFs. The Denver Regional Council of Governments (DRCOG) transportation analysis zones (TAZ) and the associated population and employment projections were used to establish future sanitary base flows.

In April 2015, the city installed ten permanent flow monitors throughout the WUSA. Data from these permanent flow monitors are used to update and calibrate the model for dry weather infiltration and wet weather inflow.

The following sections describe the estimation and development of dry weather flows for the updated model.

3.3.1 Population and Employment

The city provided existing (2014), 2035, and buildout data for city population and employment. This data, along with 2010 Census Data, was used to update city population and employment summaries for the 2016 WWCSMP. Growth projections are made to 2035 based on zoning capacity and growth rate assumptions. The 2010 BVCP has a planning timeframe of 15 years, but calls for growth projections to extend 20 years beyond the last update of the plan.

In 2002, as part of the Jobs to Population project, the city developed new projection methods. Previous growth projections were done by identifying vacant land, opportunity sites, and areas of anticipated growth. A review of this method determined that it was not very accurate. One of the defined roles of the Jobs to Population Task Force was to examine the growth projections, methods, and assumptions, and to offer advice on how to improve the accuracy and quality of the projections. The task force provided guidance on developing a new method of projections that uses a combination of a land use model and an economic model. It requested examination of the total non-residential development that could occur under existing zoning. This zoning capacity (or buildout) number is useful to determine whether building under current zoning regulations results in the amount and mix of development that is desired for the future and has no associated time frame. The BVCP 20-year projections are based upon this zoning capacity information supplemented by growth assumptions and input from DRCOG, the State Demographer's Office, and local and state economists. The WUSA is made up of the BVCP planning Areas I and II within these projections. Table 3-2 presents these city projections for the WUSA. The population projections summarized as part of the 2009 WWCSMP were greater for the 2030 population (128,162) compared to this 2035 population projection (125,468), however, for employment the previous buildout projection (155,864) was less compared this projection (165,230).

Table 3-2. Population and Employment Projections for WUSA

Year	2010	2014	2035	Buildout
Population	109,200	114,200	125,468	125,468[1]
Employment	99,750	105,450	119,180	165,230

Source: City of Boulder Department of Community Planning and Sustainability, 1/20/2012; and 2014 Community Profile, 04/2014.

[1] Population was not separated between 2035 and buildout in the provided projections.

In the 2009 WWCSMP DRCOG TAZ polygons, with population and employment projections, were used to establish existing and future sanitary base flows. The TAZ polygons, however, have not been updated in several years, and the BVCP update process is just being initiated and will not be available to use for the 2016 WWCSMP. Therefore, 2014 use data from potable water meters and their GIS locations were used exclusively to spatially allocate the base sanitary loads to the hydraulic model.

3.3.2 Sanitary Flows

Existing potable water meter data from winter periods, SIU information, and buildout (2035) water demand projections (from the water model 2035 demands) were used to allocate BSF. Using winter potable water meter data for BSF generation is generally accepted within the industry for its increased data accuracy, detail, and reliability over other methods, such as TAZ polygons.

3.3.2.1 Winter Water Meter Data (Existing)

The city provided monthly potable water meter data from November 2013 through March 2014, as well as the spatial location of these meters. This water meter data was filtered to remove duplicate values and further filtered to December 2013 through February 2014, with the assumption that outdoor water use is minimal during this time and therefore the majority of water is discharged to the sanitary sewer system. Winter water meter data is also characteristically equal to dry weather wastewater flows because at this time of year there is limited infiltration caused by increased groundwater levels due to irrigation ditches and high stream flows. Because of this, the potable water use records from this time period are considered the most accurate spatial representation of existing BSF contributions to use for the 2016 WWCSMP.

Monthly metered water use volumes were converted to a monthly rate of consumption. The monthly flow rates, converted to gallons per minute (gpm), were averaged over the three months for each meter. Some meters used in the analysis did not have records for each of the three months, and this was accounted for by including only the months with data in the average. These averages converted to a BSF of 8.9 million gallons per day [mgd] (6,158 gpm). This flow rate includes SIUs, which are described in the next section.

3.3.2.1 Significant Industrial Users

SIUs are owners who contribute high sanitary loadings and need to be accounted for in the sanitary flow projections. Since the 2009 WWCSMP, several SIUs have gone out of business and one is no longer permitted to discharge. New SIUs include Advanced Probing Systems, Agilent Technologies Inc., Avery Brewing Company, Corden Pharma Colorado Inc., KBI Biopharma, Merck Boulder, and the National Institute of Standards & Technology (NIST).

The city provided the updated average annual 2014 daily flows for the current SIUs, shown in Table 3-3. Figure 3-3 shows the locations of the SIUs in the WUSA. Since water meter data is being used for this 2016 WWCSMP, these average annual flows were compared against the winter water meter data from December 2013 through February 2014 to estimate an average flow for each SIU. The winter water meter flow (provided in Table 3-3) was either:

- Kept the same if it compared well to city provided SIU flow.
- Modified to the city provided SIU flow as an additional load to the system if winter water use was underestimating that SIU's average flows.

The last column in Table 3-3 provides the final flow rates for each respective SIU used in the 2015 model update.

Note that based on the University of Colorado at Boulder's Master Plan, only 30 percent of the potable water used in the main campus area reaches the sanitary collection system due to use, loss, and recycle in its steam heating and chilled water cooling system. Therefore, only 30 percent of winter water use for the University of Colorado at Boulder's main campus is used for its SIU contribution.

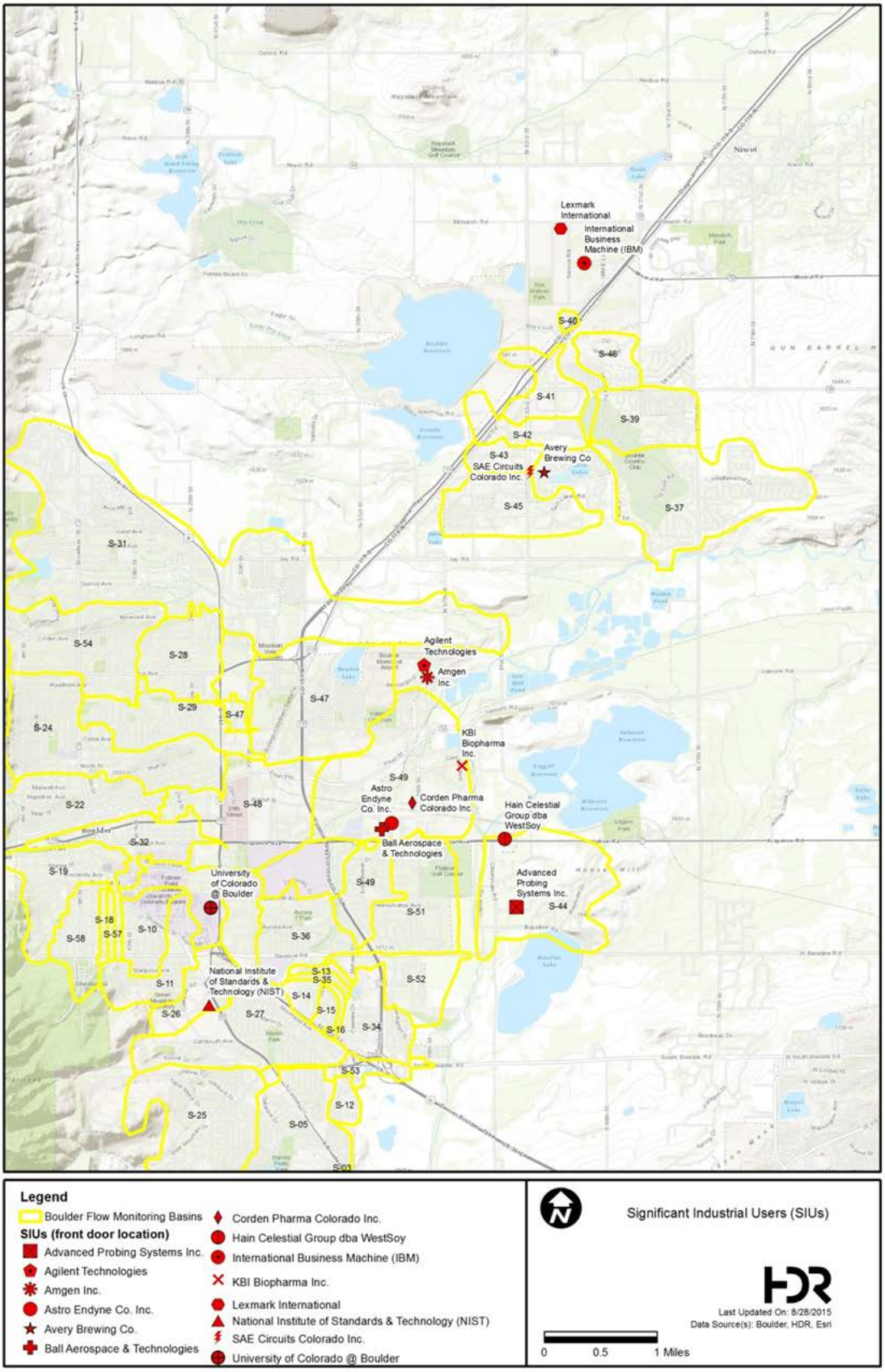
The water use for all SIUs is estimated to be approximately 924 gpm (1.33 mgd) from the annual averages and 819 gpm (1.18 mgd) from the winter water meter data. Extracting the larger of the two values for each SIU and applying a 70 percent reduction (30 percent flow through) for the University of Colorado at Boulder's main campus yields a total modeled SIU sanitary contribution of 816 gpm

(1.17 mgd), or 13 percent of the total 8.9 mgd BSF to the WWTF for 2014. Unlike the 2009 WWCSMP, future SIUs are not planned for or modeled in this 2016 WWCSMP.

Table 3-3. 2014 SIU Data from the City of Boulder

Significant Industrial User (SIU)	Service Address of SIU	New SIU since 2009 WWCSMP	Discharge for Previous 12 months (gpd)	Avg. Sewer Flow from Jan. to Dec. 2013 (gpd)	Avg. Water Meter Flow from Dec. 2013 to Feb. 2014 (gpd)	Flow Allocated to the Model (gpd)
Advanced Probing Systems, Inc.	PO Box 17548	Yes	<100	44	0	**44**
Agilent Technologies	5555 Airport Blvd.	Yes	101-10,000	1,738	6,966	**6,966**
Amgen, Inc.	4000 Nelson Road	No	> 25,000	35,911	37,207	**37,207**
Astro Endyne, Co., Inc.	1770 Range St	No	< 100	75	146	**146**
Avery Brewing Co	4910 Nautilus Court	Yes	10,001-25,000		-	**-**
Ball Aerospace & Technologies	1600 Commerce St, MS FT-3S	No	> 25,000	30,040	33,351	**33,351**
Corden Pharma Colorado, Inc.	2075 N 55th St	Yes	> 25,000	26,507	74,827	**74,827**
Hain Celestial Group	6123 Arapahoe Rd	No	>25,000	40,710	23,054	**40,710**
International Business Machine (IBM)	PO Box 1900; 001B	No	> 25,000	194,000	276,252	**276,252**
KBI Biopharma, Inc.	2590 Central Avenue	Yes			11,722	**11,722**
Lexmark International	6555 Monarch Rd	No	> 25,000	30,846	Part of IBM Loading	
National Institute of Standards & Technology (NIST)	325 Broadway, MC 173.02	Yes	> 25,000	423,580	125,717	**423,580**
SAE Circuits Colorado, Inc.	4820 N 63rd St	No	> 25,000	41,261	39,127	**39,127**
University of Colorado @ Boulder	EH&S, 413 UCB, Univ of CO	No	> 25,000	505,959		
	Main Campus (assume 30% pass through contribution):				457,591	**137,277**
	East Campus:				94,376	**94,376**
Total SIU Flow (gpd)				**1,330,671**	**1,180,336**	**1,175,585**

Figure 3-3. Significant Industrial Users (SIUs)



3.3.2.1 BSF Allocation

The following section describes the process of how BSF wastewater loads were allocated spatially to the model.

Stantec Consulting Services Inc. (Stantec) was contracted to perform a flow monitoring analysis across the city with the analysis summarized in the *2014 Flow Monitoring Program* (Stantec, 2014). This analysis performed flow monitoring throughout the wastewater collection system at 60 manholes between April and July, 2014 and refined contributing sewersheds for each flow monitor were developed as part of this analysis. Therefore, sanitary sewersheds from the 2009 WWCSMP were updated based on the further refined flow monitoring basins from the *2014 Flow Monitoring Program*. The resulting sewersheds, along with the 2014 flow monitoring basins, are presented in Figure 3-4.

The water meter data was joined to the GIS water meter spatial locations. Of the 26,961 water meters, only 12 meters did not have a GIS equivalent and amounted to only 1 gpm of flow. Thiessen polygons for the model manholes were generated within each of the adjusted sewersheds and joined spatially to the GIS meter locations. The water meter data flow rates, described in Section 3.3.2.1, were summed within each Thiessen polygon for each model manhole (the majority of Thiessen polygons contain multiple water meters) and assigned as BSF to that respective model manhole (Load 1 column). If a Thiessen polygon for a model node did not contain a water meter, then that model node was not assigned a BSF load. Figure 3-5 illustrates an example of this BSF load allocation using Thiessen polygons within each sewershed.

The location of SIUs with respect to the Thiessen polygons was then reevaluated and, if necessary, flow allocations were adjusted so that they were loaded to the closest manhole to that SIU's outlet location, as provided by the city. For instances when the winter water meter data underrepresented the total SIU load, or when the winter water meter data had to be distributed among numerous outfalls, the additional SIU load was accounted for as an additional model load rather than an increase in the winter water meter load (Load 2 column).

These winter water meter loads and additional SIU flows result in the total 8.9 mgd BSF allocated to the model (Load 1 plus Load 2 columns) and are the basis for the existing scenario flows. The total existing conditions BSF allocated to the model is 6,158 gpm (8.87 mgd), including the SIUs.

Figure 3-4. Sewershed and Flow Monitoring Basins

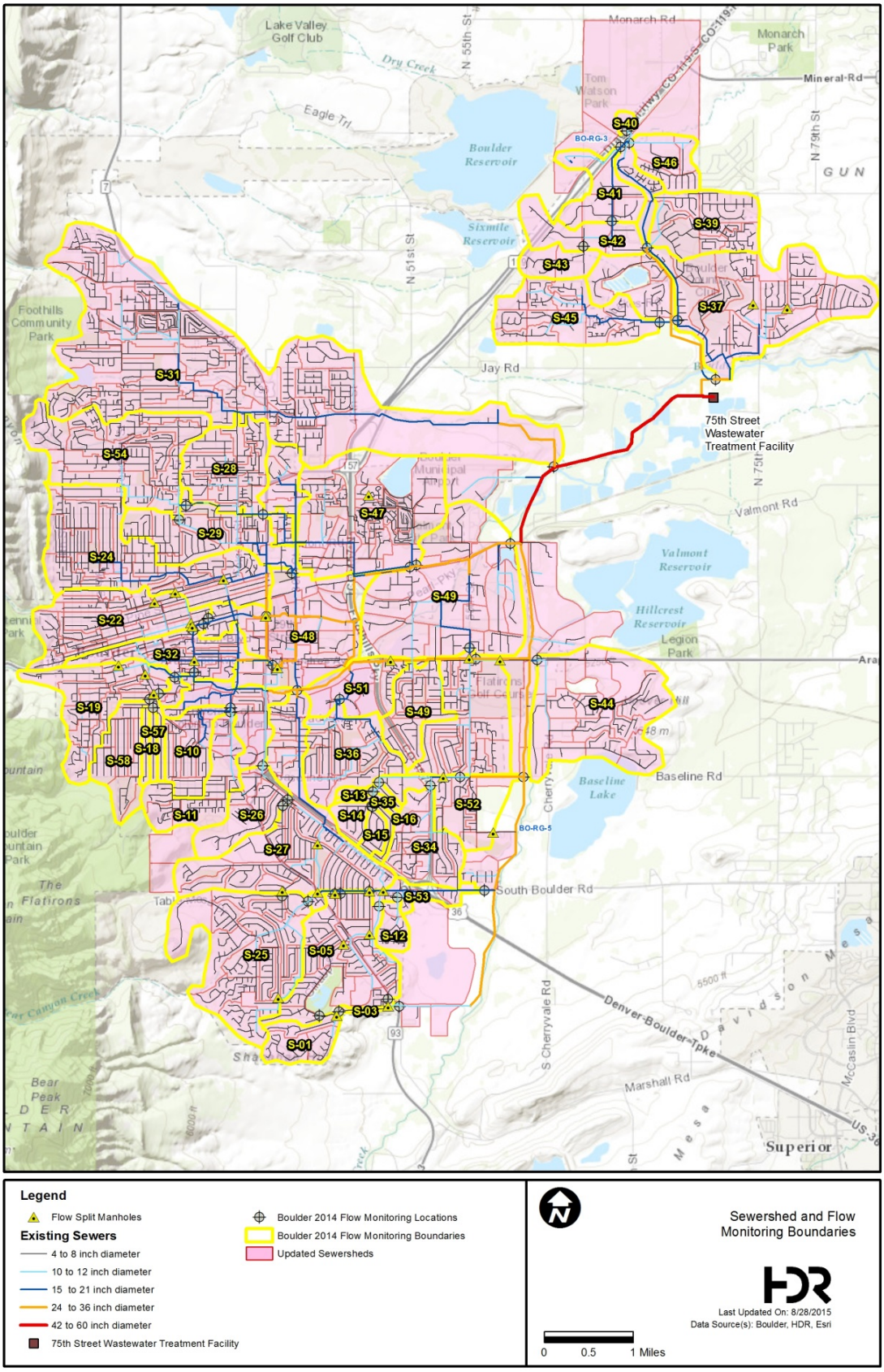
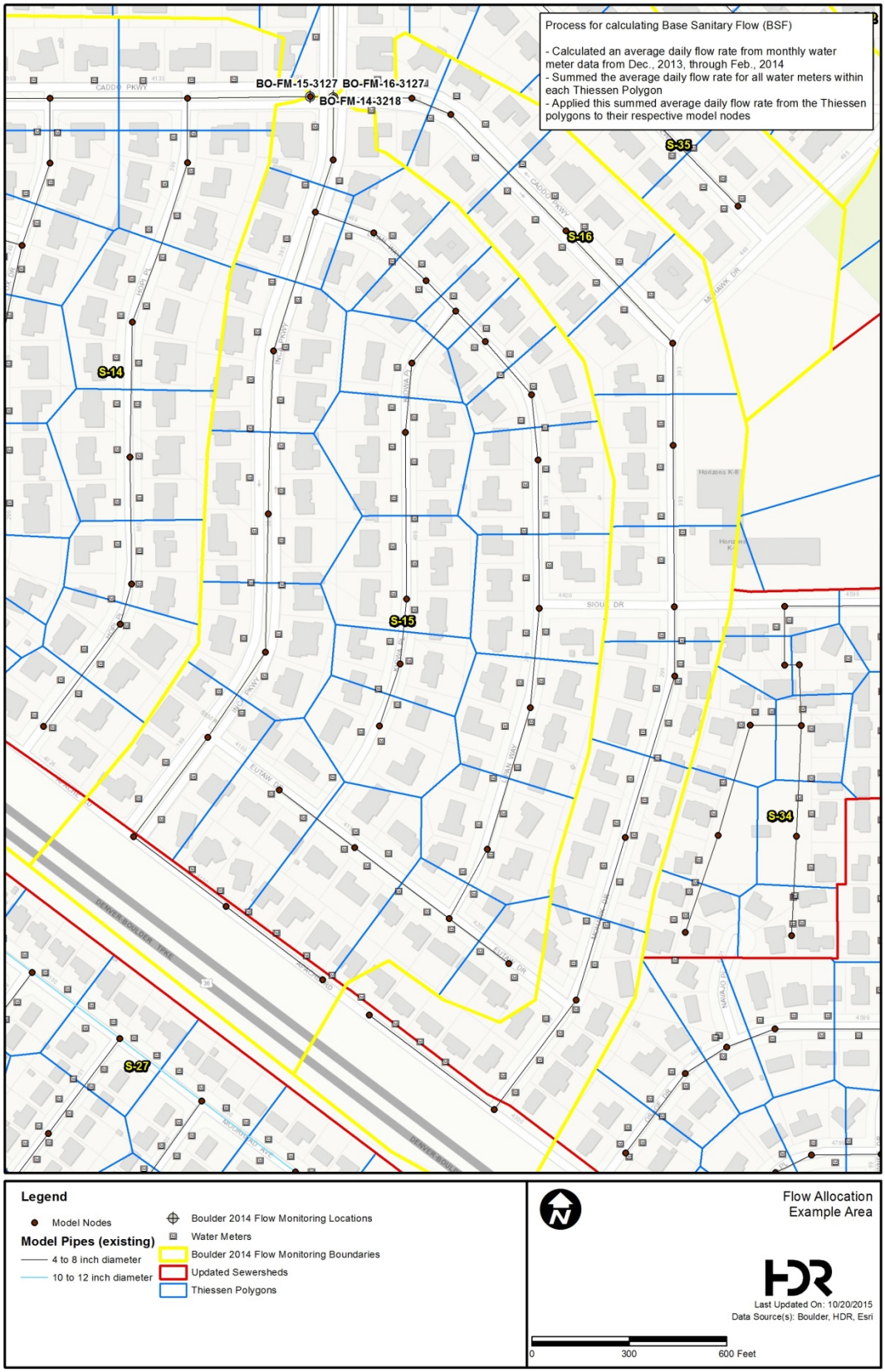


Figure 3-5. Flow Allocation Example Area



3.3.2.1 Water Utility Master Plan Demands (Buildout)

The city's 2011 WUMP water distribution model contains a detailed allocation of future water use and, therefore, represents the corresponding future sanitary load generation and how it is anticipated to be distributed across Boulder. By incorporating the city's 2011 WUMP future water use, future conditions modeling in the 2015 WWSMP Update is consistent with the water plan. The future water use allocation in the 2011 WUMP model, reduced by an appropriate winter (indoor) use factor, is applied as future BSF loading for the 2016 WWCSMP. This future sanitary load allocation process aligns the future water use and sanitary sewer loads.

The buildout sanitary base loading is based on the 2011 WUMP water use projections and the associated water distribution model. The existing condition (2011) flows were subtracted from the future condition (2035) demands in the water distribution model to estimate the projected increase in water use.

Assuming that outdoor water use is minimal during the winter months, an estimate of the winter water demand was calculated using a winter water use fraction. This winter water use fraction was derived by dividing the average water use for a year (December 2013 through November 2014) by the average water use in the winter (December 2013 through February 2014). This results in a winter use fraction of 0.65, which was applied to the projected increase in water use. Based on this process, it is estimated that Boulder's winter water demand will increase 2,395 gpm (3.45 mgd) by 2035.

Because of the uncertainty of industrial process contribution, the SIU loads will be held constant for existing and future flow scenarios. BI allocations are also considered unchanged from existing to future conditions.

The 2011 WUMP water distribution model used Thiessen polygons to allocate water loads to their respective water junctions. This spatial allocation of water demand was compared to the sewer manhole Thiessen polygons to determine projected increases which fall outside of the WUSA and should not be included in the wastewater system model.

Based on this comparison process, of the 2,395 gpm (3.45 mgd) increase in 2035 winter water demand, 92 percent, or 2,208 additional gpm (3.18 mgd), will enter the WUSA.

The total BSF for 2035 conditions is therefore estimated be 8,366 gpm (12.0 mgd). Future SIU flow is estimated to be approximately 10 percent of this 2035 BSF.

3.3.3 Dry Weather Infiltration Flows

Dry weather infiltration, or BI, occurs even during dry weather due to groundwater and can be influenced by stream flows and irrigation ditches. BI is an important consideration when analyzing system capacity because this flow component of ADWF can increase sanitary flows substantially. To illustrate, the BSF was estimated to be 8.87 mgd (6,158 gpm) based on the potable water meter data, however, the average daily WWTF influent flow for the same time period was measured to be 13.2 mgd. BI can therefore be inferred to account for the 4.3 mgd (33 percent) difference since there were no other major sources of wastewater contributions such as wet weather events. In the summer, flows in irrigation ditches and high stream flows further elevate the groundwater table and cause even greater BI. Since summer BI is higher than winter BI, the summer BI is used for this model update.

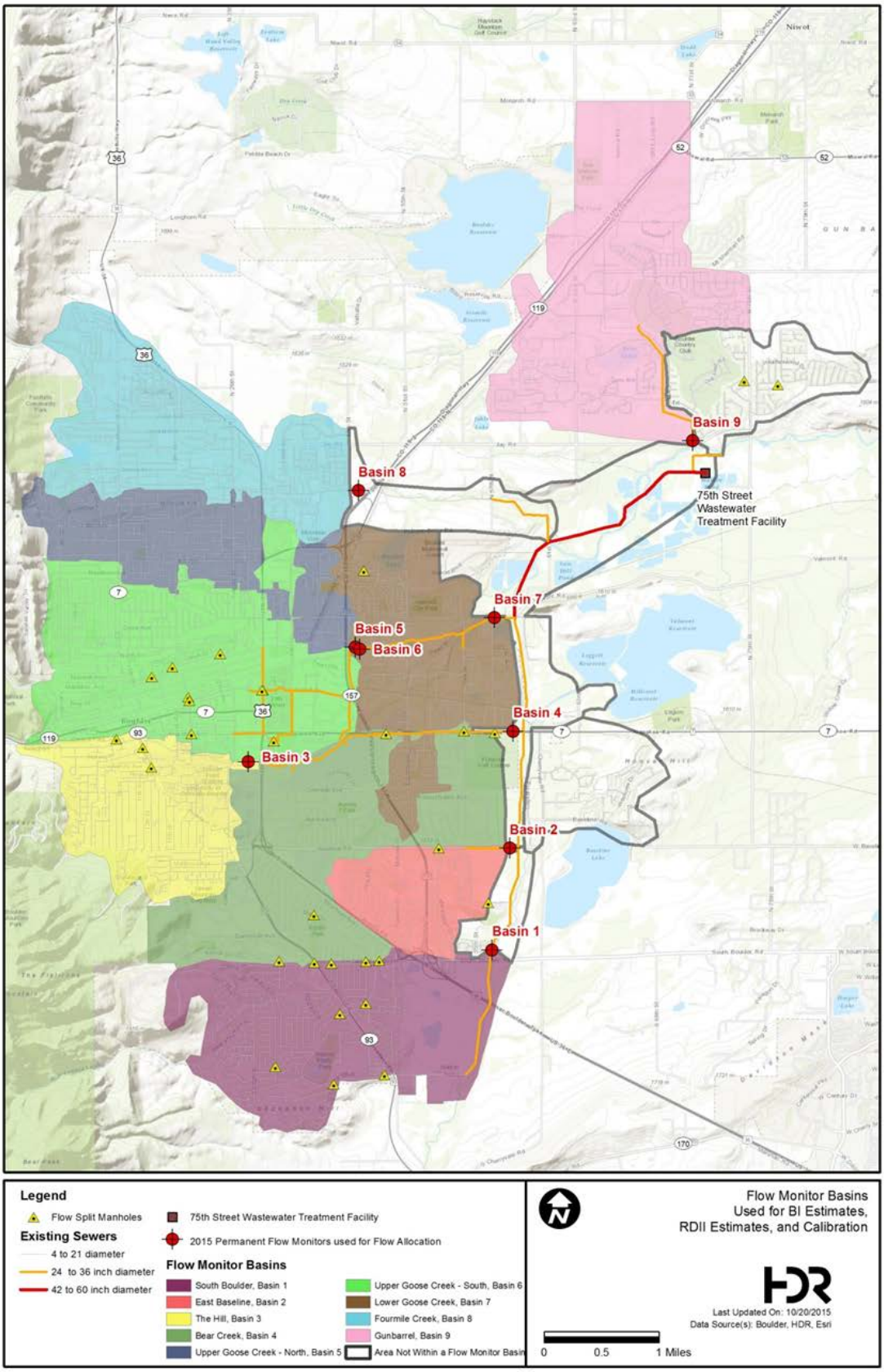
Stantec conducted a comprehensive I&I analysis as part of the *2014 Flow Monitoring Program*. The analysis produced spring and summer groundwater infiltration values for each flow monitoring basin. The results of the study were not used for the current modeling effort because:

- Some basins were calculated to have negative groundwater infiltration which is not reasonable.
- Some of the model network was not represented in the 2014 Flow Monitoring Program.
- Groundwater infiltration values in the 2014 Flow Monitoring Program were estimated based on calculated ADWF at the flow monitors rather than from BSF. This may be the reason some of the calculated groundwater infiltration values were negative.
- There is suspect data at some of the flow monitors due to negative groundwater infiltration or some data was noted as being suspect in the report. Flow monitors assigned with “Some Limitations” or “Poor” quality in the report were used in the I&I calculations, which can create uneven flow balancing and skew modeling results.
- A significant rainfall event (both in total rainfall depth and distribution across Boulder) did not occur during the 2014 Flow Monitoring Program.

In April 2015, the city installed ten permanent flow monitors into major trunk sewers throughout its sanitary sewer system. Most of the permanent flow monitors have recorded flows that are influenced by the mix of land uses within the system. There were a number of significant rainfall events in May 2015 that caused the WWTF influent monitor to reach its capacity of approximately 50 mgd. Rainfall data observations also indicate that these May rainfall events had a relatively even distribution across Boulder, which is good for balanced hydraulic modeling across the collection system. Due to these factors, the permanent flow monitors were used instead of the *2014 Flow Monitoring Program* data for developing and calibrating the summer BI.

Contributing areas were developed for the permanent flow monitors based on the sewersheds described in Section 3.3.2. These contributing areas are referred to as flow monitor basins and are illustrated in Figure 3-6. The flow monitor basins were used for BI and RDII estimates and calibration.

Figure 3-6. Flow Monitor Basins Used for BI Estimates, RDII Estimates, and Calibration

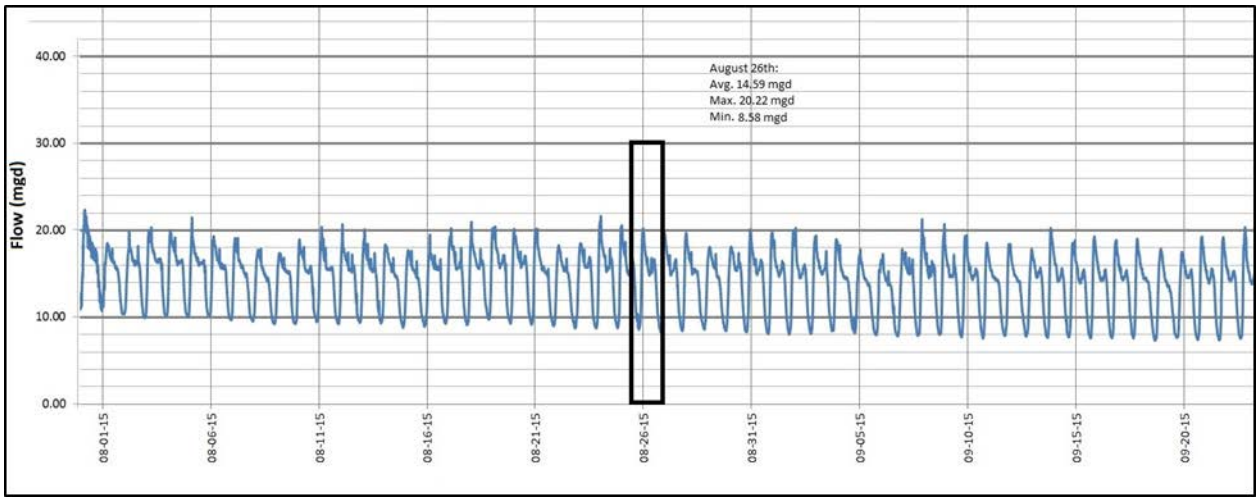


After a review of WWTF influent flow monitor data and rainfall data, August 26, 2015, was chosen as the date of BI development and dry weather model calibration based on the following:

- It is at a time of year when irrigation ditches and creeks were flowing so the groundwater-induced BI is likely present at a higher level in the flow meter data.
- Classes for the University of Colorado at Boulder started on August 24, and August 26 is a date that reflects when students are on campus. It was observed that the start of classes has an appreciable influence on sanitary flow within Basins 3 and 4 when meter data was compared for off-class/summer periods. BSF estimates were also developed for the winter period when students are on campus and this date reflects the higher flows in these basins when school is in session.
- There was about 0.2 - 0.3 inch of rainfall on the August 19, but no rainfall between August 20 and 26. Any remaining effect from the rainfall is not apparent in the flow monitors or at the WWTF on August 26.
- The average daily flow at the WWTF on August 26 was 14.59 mgd. This flow rate is similar to other summer dry days recorded at the WWTF in 2015.

Figure 3-7presents the WWTF influent flow for August 2015 with August 26 highlighted, indicating its appropriateness for BI generation and dry weather model calibration.

Figure 3-7. WWTF Influent Flow for August 2015 with the Day of BI Development Highlighted



The process for developing BI was as follows:

- Every pipe and manhole was assigned to its corresponding 2015 flow monitor basin that was developed from the sewersheds described in Section 3.3.2.1.
- Flow meter data for the dry day of August 26, 2015, was extracted from the 2015 flow monitoring data.
- Potable water meter data was summarized for each flow monitor basin to determine the estimated BSF contribution to the respective permanent flow monitors.

- Average daily flow for August 26 was determined for each permanent flow monitor. If there was a flow monitor basin upstream of another flow monitor basin, this upstream flow was removed to isolate flow contributions specific to each flow monitor basin.
- BI was calculated for each flow monitor basin by subtracting the contributing BSF from the average flow at the corresponding permanent flow monitor.
- Each sewer pipe was multiplied by its corresponding diameter (inches) and length (miles) and assigned to its upstream manhole.
- The total pipe diameter (in)-length (feet) was summed in each flow monitor basin.
- The calculated BI was then allocated to the pipes based on their individual diameter (in)-length (feet) in proportion to the total diameter (in)-length (feet) in each flow monitor basin.
- BI was summed to each of the model manholes based on the BI fraction assigned to their downstream effluent pipes and assigned as BI to that manhole (Load 3 column).
- For pipes and manholes not within a flow monitor basin, the remaining winter water meter BSF was calculated and compared against the WWTF ADWF minus the ADWF of the upstream flow monitors. The remaining BI was then allocated to these manholes based on the diameter (in)-length (feet) of the downstream effluent pipes.

This process resulted in non-negative BI values and a good correlation to existing dry weather flows.

3.3.4 Dry Weather Calibration

Modeled dry weather flows were calibrated against the flow monitoring data from the ten permanent flow monitors and the overall WWTF influent flow. The results of the dry weather calibration and verification are described below.

3.3.4.1 Dry Weather Calibration – Permanent Flow Monitoring Data

Following the completion of the Section 3.3.3 processes, the updated existing conditions uncalibrated model was run for the base dry weather scenario. Initial results were compared to the permanent flow monitor data for August 26, 2015 to calibrate BI allowances, assuming that BSF was well-represented by the water meter and SIU data. The target for the model calibration was to be within +10 percent of the ADWF peak and daily volume for the permanent flow monitors.

BI allowances were refined for the model pipes within each flow monitor basin based on the following process:

- The initial, uncalibrated model results for ADWF (total daily dry weather volume) were compared to the August 26, 2015, monitored flows for each permanent flow monitor.
- BI allowances were adjusted to reflect the measured average daily flow (or total volume).
- This modeled BI adjustment was repeated iteratively until the calibration goal was met within each flow allocation basin (within +10 percent of the ADWF peak and daily volume for the permanent flow monitors).

This process created a good correlation between the model and the observed flows at the permanent flow monitors and at the WWTF. The calibrated BIs for each permanent flow monitor basin are presented in Table 3-4. Table 3-5 provides the calibration results for the steady-state, dry weather model based on the methods described above.

Table 3-4. Calibrated Infiltration Parameters per Permanent Flow Monitor Basin

Permanent Flow Monitor Basin	Alternate Permanent Flow Monitor Basin Name	ADWF at Permanent Flow Monitor for August 26th, 2015	ADWF for Flow Monitor Basin (minus upstream monitors)	Base Sanitary Flow (BSF) (gpm)	Calibrated Base Infiltration (BI) (gpm)	Calibrated Base Infiltration (BI) (%)	Calibrated ADWF for Flow Monitor Basin (minus upstream monitors)
South Boulder	Basin 1	976	976	455	652	59%	1,106
East Baseline	Basin 2	563	563	256	337	57%	593
The Hill	Basin 3	642	642	602	56	8%	658
Bear Creek1	Basin 4	2,096	1,4541	1,106	348	24%	1,454
Upper Goose Creek - North	Basin 5	883	883	439	466	52%	905
Upper Goose Creek - South	Basin 6	1,644	1,644	1,463	181	11%	1,644
Lower Goose Creek2	Basin 7	3,367	8392	411	449	52%	861
Fourmile Creek	Basin 8	1,146	1,146	461	684	60%	1,146
Gunbarrel	Basin 9	1,286	1,286	642	644	50%	1,286
N/A[3]	WWTF	10,132	699[3]	323	376	54%	699
Total				**6,158**	**4,194**		**10,351**

[1] The Hill (Basin 3) permanent flow monitor is upstream of the Bear Creek (Basin 4) permanent flow monitor and needed to be subtracted from the ADWF for BI allocation.

[2] The Upper Goose Creek North and South (Basins 5 and 6) permanent flow monitors are upstream of the Lower Goose Creek (Basin 7) permanent flow monitor and needed to be subtracted from the ADWF for BI allocation.

[3] The WWTF ADWF used for BI allocation results from the ADWF influent flow minus the ADWFs from the directly contributing permanent flow monitors.

Table 3-5. Dry Weather Calibration Steady-State Results Based on Flow Data for August 26, 2015

Permanent Flow Monitor Basin	Alternate Permanent Flow Monitor Basin Name	Monitored ADWF (gpm)	Modeled ADWF (gpm)	Model vs. Monitor ADWF (Difference)
South Boulder	Basin 1	976	999	23
East Baseline	Basin 2	563	580	17
The Hill	Basin 3	642	645	3
Bear Creek	Basin 4	2,096	2,230	134
Upper Goose Creek - North	Basin 5	883	898	15
Upper Goose Creek - South	Basin 6	1,644	1,643	-1
Lower Goose Creek	Basin 7	3,367	3,399	32
Fourmile Creek	Basin 8	1,146	1,146	0
Gunbarrel	Basin 9	1,286	1,289	3
N/A	WWTF	10,132	10,351	219

3.3.4.1 ADWF vs. Base Sanitary Flow Relationship

The modeled ADWF at the treatment plant for August 26, 2015, is 14.9 mgd (10,351 gpm), as shown in Table 3-5. The average daily BSF, assuming the water meter and SIUs are the sole BSF contributions, is estimated to be 8.87 mgd (6,158 gpm). These results imply that the BI accounts for 6.04 mgd (4,194 gpm) or 41 percent of flow, which is higher than the 33 percent winter season BI calculated in Section 3.3.3. The BI may be influenced by higher stream flows and actively flowing irrigation ditches and is considered a significant contributor of wastewater flows this time of year.

3.3.4.1 Dry Weather Model Comparison to 2009 WWCSMP

The results from the 2009 WWCSMP indicated a modeled existing condition ADWF of 16.9 mgd at the WWTF and a projected 2015 ADWF of 19.2 mgd. The 2015 model results are lower than the previous ADWF flow at 14.9 mgd. However, the average WWTF flow for the meteorological summer months (June, July, and August) from 2009 to 2014 is around 15.1 mgd, which is similar to the results of the current analysis (14.9 mgd).

The reasons for this difference in ADWF can be attributed to slower than predicted population and employment growth, water conservation (including installation of water efficient fixtures), better monitoring data with the newly installed permanent flow meters, and more refined monitoring data at the WWTF.

3.3.5 Buildout (2035) Flows

The additional buildout flows in the WUSA totaling 2,208 gpm (3.18 mgd), as described in Section 3.3.2.1, were applied as a separate model load (Load 5 column). This generated a total BSF of

8,366 gpm (12.0 mgd). Keeping BI consistent with existing conditions, these future loads increased model ADWF flows at the WWTF from 14.9 mgd to 18.1 mgd.

3.3.6 Summary

The following summarizes the dry weather steady-state flow analysis for values at the WWTF influent:

- The calculated 2015 BSF for this analysis is 8.87 mgd (6,158 gpm).
- The modeled 2015 ADWF for this analysis is 14.91 mgd (10,351 gpm).
- The calculated 2035 BSF for this analysis is 12.05 mgd (8,367 gpm).
- The modeled 2035 ADWF for this analysis is 18.08 mgd (12,559 gpm).

Table 3-6 summarizes the existing and buildout (2035) BSFs based on the calibrated model for each permanent flow monitor basin. Table 3-7 summarizes the BI values.

Table 3-6. Existing and Buildout Base Sanitary Loads at the Flow Allocation Basins

Permanent Flow Monitor Basin	Alternate Permanent Flow Monitor Basin Name	Existing (2015) Sanitary Loads (gpm)	Additional Buildout (2035) Sanitary Loads (gpm)	Total Buildout (2035) Sanitary Loads (gpm)
South Boulder	Basin 1	455	98	553
East Baseline	Basin 2	256	87	343
The Hill	Basin 3	602	182	784
Bear Creek	Basin 4	1,106	267	1,373
Upper Goose Creek - North	Basin 5	439	193	632
Upper Goose Creek - South	Basin 6	1,463	728	2,191
Lower Goose Creek	Basin 7	411	164	576
Fourmile Creek	Basin 8	461	205	666
Gunbarrel	Basin 9	642	189	831
N/A	WWTF	323	95	418
TOTAL		**6,158**	**2,209**	**8,367**

Table 3-7. Existing and Buildout Base Infiltration Loads at the Flow Allocation Basins

Permanent Flow Monitor Basin	Alternate Permanent Flow Monitor Basin Name	2015 Summer BI (gpm)	2035 Summer
South Boulder	Basin 1	652	652
East Baseline	Basin 2	337	337
The Hill	Basin 3	56	56
Bear Creek	Basin 4	348	348
Upper Goose Creek - North	Basin 5	466	466
Upper Goose Creek - South	Basin 6	181	181
Lower Goose Creek	Basin 7	449	449
Fourmile Creek	Basin 8	684	684
Gunbarrel	Basin 9	644	644
N/A	WWTF	376	376
TOTAL		**4,193**	**4,193**

3.3.6.1 Unit Flow Factors

Unit flow factors were updated based on the city's population and employment projections to compare to unit flow factors used in the 2003 and 2009 WWCSMPs. They are calculated using ADWF flows and the existing and projected population and employment numbers. Per capita wastewater flow production values of 102 gallons per day (gpd) per capita and 50 gpd per employee were developed in the 2003 WWCSMP, used in the 2007 WWTP Master Plan, and were adopted for the 2009 WWCSMP and the 2010 WUMP. These values are based on historical flow data at the WWTF versus population and employment numbers from 1996 to 2001.

Using updated available data, new unit flow factors for the population, assuming the employment factor is kept at 50 gpd per employee, were developed for comparison and are presented in Table 3-8. Without more information, recalculating both population and employment unit factors is difficult. It is likely the employment factor has decreased, making the population unit flow factor increase in the calculations presented in Table 3-8. Overall, it appears that the unit flow factors have decreased some due to water conservation, water efficient fixtures in new construction and renovations, and actions to reduce infiltration and inflow such as sewer lining activities. For future conditions, the calculated new population unit flow factor is a little higher than the value used in previous planning efforts. This means that the future modeling conducted for this 2016 WWCSMP is likely conservative and appropriate for master planning.

Table 3-8. Unit Flow Factor Comparison

Condition	Population (number of capita)	Population Unit Flow Factor (gpd per capita)	Employment (number of employees)	Employment Unit Flow Factor (gpd per employee)
2003 WWCSMP	-	102	-	50
2014 BSF Conditions	102,420	95	102,500	50
2035 BSF Conditions	114,025	105	116,230	50

Since this 2016 WWCSMP uses the permanent flow monitors for existing flows and the 2011 WUMP water demand projections for 2035 flows, the flow factors are presented in this section only for comparison purposes.

3.4 Summary

The dry weather steady-state modeling results presented in this Section are satisfactory for developing wet weather flows and capacity analyses going forward.

The next steps in model development are as follows:

- Develop the level of service RDII versus rainfall recurrence interval relationship using influent flow monitor data from 2009 to 2015.
- Identify level of service for 50 and 60 mgd flow scenarios and identify estimated flow rate associated with 25-year level of service.
- Compare resulting peaking factors with other regional agencies/municipalities (Metropolitan Water Reclamation District, DRCOG, Westminster, etc.).
- Develop and calibrate wet weather flows based on the permanent flow meter data.

4 RDII Response and Level of Service Assessment

This section documents the process and results of updating rainfall-derived inflow and infiltration (RDII) allowances and wet weather flow projections used for current model development in association with the City of Boulder (city) 2016 WWCSMP. This section also discusses the estimated levels of service associated with these RDII allowances.

This section discusses the following:

- Updates to the level of service equation using the city's 75th Street WWTF influent flow meter and available rain gauge data from 2009 to 2015
- Identifies the level of service for 50 and 60 mgd flow scenarios as well as the estimated flow rate associated with 25-yr level of service
- Compares resulting peaking factors with other regional agencies/municipalities' peaking equations or actual peaking factor values (MWRD, DRCOG, Westminster, etc.)

4.1 Wet Weather Analysis

Wet weather flows are comprised of RDII. Wet weather infiltration is the additional infiltration that occurs due to rainfall-induced higher groundwater conditions and is typically seen in the hours or days following significant rain events. Inflow is rainfall related water that enters a collection system from sources such as private laterals, downspouts, manhole defects, foundation piping, and cross-connections with storm drains. RDII is directly influenced by the intensity and duration of a storm event as well as antecedent soil moisture conditions and is therefore a variable quantity.

RDII, coupled with BI, is an important aspect when analyzing system capacity because wet weather flow in the city can be significantly greater than the BSF. During storm events, and for a period afterwards, flows within the collection system rise in response to the rainfall. The peak RDII flow component is combined with ADWFs to define the total peak wastewater flow that must be conveyed by the wastewater collection system and treated at the WWTF.

This peak wet weather flow condition is a worst-case scenario in evaluating a collection system, especially when locating capacity restrictions and potentials for sanitary sewer overflows (SSOs). However, due to unavailable instantaneous flow data at flow monitors and the WWTF influent meter, PHWWF is often used during planning and modeling efforts like this one. Instantaneous flow is also highly variable and makes it very difficult to model. Local storage in manholes and pipes helps address short-term instantaneous flows in a collection system; however wet-weather responses in a system over a longer duration from one hour to one day can be indicative of a better system-wide response and systemic capacity deficiencies. Steady state PHWWF modeling was used to represent the average flow over the peak hour and associated response in the system to RDII.

4.1.1 Wastewater Treatment Facility Capacity

The existing peak capacity at the WWTF is 50 mgd due to hydraulic limitations at the headworks and pumping capacity from the primary to secondary treatment processes. The secondary and downstream treatment processes can treat up to 60 mgd. The modeling effort investigated three

peak wet weather flow scenarios; with the 50 mgd treatment capacity being used for the minimum wet weather flow scenario because the sewer system will need to deliver at least that quantity to take advantage of the WWTF's existing peak capacity. The difference between the existing condition dry weather calibrated model flow (14.9 mgd) and the 50 mgd wastewater flow target was made up with a system-wide RDII increase distributed across the flow meter basins. The resulting 35.1 mgd RDII allowance translates to a wet weather peaking factor of 3.4. The secondary treatment process hydraulic capacity of 60 mgd was used as another peak wet weather flow scenario. The resulting 45.1 mgd RDII allowance translates to a wet weather peaking factor of 4.0. The third wet weather flows scenario was not based on any existing WWTF capacities but rather the peak flows resulting from a 25-year storm.

4.1.2 Level of Service

The collection system's level of service is defined by the level of wet weather event that the system can sustain without causing sanitary sewer overflows or backups into buildings. The collection system's level of service is therefore directly related to the excess capacity in the collection system which is available to convey RDII flows. The level of service can therefore be represented by the rainfall recurrence interval that results in the maximum conveyable RDII.

A rainfall recurrence interval is the likelihood of a given rainfall event occurring based on both the event's depth and duration. Rainfall recurrence intervals are used for risk analysis and are defined as the inverse of the probability that a certain magnitude of rainfall event (defined by both depth and duration) will be exceeded in any one year. For example, a 25-year rainfall event has a 0.04 (1/25) or 4 percent chance of being exceeded in any one year while a 100-year rainfall event has a 0.01 (1/100) or 1% chance of being exceeded in any one year.

4.1.2.1 RDII Response to Rainfall Events and Associated Level of Service

Flows in the city's wastewater collection system increase as a result of significant precipitation events (i.e., 2-year storms and greater). Similar rainfall events may not result in similar responses in the collection system though due to a number of factors including:

- Antecedent soil moisture conditions prior to the rainfall event (saturated versus dry).
- Sanitary loadings at the time of the event.
- Rainfall intensity and how long the intensity is sustained.
- Height of groundwater table above or below collection system prior to rainfall event.

For the 2009 Master Plan, HDR evaluated 20 years of precipitation data to identify storm events that had a measurable RDII impact on collection system flows. Large rainfall events were identified and a corresponding rainfall recurrence interval was estimated using the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service's (NWS) rainfall Atlas 2 (1973). Given data limitations, RDII was estimated for a rainfall event by taking the peak total daily flow for the month in which the rainfall event occurred and subtracting the lowest total daily flow for the month. The estimated recurrence intervals of several rainfall events were then plotted against the associated RDII and a linear relationship was developed.

Since the 2009 Master Plan, more detailed WWTF influent flow and rainfall data has become available. In addition, NOAA released Atlas 14 Volume 8 (2013) which supersedes NOAA rainfall Atlas 2 (1973) used in the previous analysis.

Recorded precipitation data from several rainfall gauges within the city were compared with RDII flow increases at the WWTF influent flow meter to develop a new correlation between precipitation and the total peak wet weather flow. For this effort, RDII was determined by taking the approximate ADWF prior to the start of increased WWTF influent flows and subtracting it from the 15-minute maximum WWTF influent flow. The total rainfall duration and associated depth were extracted from all the available gauges. Atlas 14 was then used to estimate the corresponding rainfall recurrence interval for the extracted rainfall depths and durations. Rainfall recurrence intervals for each event were determined via the following:

- For rainfall durations that fall between those reported in Atlas 14, linear interpolation was used estimate rainfall depths between the reported durations.
- Exponential relationships between rainfall recurrence intervals and rainfall depths were developed for each rainfall duration.
- To determine the rainfall recurrence for an event, the exponential rainfall recurrence/rainfall depth relationship associated with rainfall duration was used.
- The calculated rainfall recurrence interval was back checked against the Atlas 14 source data for validation.

According to city staff, longer duration rainfall events for storm periods in excess of 24-hours were identified to have the most influence on RDII. Therefore, only events longer than 12 hours and greater than a 1-year calculated recurrence interval were retained in the analysis. Due to the different analysis approach and better data sources, only the data from 2010 until present (2015) was applied to this RDII response and level of service evaluation. For dates in which there was rainfall data from more than one gauge, the gauge that produced the greatest rainfall recurrence interval versus RDII correlation was retained. Table 4-1 presents the results of this analysis, with the shortest duration rainfall event being 24 hours and longest being 550 hours (23-day). The lowest rainfall recurrence interval being used is a 1-year event and the highest is a 15.9-year event. Note that the September 2013 event was not used for analysis due to unreliable flow data.

Table 4-1. WWTF Peak Flow Response to Various Rainfall Events

Date	Estimated Rainfall Data			Estimated WWTF Response		
	Total Rainfall Depth (in)	*Total Rainfall Duration (hr)*	*Estimated Rainfall Recurrence Interval*	*Approx. ADWF at First Date of WWTF Response (mgd)*	*WWTF Peak Flow (mgd)*	*Calculated RDII (mgd)*
May 9, 2015	6.64	550	15.9	15.00	51.24	36.24
April 17, 2015	2.32	24	3.1	15.00	35.61	20.61
July 30, 2014	2.68	29	4.9	16.00	35.31	19.31
May 11, 2014	1.88	35	1.4	17.00	26.92	9.92
September 15, 20131	15-16	140	500 to 1,000	14.00	>51.691	>37.69
April 1, 2013	1.5	24	1.0	16.50	24.14	7.64
June 7, 2012	2.2	45	1.8	13.4	20.87	7.47
July 9, 2011	1.84	54	1.4	16.00	24.52	8.52
May 18, 2011	3.28	194	2.6	12.80	31.52	18.72
June 13, 2010	2.3	53	2.0	17.00	29.41	12.41
April 21, 2010	3.2	53	5.6	16.00	35.01	19.01

[1]The WWTF influent flow meter reached capacity above 50 mgd. Most likely the WWTF influent flow was greater than indicated in the table. As a result, this date was not used for the rainfall recurrence versus RDII correlation.

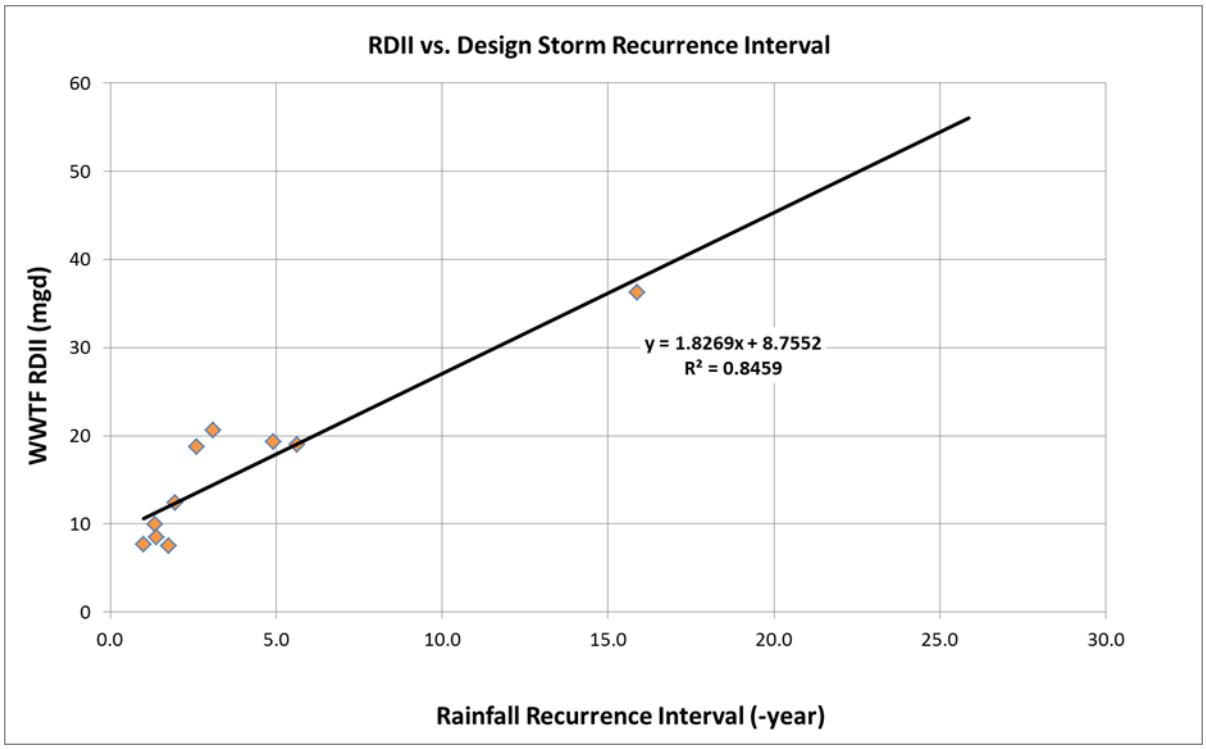
The estimated rainfall recurrence interval versus the calculated RDII of Table 4-1 is plotted in Figure 4-1. The linear relationship between rainfall recurrence interval and the corresponding RDII at the WWTF is defined by Equation 1.

Equation 1

$$y = 1.8269x + 8.7552$$

Where x equals the probability of the event expressed as recurrence interval in years and y equals the estimated wet weather flow increase (RDII allowance in mgd) at the WWTF. The coefficient of determination (R^2) of Equation 1 is 0.85 and indicates that it is well suited for the 2016 WWCSMP.

Figure 4-1. Rainfall Recurrence Interval versus Peak RDII for the WWTF



This relationship analysis is limited based on the 50 mgd capacity of the WWTF influent flow meter. The extreme reoccurrence interval events such as the September, 2013, event had to be removed from this analysis as the actual influent flow in the collection system was likely quite higher than the 52 mgd measured at the WWTF. To better estimate the rainfall reoccurrence interval related to a certain RDII, a permanent flow monitor or flume should be installed at the WWTF influent that has a capacity up to 80 mgd. If possible, two meters separated with a wet-weather flow weir is a favorable arrangement to accurately measure lower flows as well as capture larger RDII flows during significant storm events.

4.1.2.1 Uncertainties

There are several uncertainties related to the development of the RDII versus rainfall recurrence interval. They are acknowledged and discussed below.

1. **Confidence level of Atlas 14 data.** The rainfall depths for the various durations and rainfall recurrence intervals, as presented in Atlas 14, come with their own uncertainties. To assess these uncertainties, each rainfall depth is accompanied by 90 percent confidence intervals. As recurrence intervals or rainfall durations increase, the range between the confidence intervals also increases due to the events being less frequent and therefore not having as many data points from which to generate the statistics. As an example, the 25-year recurrence interval has a range between the 90 percent confidence intervals of over an inch of precipitation. The present analysis extracted the average precipitation estimates at the 50 percent confidence interval.
2. **Reliability of rain gauge data.** Rain gauges provide information on rainfall depths in a specific location and do not reflect rainfall across the entire city for a particular event. Rain gauges can also be influenced by wind as well as turbulence and eddy currents near the

gauge. Rain gauge maintenance and rain gauge location in relation to a specific storm event can also be an issue. Radar data validated to ground rain gauge data is likely the most accurate representation of rainfall but is intensive to process and provides limited implementation into steady state modeling.

3. **Nature of the rainfall event.** Rainfall events can have periods of varying intensity at different locations or have several different peaks, depending upon the duration of the storm. How rain falls on a watershed can greatly influence the runoff and groundwater response of that watershed and have a subsequent influence on the RDII response.
4. **Rainfall events being independent of other events.** A recurrence interval associated with a rainfall event needs to be related only to that rainfall event. Subsequent events are not represented in a rainfall recurrence interval.
5. **Antecedent soil moisture conditions and base infiltration.** Similar to having a specific rainfall event independent of other rainfalls event, the antecedent soil moisture conditions such as ground saturation, groundwater levels, and time of year can influence basin infiltration and residual RDII on the sanitary collection system's response to a rainfall event.
6. **Reliability of the WWTF influent meter.** Although considered reliable, there is inherent error associated with flow measurements, especially open channel flow meters. The WWTF influent flow meter also has a maximum capacity of around 50 mgd which limits the ability to capture flow from storm events above a 14 to 15-year reoccurrence.

These uncertainties were minimized by using the following methods:

1. **Using more than one rain gauge.** As stated above, rainfall data was extracted from all available rain gauges and compared in the analysis.
2. **Consistent extraction of data.** By extracting rainfall and WWTF flow data based on the time of first influence at the WWTF, influence of antecedent soil moisture conditions was accounted for in reasonable fashion. RDII is based on the ADWF specific to the time period prior to the rainfall event and not over a monthly average or low flow. What constitutes the duration of a rainfall event was also made consistent by having it dependent upon WWTF flow. Many rainfall events used in the analysis occurred over several days and could contain several hours of no rainfall. This created many multi-day rainfall events that correspond with RDII response at the WWTF.
3. **Extracting all data with the same method.** Only recent data was used for analysis to ensure consistency of extraction and interpretation.
4. **Removing the influence of short duration storms or limited rainfall.** Since the WWTF response is greatest during long duration storms, all storms less than a 24-hour duration or a 1-year calculated recurrence interval were removed from the analysis. As a result, the shortest duration storm used for analysis is a 24-hour duration and 1-year recurrence interval type event.

4.1.3 50 MGD and 60 MGD Capacity Levels of Service

With the modeled ADWF of 14.9 mgd and a collection system capacity of 50 mgd, the associated system wide RDII that should be handled in the system is 35.1 mgd. This flow scenario equates to the collection system being able to convey flows associated with approximately a 15-year (14.4-year calculated) design storm event.

For the 60 mgd flow scenario the RDII increases to 45.1 mgd, which equates approximately to a 20-year (19.9 calculated) design storm event.

4.1.4 25-yr Rainfall Event Capacity

Using the RDII / rainfall recurrence equation (Equation 1), the RDII at the WWTF for a 25-year event was calculated to be 54.4 mgd. Adding the modeled ADWF of 14.9 mgd, the total 25-year level of service peak hour wet weather flow at the WWTF is therefore 69.3 mgd.

4.1.5 Peaking Factor Comparison

Based on an ADWF of 14.9 mgd, the peaking factor (ratio of peak hour wet-weather flow to average daily flow) for the 25-year event was calculated to be 4.7. For the 2035 buildout scenarios, a buildout peaking factor of 4.0 was calculated based on the higher ADWF of 18.1.

For reference and general validation, these peaking factors were compared with other methods and standards for calculating peaking factors.

Colorado Department of Public Health and Environment (CDPHE) Policy 96-1, Design Criteria Considered in the Review of Wastewater Treatment Facilities recommends a peaking factor not be less than 4 for laterals and sub-main sewers and not less than 2.5 for main, trunk, and outfall sewers. Neither the existing nor buildout peaking factor for the outfall sewer at Boulder's WWTF are less than 2.5.

The Metcalf & Eddy book "Wastewater Engineering: Treatment and Reuse", page 151, provides an hourly peaking factor curve based on an average flow rate. The City of Boulder's existing peaking factor based on this curve would be approximately 2.5. The buildout peaking based on this curve would be approximately 2.4.

Based on Metro Wastewater Reclamation District's (MWRD)'s equation, the calculated existing and buildout peaking factors would be 2.60 and 2.54, respectively. Based on DRCOG's equation, the calculated existing and buildout peaking factors would be 2.32 and 2.25, respectively.

Table 4-2 compares the city's calculated peaking factors against various industry and regional peaking factor determination methods. Based on this comparison, a peaking factor of 4.65 for existing conditions and 4.01 for the buildout scenarios are greater than the range of other peaking factor determination methods.

It should be noted that the 25 year level of service is a goal which the current collection system cannot yet achieve and therefore should not be compared directly to minimum design requirements which would be expected to be lower than this goal. The city is striving to provide a higher level of service for the local, collector and interceptor system based on the impacts resulting from the historic 2013 flood and the 25-year level of service reflects this.

Table 4-2. WUSA Peaking Factor Comparison

Model Flow Scenario	City Model (50 mgd)	City Model (60 mgd)	City Model (25-year[1])	CDPHE	Metcalf & Eddy	MWRD	DRCOG
Existing ADWF Peaking Factor	3.36	4.03	4.65	> 2.5	2.5	2.60	2.32
Buildout ADWF Peaking Factor	2.94	3.49	4.01	> 2.5	2.4	2.54	2.25

[1] The 25-year level of service equates to 69.4 mgd and 72.5 mgd at the WWTF influent, respectively.

Peaking factor comparisons were also made to other neighboring Colorado utilities including Westminster, Evans, and Northglenn. The source of the peaking factors was from their latest collection system master plans. In contrast to the city, these peaking factors are not tied to levels of services but were based on observed peak flows at the respective WWTFs from previous years. Table 4-3 summarizes the peaking factor comparison between the city and other similar-sized utilities in the same vicinity. The city's peaking factor is somewhat greater than for these other utilities. This difference can be attributable to Boulder's older sewer system which contains a significant portion of clay sewers and Boulder's hydrology which may include more creeks, irrigation ditches, and swamps that cause elevated groundwater tables.

Table 4-3. Neighboring Communities Basin and Design Peaking Factor Comparison

Model Flow Scenario	City Model (50 mgd)	City Model (60 mgd)	City Model (25-year)[1]	Westminster	Evans[2]	Northglenn
Existing WWTF Peaking Factor	3.36	4.03	4.65	3.11	2.67	2.80
Buildout WWTF Peaking Factor	2.94	3.49	4.01	2.93	2.85[2]	3.00[2]
Peaking Factor Based on Design Equations for 1 mgd	3.50[3]	3.50[3]	3.50[3]	3.60	4.00[4]	3.00[5]

[1] The 25-year level of service equates to 69.4 mgd and 72.5 mgd at the WWTF influent, respectively.

[2] The main Evans Wastewater Treatment Plant was used in the comparison. Their Hill-n-Park Wastewater Treatment Plant has too low of average day flows to make a proper comparison.

[3] The Evans and Northglenn buildout peaking factors were based on increasing the existing peaking factor since they were lower than desired for the purposes of master planning based on historically available basin flow data.

[4] The City design peaking factor is based on pipe size categories. 1 mgd would be in the 12 to 15 inch category which has a design peaking factor of 3.50.

[5] The Evans design peaking factor is a constant 4.00 independent of pipe size or ADWF flow.

[6] The Northglenn design peaking factor is based on the highest observed peaking factor in their system based on their current Wastewater Treatment Facility Master Plan and the Northglenn Collection System Modeling Report.

4.2 Summary

The RDII versus rainfall recurrence interval analysis and the associated levels of service presented in this section will be used as the basis for developing wet weather flows and capacity analyses going forward. Table 4-4 summarizes the calculated levels of service associated with Equation 1 as well as the calculated RDII flows at the WWTF. Some of the numbers in Table 4-4 may be adjusted

slightly in subsequent modeling efforts based on the results of wet-weather modeling and calibration. The 50 mgd scenario was determined to equate to a 15-year level of service. For the 60 mgd scenario, the level of service increases to a 20-year level of service. For a 25-year level of service, the collections system would have to be able to convey 69.3 mgd.

Table 4-4. WWTF Peak Flow Response to Various Rainfall Events

Model Flow Scenario	Existing RDII (mgd)	Existing Flow (Base plus RDII) (mgd)	Existing Level of Service	Buildout RDII (mgd)	Buildout Flow (Base plus RDII) (mgd)	Buildout Level of Service
ADWF	-	14.9	-	-	18.1	-
50 mgd WWTF Capacity	35.1	50	15	35.1	53.2	15
60 mgd WWTF Capacity	45.1	60	20	45.1	63.2	20
25-Year Event	54.4	69.3	25	54.4	72.5	25

The next steps in model development and documentation in the next section are as follows:

- Develop and calibrate wet weather flows based on the permanent flow meter data.
- Perform a system wide capacity analysis based on the 25-year level of service.

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5 Wet Weather Flow Generation and Model Calibration

This section documents the process and results of the wet weather model update and calibration for the City of Boulder (city) 2016 WWCSMP. Section 3 discussed the process and results of the dry weather model update, calibration, and ADWF development and section 4 discussed the process and results of updating RDII allowances and wet weather flow projections as well as the estimated levels of service associated with those RDII allowances. This section documents updates to the RDII allocations for existing conditions wet weather model development and calibration. It also documents development of buildout wet weather projections and summarizes the modeling approach and existing and buildout flow projections used during the 2016 WWCSMP.

This section discusses the following:

- RDII allowances developed from the 2015 permanent flow monitoring data.
- Wet weather model calibration and results.
- Existing condition wet weather model results for the 15-year, 20-year, and 25-year levels of service for the collection system.
- Buildout condition wet weather model results for the 15-year, 20-year, and 25-year levels of service for the collection system.
- Spatial distribution of modeled existing and future condition ADWF and 25-year wet weather level of service.
- Summary of the modeling approach and existing and buildout flow projections.

5.1 Wet Weather Analysis

Wet weather flows are comprised of RDII in addition to the ADWF. Wet weather infiltration is the additional infiltration that occurs due to rainfall-induced higher groundwater conditions and is typically seen in the hours or days following rain events. Inflow is rainfall related water that enters a collection system from sources such as private laterals, downspouts, manhole defects, foundation piping, and cross-connections with storm drains. RDII is directly influenced by the intensity and duration of a storm event as well as antecedent soil moisture conditions and is therefore variable from storm to storm.

RDII, coupled with BI, is an important aspect when analyzing system capacity because wet weather flow in the city can be significantly greater than the BSF. During storm events, and for a period afterwards, flows within the collection system rise in response to the rainfall. The peak RDII flow component is combined with the ADWF to define the total peak wastewater flow that must be conveyed by the wastewater collection system and treated at the WWTF.

This peak wet weather flow condition is a worst-case scenario in evaluating a collection system, especially when identifying capacity restrictions and potential hot-spots for SSOs. PHWWF is often used during planning and modeling efforts like this one because instantaneous flow is highly variable and is therefore very difficult to monitor for and model. The wet-weather response of the collection system over a longer duration from one hour to one day can be indicative of an extended system-

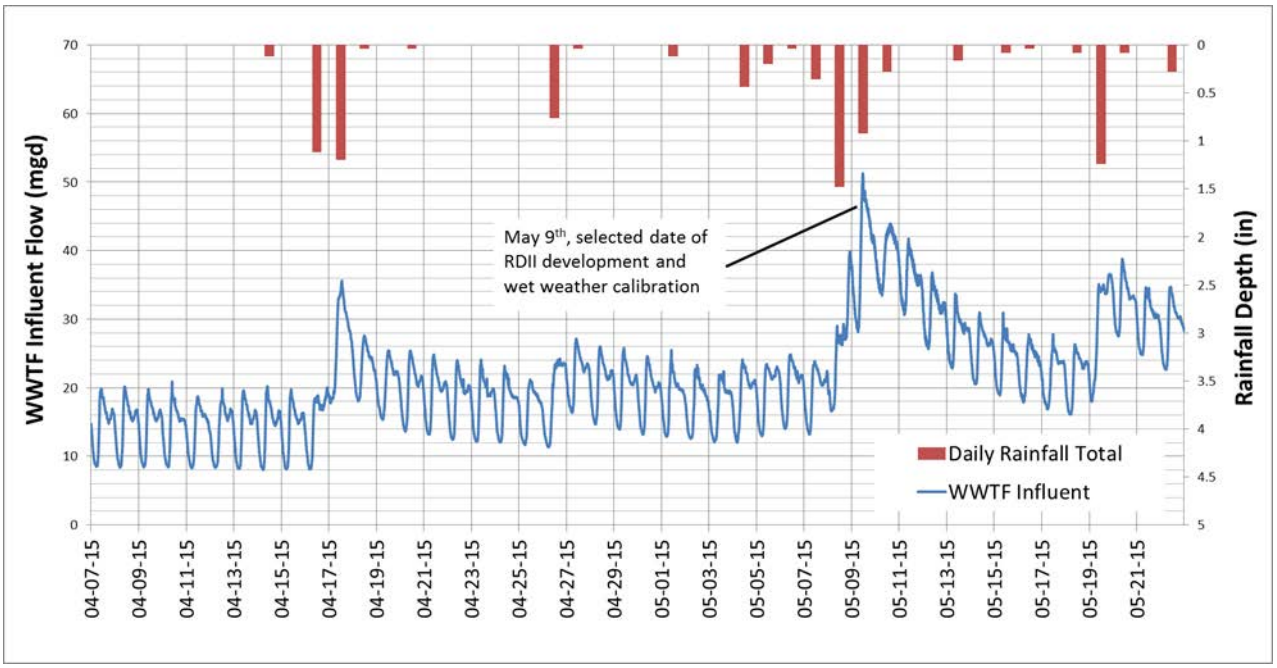
wide response and systemic capacity deficiencies. This modeling approach allows for evaluation of longer reaches of the collection system. Using longer time periods and use of PHWWF is therefore more applicable to long-term capital planning. Because of this, steady state PHWWF modeling was used to represent the average flow over the peak hour and associated response in the collection system to RDII.

5.1.1 RDII Allowances

Estimates for total RDII flow response across the system during a wet weather event were made based on a steady-state load allocation at the model manholes. As with the development of BI and ADWF estimates, the permanent flow monitors installed in April 2015 and the WWTF influent flow monitor data were used to develop the RDII allowances.

The RDII flow response is based on the sanitary sewer system's response to the wet weather event that occurred on May 9, 2015. The May 9, 2015 event caused a measured 15-minute average peak flow of 51.24 mgd at the WWTF and had a PHWWF of 50.63 mgd. The WWTF started experiencing increasing levels of RDII on April 16, 2015, 23 days before the May 9th event. It rained during 12 of the 23 days leading up to this flow event, with substantial rainfall events on April 16th (1.12 inches), 17th (1.2 inches), and 26th (0.76 inch); and May 4th (0.44 inch), 5th (0.2 inch), 7th (0.36 inch), 8th (1.48 inches), and 9th (0.92 inch). Flow at the WWTF did not return to typical ADWF conditions during this period, with the greatest flows occurring on April 16 and 17 and on May 8 and 9. The corresponding rainfall over these 23 days was measured at 6.64 inches, corresponding roughly to a 16-year rainfall recurrence interval. Radar data was used to graphically examine if the spatial extent of the rainfall events were relatively evenly distributed across the city. By modeling a storm event that covered most the city in an even fashion, a better representation of system-wide wet-weather response is provided for capacity planning purposes. Figure 5-1 provides the WWTF influent flows for the days surrounding May 9th along with the total daily rainfall depths.

Figure 5-1. WWTF Influent Flow and Daily Precipitation Depth Time Period Surrounding the May 9, 2015 Date used for RDII Development



Wet weather flows were allocated to the manholes based on the wet weather response and PHWWF for May 9, 2015, using the following method:

- Peak hour flows for the permanent flow monitors were calculated for the May 9, 2015 event by averaging the 15 minute interval meter data.
- The difference between the calibrated ADWF discussed in section 3 and the May 9 peak hour flow was determined for each permanent flow monitor to determine the RDII flow contribution from each flow monitoring basin. If there was a flow monitor basin upstream of another flow monitor basin, this upstream flow was removed to isolate flow contributions specific to each flow monitor basin.
- The sanitary system was experiencing SSOs during the May 9 event and created surcharge conditions at the Basin 7 flow monitor and overflows at the manhole immediately downstream of the meter. This resulted in unreliable measurements during the surcharge and overflow period for this meter. The interceptor leading to WWTF was also experiencing SSOs, meaning that WWTF influent flows would have been greater than what was measured. Estimated peak hour flow rates for both Basin 7 and at the WWTF were provided by the city to account for these surcharges and SSOs. The city determined these flow rates based on a flow balance from the remaining meters and trending of flow rates for the period before and after the overflow events.
- Each sewer pipe was multiplied by its corresponding diameter (inch) and length (feet) and assigned to its upstream manhole.
- The total pipe diameter (inch)-length (feet) was summed in each flow monitor basin.
- The resulting May 9, 2015 RDII was allocated to the pipes based on their individual diameter (inch)-length (feet) in proportion to the total diameter (inch)-length (feet) in each flow monitor basin.
- RDII was summed to each of the model manholes based on the RDII fraction assigned to their downstream pipes and assigned as RDII to that manhole (Load 4 column).
- For pipes and manholes not within a flow monitor basin, the remaining RDII was calculated and compared against the WWTF PHWWF minus the PHWWF of the upstream flow monitors. The remaining RDII was then allocated to these manholes based on the diameter (inch)-length (feet) of their downstream pipes.
- The model was then executed using the above RDII loadings for wet weather modeling.

The RDII allocation process described above created an evenly distributed wet-weather system response across the city for capacity planning purposes.

5.1.2 Wet Weather Calibration

Wet weather-calibration is completed to validate the RDII allowances for each flow monitoring basin. The purpose of the wet weather calibration for this project is to validate the rainfall vs. RDII relationship established in section 4 and correlate the modeled PHWWF to the observed PHWWF at both the flow monitors serving the flow monitoring basins and at the WWTF influent flow monitor.

As with the development of the wet weather RDII allocation, the May 9, 2015 event was used for the wet weather calibration. The goal of the calibration was to have a slight positive percent error and for modeled flows to be within +5% of the measured PHWWF. The wet weather events for this project

were run with a steady state analysis in InfoSewer. Table 5-1 provides the resulting adjusted RDII contribution for wet-weather conditions. Table 5-2 provides the modeled PHWWF alongside the monitored PHWWF as well as the percent error.

Table 5-1. Wet Weather Calibration Steady-State Results Based on Flow Data for May 9, 2015

Permanent Flow Monitor Basin	Alternate Permanent Flow Monitor Basin Name	Calibrated ADWF (gpm)	Calibrated RDII (gpm)	Calibrated RDII (% of total flow)
South Boulder	Basin 1	1,106	5,850	84%
East Baseline	Basin 2	593	2,358	80%
The Hill	Basin 3	658	2,372	78%
Bear Creek	Basin 4	1,454	3,577	71%
Upper Goose Creek - North	Basin 5	905	1,945	68%
Upper Goose Creek - South	Basin 6	1,644	4,664	74%
Lower Goose Creek	Basin 7	861	313	27%
Fourmile Creek	Basin 8	1,146	2,193	66%
Gunbarrel	Basin 9	1,286	3,111	71%
N/A	WWTF Influent Meter	699	914	57%
TOTAL		**10,351**	**27,297**	**73%**

Table 5-2. Wet Weather Calibration Results for the May 9, 2015 Event

Permanent Flow Monitor Basin	Alternate Permanent Flow Monitor Basin Name	Monitored PHWWF (gpm)	Modeled PHWWF (gpm)[1]	Percent Error Peak Hour Flow
South Boulder	Basin 1	6,530	6,554	0.4%
East Baseline	Basin 2	2,839	2,844	0.2%
The Hill	Basin 3	2,983	2,999	0.5%
Bear Creek	Basin 4	8,203	8,460	3.1%
Upper Goose Creek - North	Basin 5	2,794	2,827	1.2%
Upper Goose Creek - South	Basin 6	6,262	6,311	0.8%
Lower Goose Creek	Basin 7	10,000[2]	10,311	3.1%
Fourmile Creek	Basin 8	3,339	3,342	0.1%
Gunbarrel	Basin 9	4,249	4,365	2.7%
N/A	WWTF Influent Meter	37,000[3]	37,645	1.7%

[1] These flows are not additive. Basin 3 is upstream of Basin 4 and Basins 5 and 6 are upstream of Basin 7. All basins are upstream of the WWTF influent flow monitor.

[2] Flow monitor was surcharging at the time of calibration and a SSO was occurring in nearby manholes. The city provided this peak flow estimate obtained from projecting the pre and post surcharge hydrograph slopes to a point of convergence.

[3] Flow was lost via SSOs before reaching the WWTF influent monitor. The city provided this peak flow estimate based WWTF monitor data and on flow from permanent flow monitors 1, 2, 4, 9, and a corrected monitor 7 as well as 5,218 gpm of flow from the unmetered areas (with the assumption that this 5,218 gpm flow remains constant during the surcharge period)

The rainfall event used for wet weather calibration for the current modeling effort was 6.64 inches of rain in 23 days and is roughly equivalent to a 16-year rainfall recurrence interval based on NOAA Atlas 14. Based on flows at the WWTF influent monitor, the calculated RDII for this event is 39.3 mgd (27,297 gpm), which was calculated by subtracting the ADWF of 14.9 mgd from the modeled peak flow of 54.2 mgd (37,645 gpm, Table 5-2). Using Equation 1 from section 4, which relates RDII flow rates to rainfall recurrence intervals, the 39.3 mgd RDII was estimated to have been caused by a 17-year storm (16.7 calculated). This correlation between actual recurrence interval and the calculated interval validates the rainfall vs. RDII relationship established by Equation 1.

5.1.3 50 mgd and 60 mgd Capacity Assessment Scenarios

With the modeled ADWF of 14.9 mgd and the WWTF influent hydraulic limitation of approximately 50 mgd, the resulting maximum system wide RDII the influent processes at the WWTF can handle is 35.1 mgd. This 50 mgd existing conditions PHWWF scenario is comparable to the existing collection system conveying flows associated with approximately a 15-year (14.4-year calculated) storm event when this 35.1 mgd of RDII is applied to Equation 1. For the purposes of this 2016 WWCSMP, the 50 mgd model scenario is also referred to by its 15-year level of service. This 15-year level of

service model was executed by scaling down the calibrated wet weather flow of 54.2 mgd (based on the May 9, 2015 event) to reach 50 mgd at the WWTF.

When a 60 mgd WWTF hydraulic limitation is considered (based on post-primary treatment process limitations), the RDII increases to 45.1 mgd (60 mgd minus 14.9 mgd). The resulting existing condition PHWWF conveyed by the collection system were calculated to be the result of a 20-year (19.9 calculated) design storm wet weather event using Equation 1. For the purposes of this document the 60 mgd model scenario is also referred to by its 20-year level of service. The 20-year level of service scenario was developed and executed by scaling up the calibrated wet weather flow of 54.2 mgd to reach 60 mgd at the WWTF.

5.1.4 25-year Rainfall Event Capacity Assessment Scenario

Using Equation 1, the RDII for a 25-year event was estimated to be 54.4 mgd. Adding this RDII to the ADWF results in an existing condition PHWWF of 69.3 mgd. The 25-year model was developed and executed by scaling up the calibrated wet weather flow of 54.2 mgd to reach 69.3 mgd at the WWTF.

5.1.5 Buildout Conditions Modeling

Buildout conditions modeling is performed by allocating an additional future BSF load to the model as described in section 3. BI and RDII are kept consistent with the existing conditions model scenarios, meaning that future flow increases are based solely on BSF increases and the potential reduction in RDII due to current and planned sewer rehabilitation efforts is not included at this time. This was done since the potential reduction has been shown to vary greatly between utilities and it is therefore difficult to quantify the reductions. Any reductions which are realized will therefore serve to further increase the level of service of the collections system beyond what this modeling effort and master plan are planning for. The buildout condition flow increases at the WWTF are summarized in Table 5-3.

Table 5-3. PHWWF at the WWTF Influent for Existing and Buildout Condition Scenario Modeling

Model Condition	ADWF (mgd)	PHWWF 15-Year Level of Service (mgd)	PHWWF 20-Year Level of Service (mgd)	PHWWF 25-Year Level of Service (mgd)
Calibrated and Refined Existing Conditions	14.9	50.0	60.0	69.3
Buildout Conditions	18.1	53.2	63.2	72.5

5.1.6 Comparison to 2009 Wastewater Collection System Master Plan

This section compares the updated wet weather model results to those presented in the 2009 WWCSMP. Both the model results and corresponding level of service are compared.

5.1.6.1 Wet Weather Model Comparison to 2009 Master Plan

The 2009 WWCSMP included a 50 mgd WWTF capacity limiting scenario as the basis for wet weather modeling. Hence, to compare current results to the 2009 WWCSMP, the existing conditions PHWWF from the 15-year level of service scenario is used. Table 5-4 summarizes the results of this comparison. The existing and future ADWFs at the WWTF have decreased by about 5.8 mgd and

7.7 mgd, respectively, since the 2009 WWCSMP. Some of the reasons for this difference in ADWF can be attributed to slower than predicted population and employment growth, water conservation (including installation of water efficient fixtures), better monitoring data with the newly installed permanent flow meters, and more refined flow monitoring data at the WWTF. The existing PHWWF is the same due to the 50 mgd at the WWTF influent being held constant and the buildout PHWWF has decreased by about 2.1 mgd since the 2009 WWCSMP due to the reduction in ADWF and a refined future BSF projection based on the 2011 Water Utility Master Plan (2011 updated buildout base sanitary flow projections from the WUMP).

Table 5-4. Model Flow comparisons at the WWTF between the 2009 WWCSMP and the 2016 WWCSMP

Model	Existing ADWF(mgd)	Existing PHWWF (mgd)[1]	Buildout ADWF(mgd)	Buildout PHWWF (mgd)[1]
2009 WWCSMP	20.7	50.0	25.8	55.3
2016 WWCSMP	14.9	50.0	18.1	53.2

[1] For the 50 mgd at the WWTF/15-year level of service scenario

5.1.6.1 Level of Service

The 2009 WWCSMP estimated that the 50 mgd scenario was equivalent to a 12-year level of service. For the current 50 mgd scenario, this level of service is estimated at a 15-year level of service due to the decreased ADWF as well as the updated rainfall recurrence interval/RDII relationship (Equation 1) that is based on more current flow and rainfall data.

5.2 Spatial Distribution of Planning Projections

This section compares the model results for ADWF and 25-year PHWWF for existing and 2035 buildout conditions within each flow monitor basin.

5.2.1 Dry Weather

Table 5-5 and Table 5-6 summarize BSF and BI for existing and buildout conditions within each flow monitor basin. The existing and buildout BI values in Table 5-6 are the same and assumed to be consistent between all model scenarios. Figure 5-2 provides the existing conditions ADWF contributions for each flow monitor basin. Similarly, Figure 5-3 provides the buildout conditions ADWF contributions for each flow monitor basin. A comparison of these two figures illustrates that the greatest increases in the WUMP winter water use and therefore the sanitary loadings occur in Basins 6 (44 percent increase), 3 (28 percent increase), and 5 (21 percent increase) which are located in the Goose Creek and Boulder Creek sewer basins. These locations correspond to the Central Boulder, Colorado University and Cross-Roads sub-communities of Boulder and are projected to have the greatest future demands within the WUMP water distribution model. These increases in future water demand as reflected in the WUMP water distribution model are mapped on a sub-community basis in Figure 5-4 with flows presented as gpm increase per square mile.

Table 5-7 provides the corresponding model results for total BSF, BI and ADWF using the flows provided in Table 5-5 and Table 5-6. The ADWF increases 3.2 mgd from existing to buildout conditions.

Table 5-5. Existing and Buildout Sanitary Loads

Permanent Flow Monitor Basin	Alternate Permanent Flow Monitor Basin Name	Existing (2015) Sanitary Loads (gpm)	Additional Buildout (2035) Sanitary Loads (gpm)	Total Buildout (2035) Sanitary Loads (gpm)
South Boulder	Basin 1	455	98	553
East Baseline	Basin 2	256	87	343
The Hill	Basin 3	602	182	784
Bear Creek	Basin 4	1,106	267	1,373
Upper Goose Creek - North	Basin 5	439	193	632
Upper Goose Creek - South	Basin 6	1,463	728	2,191
Lower Goose Creek	Basin 7	411	164	576
Fourmile Creek	Basin 8	461	205	666
Gunbarrel	Basin 9	642	189	831
N/A	WWTF Influent Meter	323	95	418
TOTAL		**6,158**	**2,209**	**8,367**

Table 5-6. Existing and Buildout Base Infiltration Loads at the Flow Allocation Basins

Permanent Flow Monitor Basin	Alternate Permanent Flow Monitor Basin Name	2015 Summer BI (gpm)	2035 Summer BI (gpm)
South Boulder	Basin 1	652	652
East Baseline	Basin 2	337	337
The Hill	Basin 3	56	56
Bear Creek	Basin 4	348	348
Upper Goose Creek - North	Basin 5	466	466
Upper Goose Creek - South	Basin 6	181	181
Lower Goose Creek	Basin 7	449	449
Fourmile Creek	Basin 8	684	684
Gunbarrel	Basin 9	644	644
N/A	WWTF Influent Meter	376	376
TOTAL		**4,194**	**4,194**

Figure 5-2. Existing Conditions ADWF Contributions for Each Flow Monitor Basin

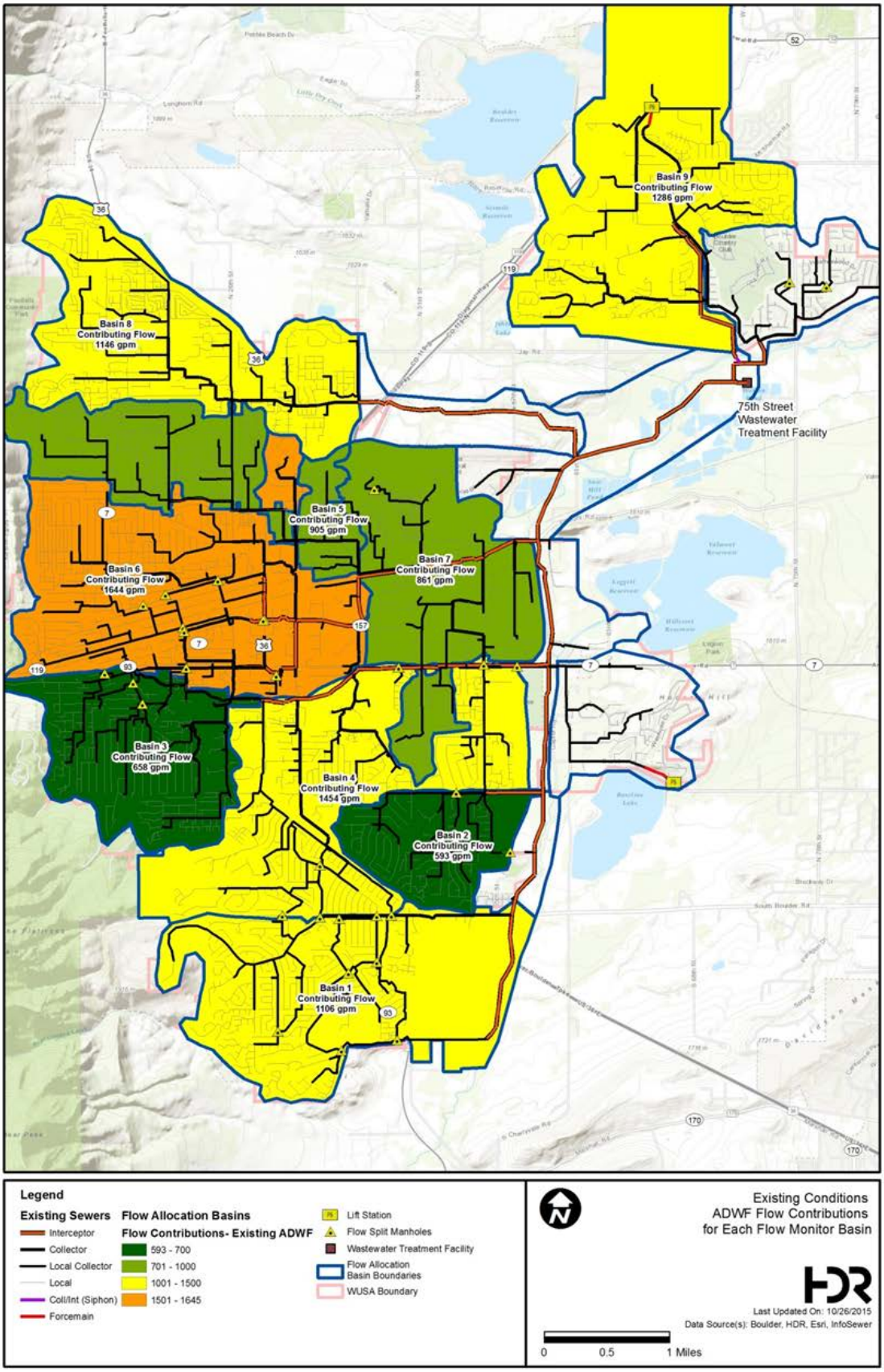


Figure 5-3. Buildout (2035) Conditions ADWF Contributions for Each Flow Monitor Basin

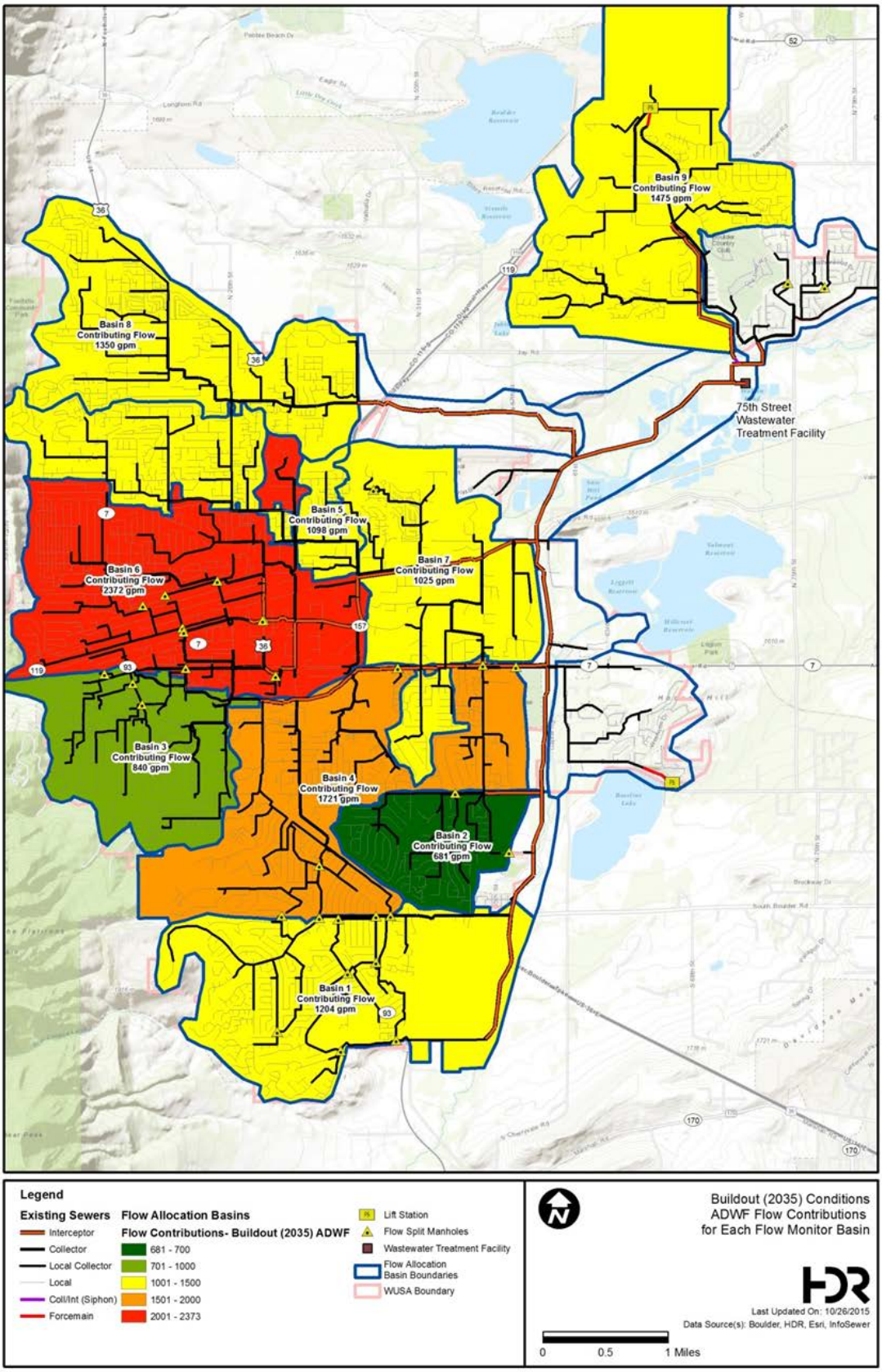


Figure 5-4. Buildout (2035) Winter Water Demand Increases in Each City of Boulder Sub-Community (Increase in GPM per Square Mile)

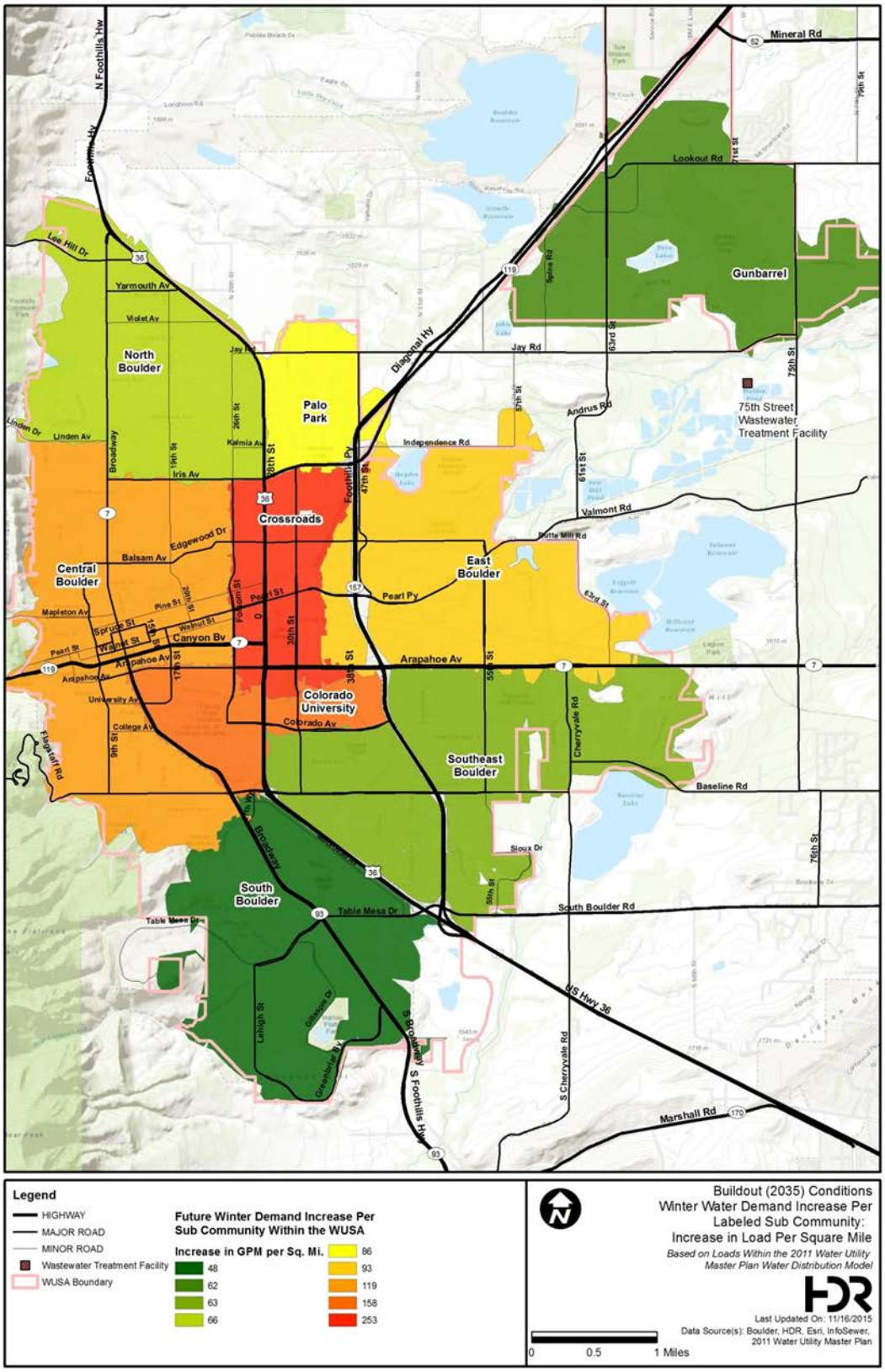


Table 5-7. Existing and Buildout Dry Weather Flows

Model Flow Scenario	Existing (2015) Flow (mgd)	Buildout (2035)
Base Sanitary Flow (BSF)	8.9	12.1
Base Infiltration (BI)	6.0	6.0
Annual Average Dry Weather Flow (ADWF)	14.9	18.1

5.2.2 Wet Weather

Figure 5-5 provides the existing conditions 25-year PHWWF contributions for each flow monitor basin. Similarly, Figure 5-6 provides the buildout conditions 25-year wet weather flow contributions for each flow monitor basin. Since the RDII values remain the same between the two, the general patterns of PHWWF are consistent between existing and buildout conditions.

Table 5-8 summarizes the RDII and PHWWF for existing and buildout conditions.

Table 5-8. Existing and Buildout Wet-Weather Flows

Model Flow Scenario	Existing (2015) RDII (mgd)	Existing (2015) Total Wet Weather Flow (mgd)	Buildout (2035) RDII (mgd)	Buildout (2035) Total Wet Weather Flow (mgd)
Annual Average Dry Weather Flow (ADWF)	-	14.9	-	18.1
15-Year Level of Service	35.1	50.0	35.1	53.1
20-Year Level of Service	45.1	60.0	45.1	63.2
25-Year Level of Service	54.4	69.3	54.4	72.5

Figure 5-5. Existing Conditions 25-Year PHWWF Contributions for Each Flow Allocation Basin

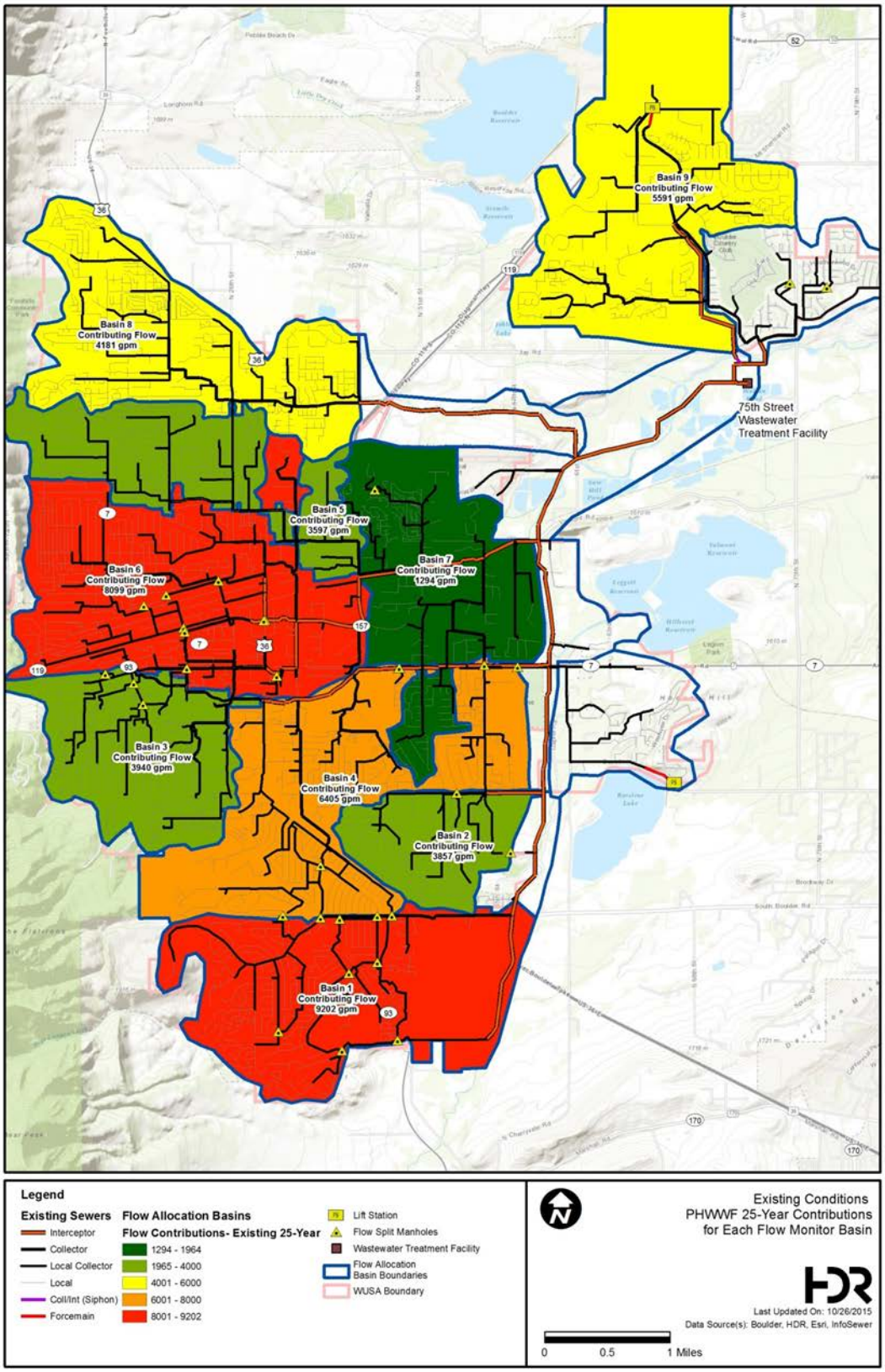
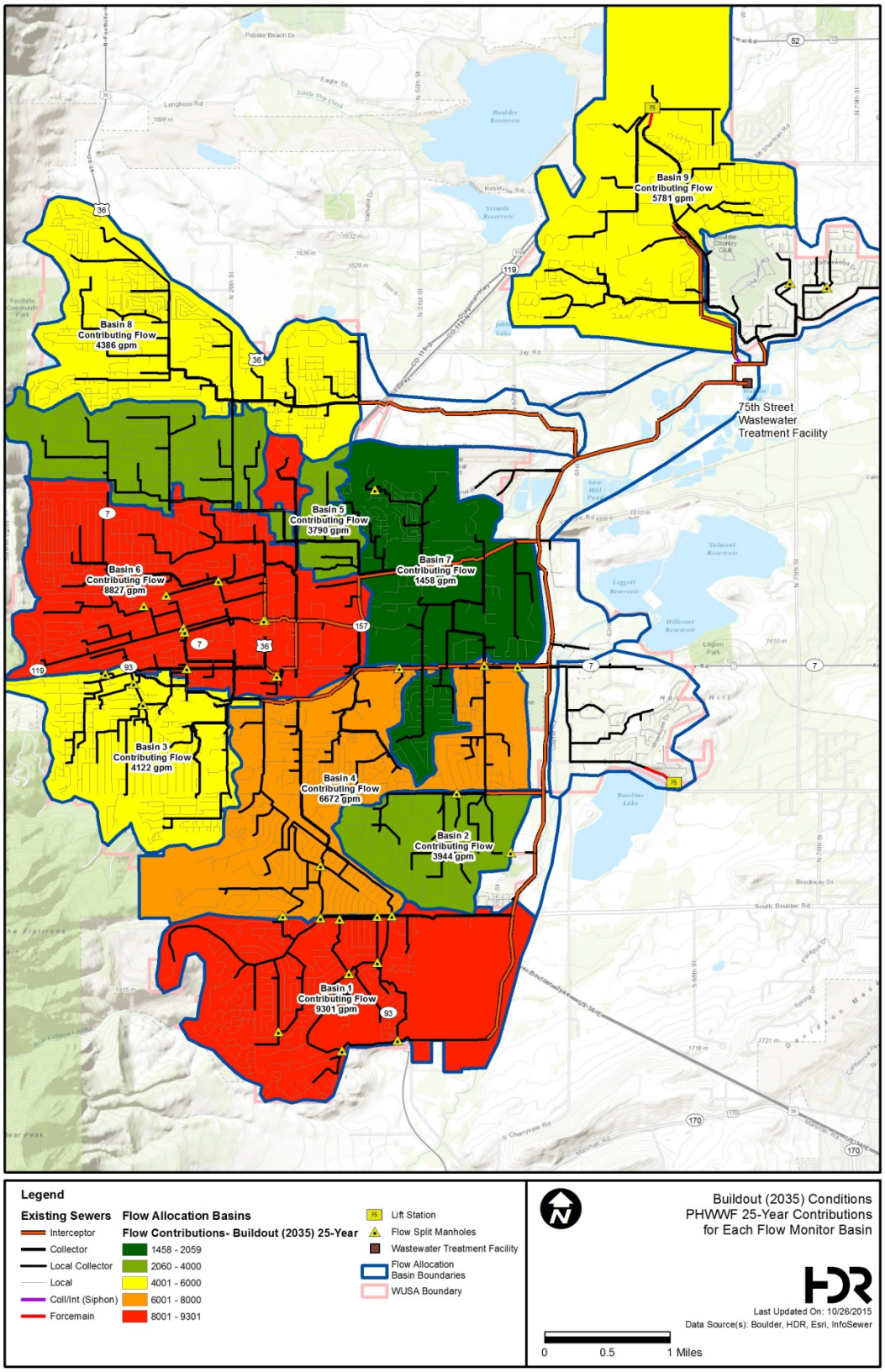


Figure 5-6. Buildout (2035) Conditions 25-Year PHWWF Contributions for Each Flow Allocation Basin



5.3 Summary

Since the 2009 WWCSMP, there is several more years' worth of available data to assess wet weather flows and update the hydraulic model. Two key new data sets used in this analysis include data from the city's new permanent flow monitoring program and more detailed data related to flow split manholes. As a result, several changes were made to the modeling approach to incorporate this data and provide more confidence in the model results and subsequent capacity analysis.

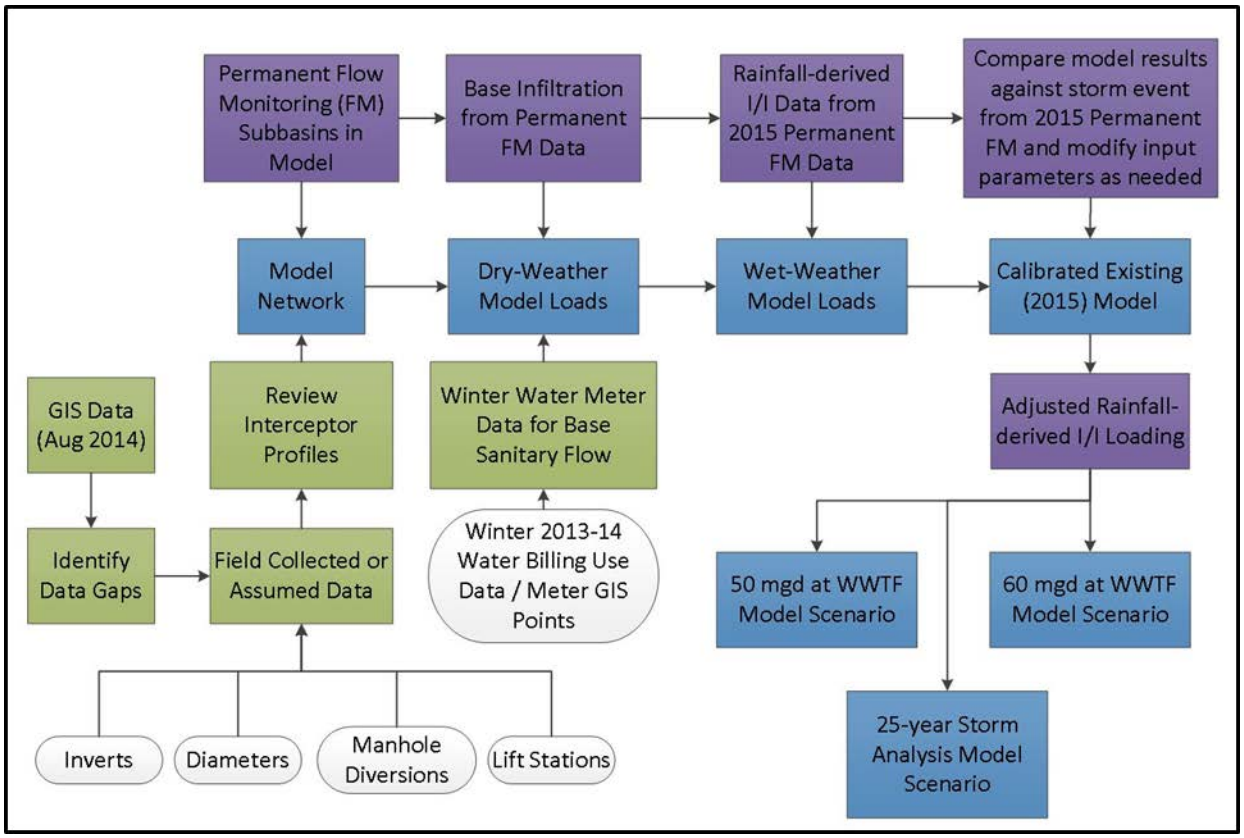
5.3.1 Modeling Approach

The following list summarizes the modeling approach used for this effort:

- The model network was updated using recent collection system GIS data and additional information on flow split manholes.
- Sewersheds were altered based on the flow monitoring basins in the 2014 Flow Monitoring Program. Model nodes and pipes were assigned a corresponding flow monitoring basin from the permanent flow monitors.
- BSF was generated both from water meter and SIU data. BSF was calculated from monthly water meter data from December, 2013 through February, 2014 and allocated to the model nodes using Thiessen polygons aligned to the sewersheds and flow monitoring basins.
- BI rates were calculated for each flow monitor basin based on the dry day of August 26, 2015. BI was calculated by subtracting the BSF estimated from the water meter data from the average day flow for the corresponding permanent flow monitors. BI was then assigned to the manholes based on the diameter and length of the downstream pipe.
- ADWF was calibrated in a steady state analysis based on the August 26, 2015 average daily flow to the 2015 permanent flow monitors and the WWTF influent monitor.
- Wet weather flows were generated for each flow monitor basin from the 2015 permanent flow monitors and WWTF influent monitor based on the May 9, 2015 rainfall event. RDII was calculated by subtracting the calibrated ADWF from the measured PHWWF for the permanent flow monitors. RDII was assigned to the manholes based on their corresponding flow monitoring basin and on the diameter and length of the downstream pipe.
- The PHWWFs were calibrated in a steady state analysis to the May 9, 2015 event to reflect the peak flows in the steady-state analysis to the 2015 permanent flow monitors and the WWTF influent monitor.
- The rainfall data/WWTF influent flows since the previous master plan were incorporated into the RDII equations to determine a new RDII/rainfall reoccurrence interval relationship (Equation 1). The calibrated flows were determined to correspond to a rainfall recurrence interval of 17-years based on this equation, which correlates well to the actual 16-year rainfall recurrence interval determined strictly from the precipitation data using NOAA Atlas 14.
- The 15-year, 20-year, and 25-year level of service scenarios were then developed based on Equation 1 and the calibrated wet weather model.

The existing conditions model update and calibration approach used during this project can be summarized by the schematic presented as Figure 5-7.

Figure 5-7. Existing Conditions (2015) Modeling Approach Schematic

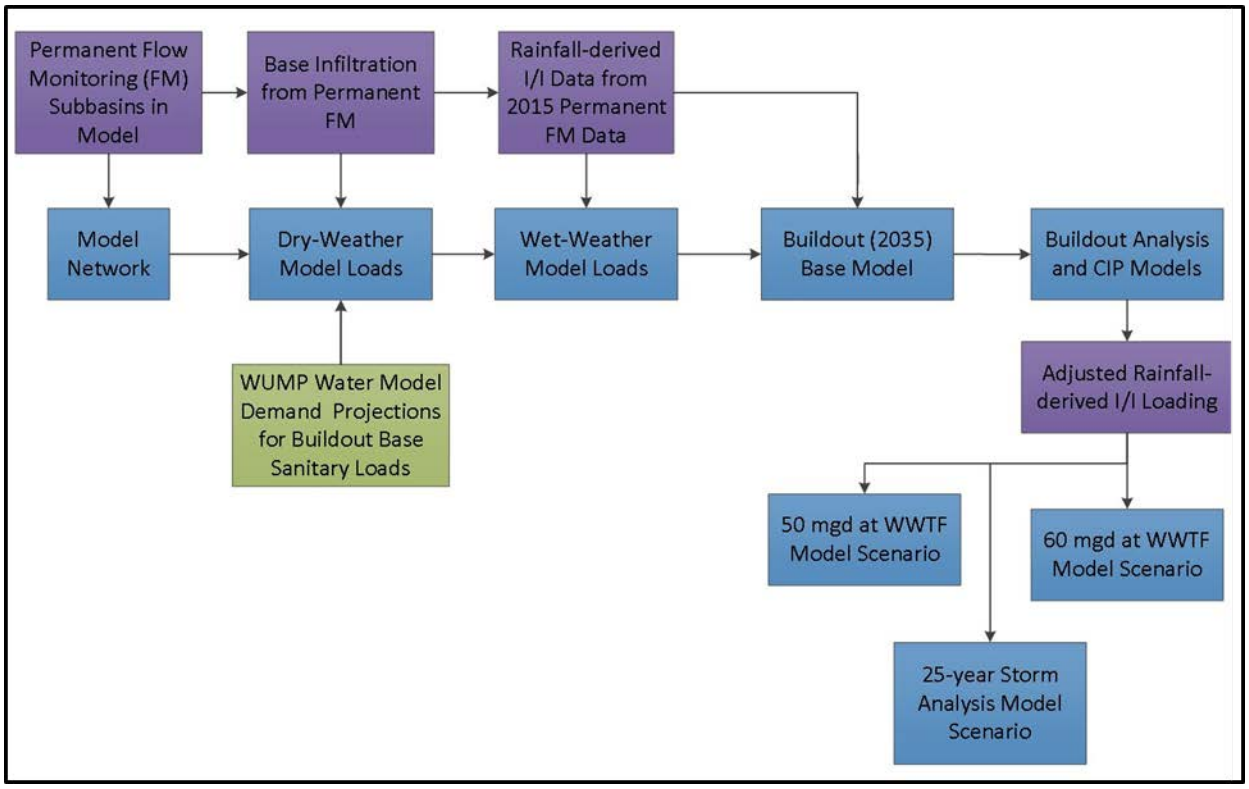


Future buildout (2035) flows were also estimated with a different approach since the previous master plan. The following list summarizes the 2035 conditions modeling approach used for this effort:

- 2035 BSF was developed based on the 2011 WUMP water use projections from the associated water distribution model and modified to reflect winter water use. The resulting BSF was applied to the sanitary sewer model manholes by using the 2011 WUMP water model Thiessen polygons in conjunction with the sewer Thiessen polygons developed in this effort.
- The same BI and RDII flow from the existing conditions modeling was applied to the future conditions modeling for the buildout 50 mgd, 60 mgd, and 25-year event model scenarios.

The buildout (2035) conditions model update and calibration approach used during this project can be summarized by the schematic presented as Figure 5-8.

Figure 5-8. Future Buildout (2035) Conditions Modeling Approach Schematic



5.3.2 Existing Flow Summary

Table 5-9 summarizes the existing (2015) condition model results for collection system capacity analysis.

Table 5-9. Modeled (Steady-State) Flows for Existing (2015) Conditions

Existing Model Flow Scenario	Flow (gpm)	Flow (mgd)	Peaking Factor[1]	Level of Service
Base Sanitary Flow (BSF)	6,158	8.9	-	-
Base Infiltration (BI)	4,193	6.0	-	-
Average Dry-Weather Sanitary Flow (ADWF)	10,352	14.9	-	-
15-Year Level of Service Peak Hour Wet Weather Flow (PHWWF)	34,725	50.0	3.4	15-year
20-Year Level of Service PHWWF	41,685	60.0	4.0	20-year
25-Year Level of Service PHWWF	48,126	69.3	4.6	25-year

[1] Peaking factor calculated based on ADWF

For comparison, recent influent flow data for the city's 75th Street WWTF was analyzed to determine maximum influent flows over the last five years. According to the data, the maximum average daily influent to the WWTF occurred on September 13, 2013 at 51.7 mgd during the 2013 flood event; however, the peak flows within the collection system were much higher than what could be recorded at the WWTF influent meter. To model what the flows in the collection system may have been for such high-flow events, the 20- and 25-year level of service PHWWF scenarios push the entire interceptor system to convey higher flows that can be analyzed during planning efforts.

5.3.3 Buildout Flow Projections

Table 5-10 summarizes the buildout (2035) condition model results for collection system capacity analysis.

Table 5-10. Modeled (Steady-State) Flows for Buildout (2035) Conditions

Buildout Model Flow Scenario	Flow (gpm)	Flow (mgd)	Peaking Factor[1]
Additional Buildout BSF	2,209	3.2	-
Total BSF	8,367	12.1	-
Base Infiltration (BI)	4,193	9.8	-
Average Dry-Weather Sanitary Flow (ADWF)	12,560	18.1	-
15-Year Level of Service PHWWF Scenario (50 mgd at the WWTF)	36,933	53.2	2.9
20-Year Level of Service PHWWF Scenario (60 mgd at the WWTF)	43,897	63.2	3.5
25-Year Level of Service PHWWF Scenario	50,335	72.5	4.0

[1] Peaking factor calculated based on ADWF

5.3.4 Summary

The wet-weather model update, calibration, verification, and refinement described in this section yield a hydraulic model that fulfills the requirement of the 2016 WWCSMP and provides a higher degree of confidence for capacity evaluation of they city's collectors and interceptors than the 2009 WWCSMP. This model can therefore be used for system capacity analysis and sanitary sewer capital improvement planning purposes.

6 Collection System Capacity Analysis and Capacity Limitations Identification

This section documents the collection system capacity analysis in association with the City of Boulder (city) 2016 WWCSMP. The analysis is developed from the updated planning level model described section 5. The basis of this analysis are the buildout conditions flow projections for BSF, the calibrated BI allowances, and the RDII allowances associated with the 15-, 20-, and 25-year levels of service.

6.1 Collection System Capacity Analysis

The purposes of the conveyance system analysis are to:

1. Document the analysis of the existing collection system with existing wet weather flows compared to the 2013 flood survey results.
2. Document the analysis of the existing collection system with buildout wet weather flows with RDII associated with the 15-, 20-, and 25-year levels of service.
3. Identify and characterize hydraulic capacity issues based on buildout wet weather flows with RDII associated with the 15-, 20-, and 25-year levels of service.

Capacity-limited areas were identified by analyzing the existing collection system under buildout flow conditions against the established system analysis criteria. Characterizing the capacity- limited areas assists in developing and prioritizing improvement alternatives and recommendations. For the capacity analysis, there are three model scenarios, all of which are under buildout conditions, which will be used to evaluate the capacity of the system.

1. Buildout conditions wet-weather with RDII associated with the 15-year level of service
2. Buildout conditions wet-weather with RDII associated with the 20-year level of service.
3. Buildout conditions wet-weather with RDII associated with the 25-year level of service.

6.1.1 System Analysis Criteria

The calibrated collection system model was used for the hydraulic analysis to locate capacity- limited areas during wet weather scenarios under existing and buildout conditions. The modeling approach for the WUSA uses data from all the pipes and manholes that exist in the city's collection system to develop an "all pipes" model. The benefits of an all-pipes model include increased accuracy in allocating wastewater flows to the sewer system, improved flow routing and attenuation from upper reaches of system, and simplifying the task of adding to and updating the model in the future from GIS.

Although the entire system is modeled, some of the system will not be analyzed as part of the 2016 WWCSMP. Due to the trend of less accurate or missing invert and diameter data for the local 8-inch pipes, this portion of the collection system will not be analyzed in the evaluation phase of the project. The missing information for these smaller, local pipes could cause inaccurate or misleading results and therefore misidentify capacity- limited areas. As redevelopment occurs within the local system, missing data can be collected and the accuracy of the local system model can be increased. The

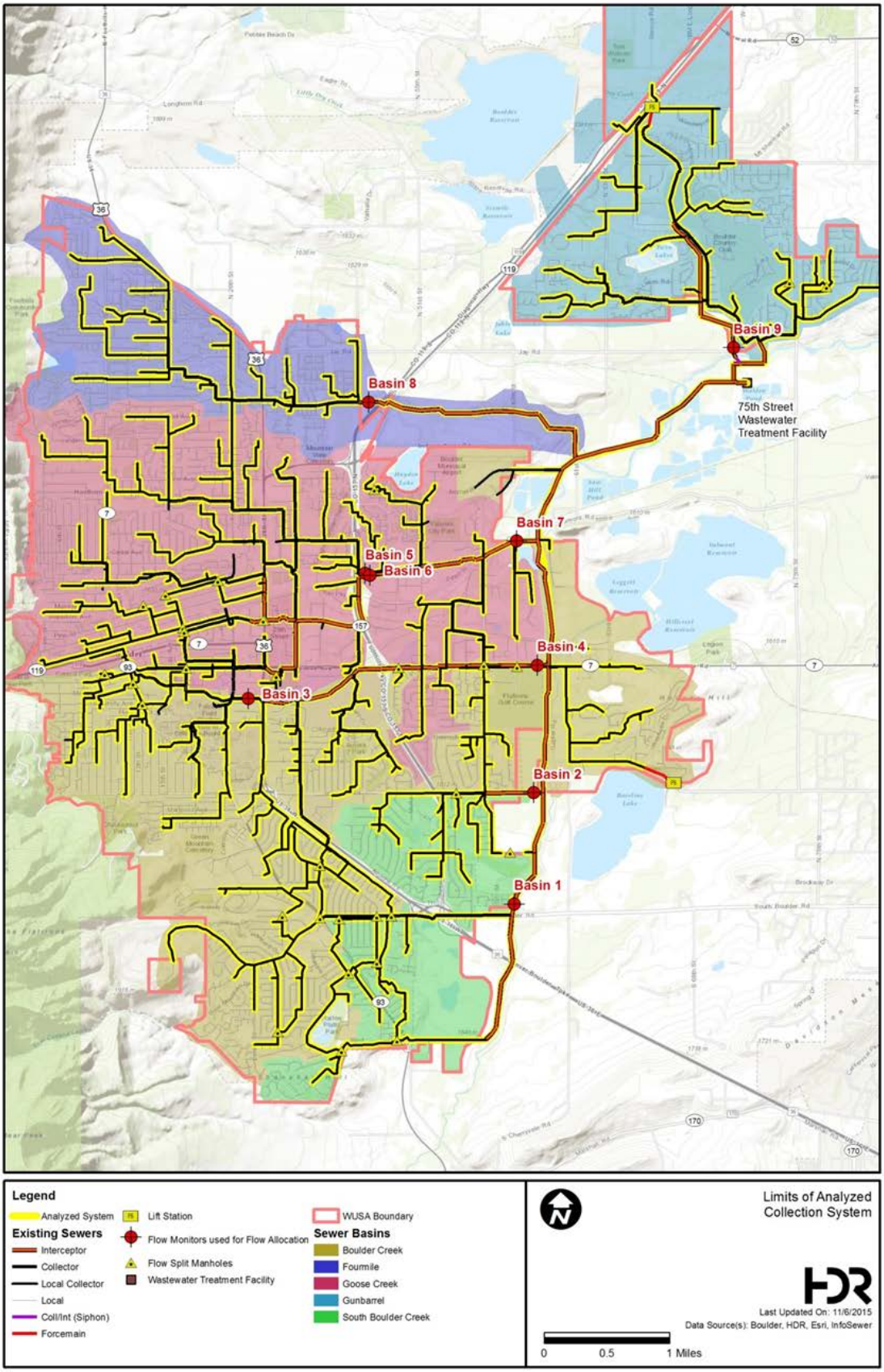
scope of this project was to analyze the local collector, collector and interceptor systems for hydraulic capacity. The limits of the analyzed system are shown on Figure 6-1.

To accomplish the analysis, project capacity criteria were developed based on discussions with city staff and the city's Design and Construction Standards (DCS). Capacity limitation identification criteria are based on the percentage of full-flow within pipes and surcharge conditions at manholes.

The criteria remain the same for existing and future buildout scenarios but differ between peak dry weather and peak wet weather flow scenarios and pipe class. The capacity limitation identification criteria is based on the pipe class (interceptor/collector, local collector/local), the modeled depth divided by the full flow depth (d/D), and sanitary sewer overflows (SSOs). The capacity limitation identification criteria established for the 2016 WWCSMP consist of the following:

1. Local Collector / Local System (8-inch – 24-inch)
    a. Sanitary sewer overflows (SSO) prohibited.
    b. Peak-hour ADWF - flow equal to a depth of one-half of the full pipe (50 percent d/D).
    c. Peak-hour wet weather - flow equal to a depth of 60 percent of the full pipe (60 percent d/D).
2. Interceptor / Collector System (> 24-inch) System
    a. Sanitary sewer overflows (SSO) prohibited.
    b. Peak-hour dry weather - flow equal to a depth of 70 percent of the full pipe (70 percent d/D).
    c. Peak-hour wet weather - flow equal to a depth of 80 percent of the full pipe (80 percent d/D).

Figure 6-1. Limits of Analyzed Collection System



The interceptor system has a greater peak-hour dry weather criterion since flow depths within the corresponding larger pipes are not as impacted by equal flow increases compared to the smaller pipes in the collector system.

Compared to local and local collector system pipes, interceptors typically have less variable flow depth versus pipe diameter (d/D) values during normal dry weather and smaller wet weather conditions. For sewer mains (not interceptors), the design criteria set forth in the DCS, Section 6 - Wastewater Design, Paragraph 6.06 (A) (2) are the same as presented above for peak-hour flow, although the DCS does not differentiate between dry and wet weather conditions.

6.1.2 Model Results

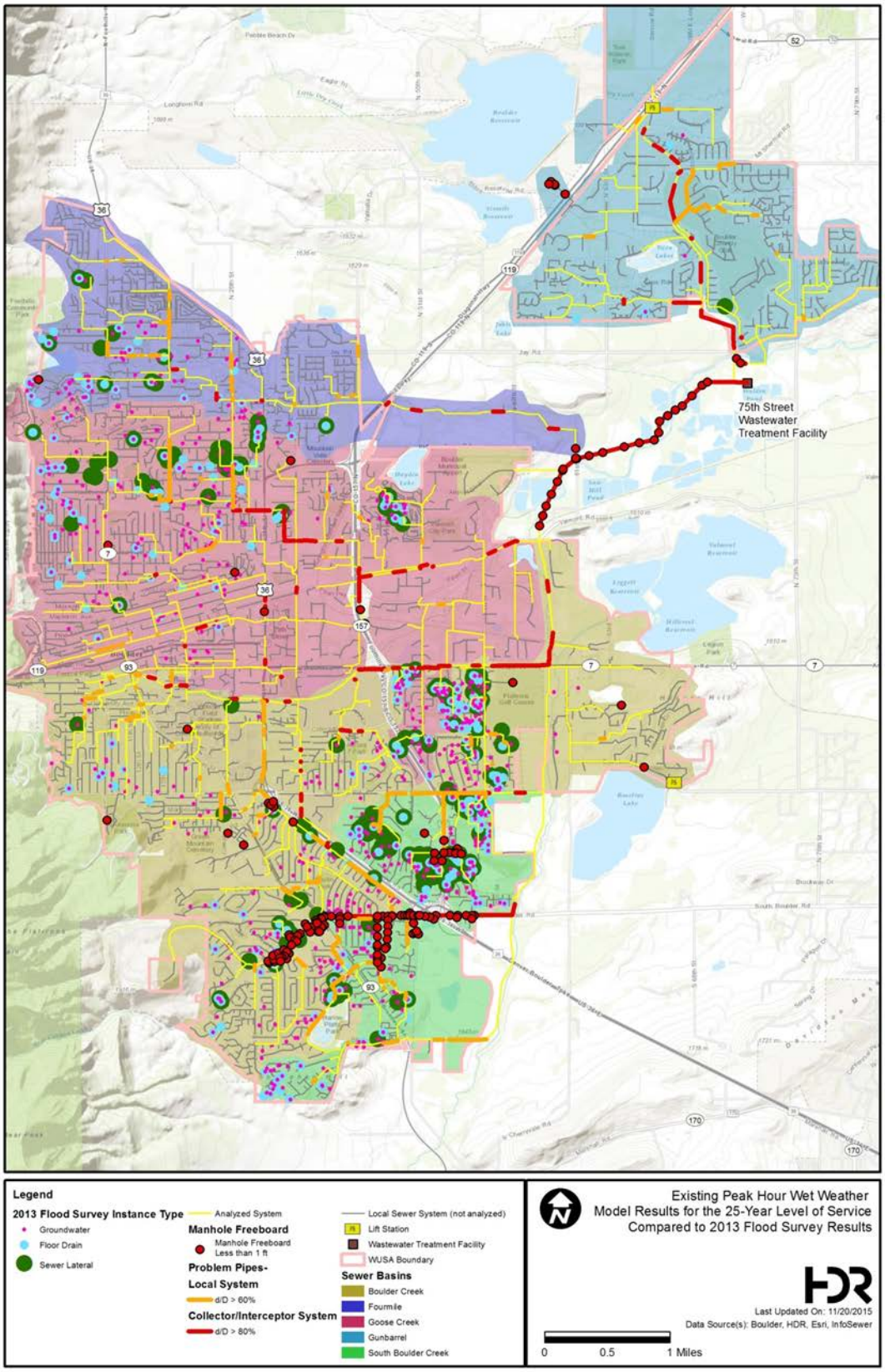
Model results were compared against the analysis criteria to locate potential hydraulic limitations within the system. The model results were recorded for PHWWF for each individual analyzed pipe to capture the worst-case loading scenario throughout the system. These model results represent the greatest stress placed on the collection pipes for each scenario. Manhole freeboard depth was taken from the model results to locate possible SSO risk.

6.1.2.1 Comparison to 2013 Flood Capacity Problems

Existing condition 25-year model results were overlaid with the 2013 flood capacity problems. This overlay is provided in Figure 6-2, which shows the locations of the reported instances of groundwater seepage, floor drain backups, and sewer lateral backups in comparison to the capacity issues indicated by the existing condition 25-year level of service model. The city's post-flood survey asked residents that reported damage to FEMA to identify whether the source of the flooding originated from surface flooding, groundwater seepage through foundations, sewer lateral backups, floor drain backups, or a combination of the above. It should be noted that although the survey distinguished between sewer lateral backups and floor drain backups, the city's building codes require floor drains to be plumbed to the sanitary sewer. This means that floor drain backups should also be considered a sewer lateral backup and the difference between these two survey responses can be interpreted as the severity of the surcharge which caused the backup. A low-level surcharge may cause a backup from floor drains but may not be severe enough to reach the level of higher plumbing fixtures such as toilets or sinks which would cause a resident to clearly identify it as a sewer backup. Residents that do not have bathrooms in their basements would only experience sanitary sewer backups through the basement floor drains.

Figure 6-2 indicates that there are similar locations where the reported flood instances appear in areas with collection system capacity issues. The data from the 2013 post-flood survey will be used to help prioritize capital improvement projects in the 2016 WWCSMP.

Figure 6-2. 25-Year Existing Peak Hour Wet Weather Results for the 25-Year Level of Service Compared to 2013 Flood Survey Results



6.1.3 Buildout Condition Model Results

A summary of peak-hour flows at the 75th Street WWTF are shown in Table 6-1 for each of the four buildout scenarios.

Table 6-1. Modeled WWTF Influent Flows for Buildout Conditions

Buildout Model Flow Scenario	Flow (gpm)	Flow (mgd)	Peaking Factor[1]
Average Dry-Weather Sanitary Flow (ADWF)	12,560	18.1	-
15-Year Level of Service PHWWF Scenario	36,933	53.2	2.9
20-Year Level of Service PHWWF Scenario	43,897	63.2	3.5
25-Year Level of Service PHWWF Scenario	50,335	72.5	4.0

[1] Peaking factor calculated based on ADWF

The model results for buildout wet weather scenarios are depicted in Figure 6-3, Figure 6-4, Figure 6-5, and Figure 6-6 for flow associated with the ADWF and the 15-, 20-, and 25-year levels of service, respectively. Potential capacity-limited pipes were based on the established criteria and manholes with freeboard of less than 1 foot have also been highlighted. Manholes with freeboard of less than 1 foot are considered at-risk for SSOs.

RDII loading for the 25-year level of service was thematically mapped for each of the permanent flow monitoring basins to illustrate the RDII contributions from different areas within the collection system (Figure 6-7). The relative distribution of RDII loading is the same for all wet weather scenarios, with only the magnitude and flow percentages increasing. Only RDII for the 25-year level of service was mapped because this model scenario represents the highest wet weather flows that were analyzed. The location of greatest SSO occurrence is in Basin 1 and corresponds to the location of greatest RDII loading.

Figure 6-3. Buildout (2035) Model Results for Average Dry Weather Flow

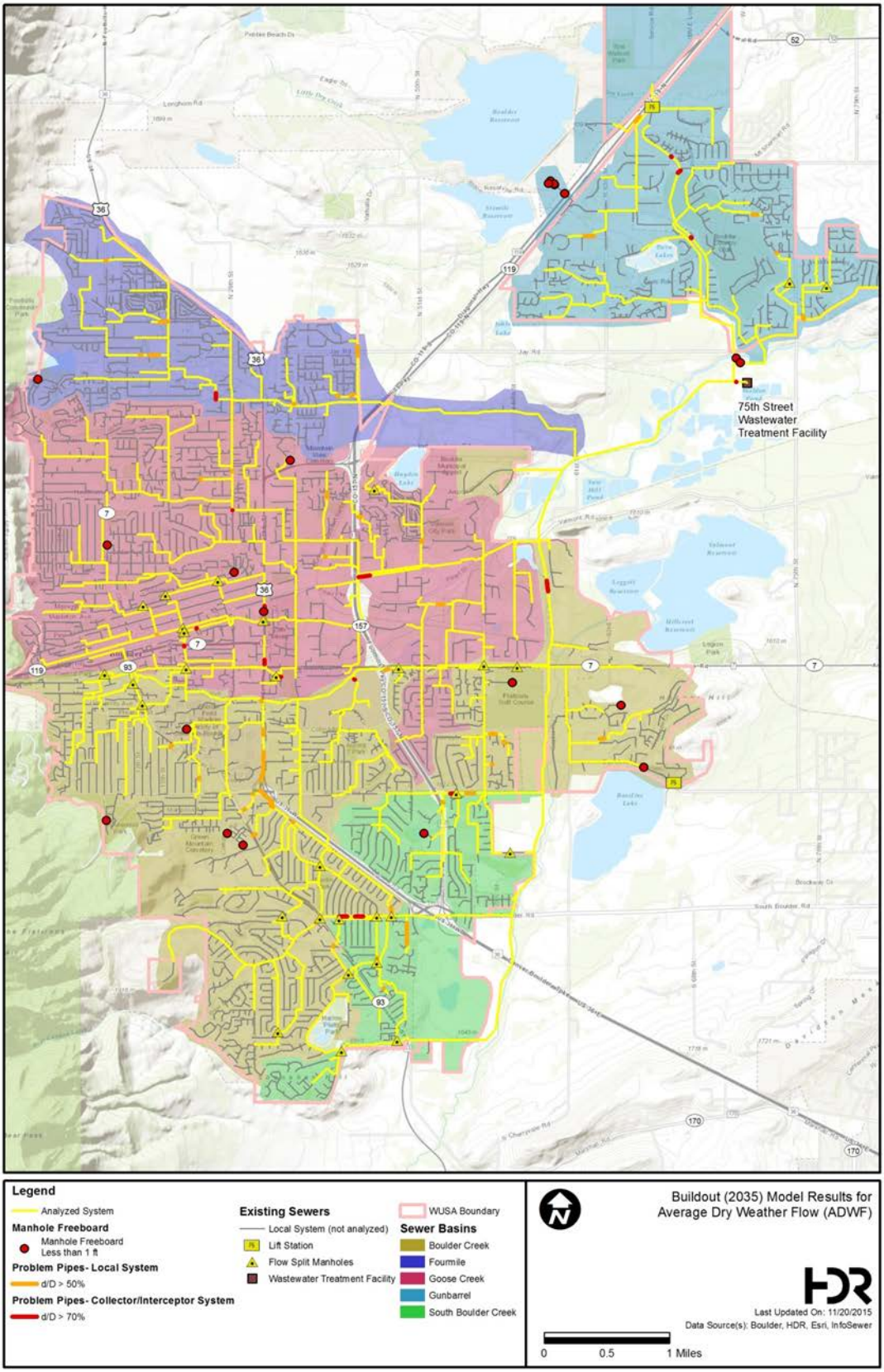


Figure 6-4. Buildout (2035) Peak Hour Wet Weather Model Results for the 15-Year Level of Service

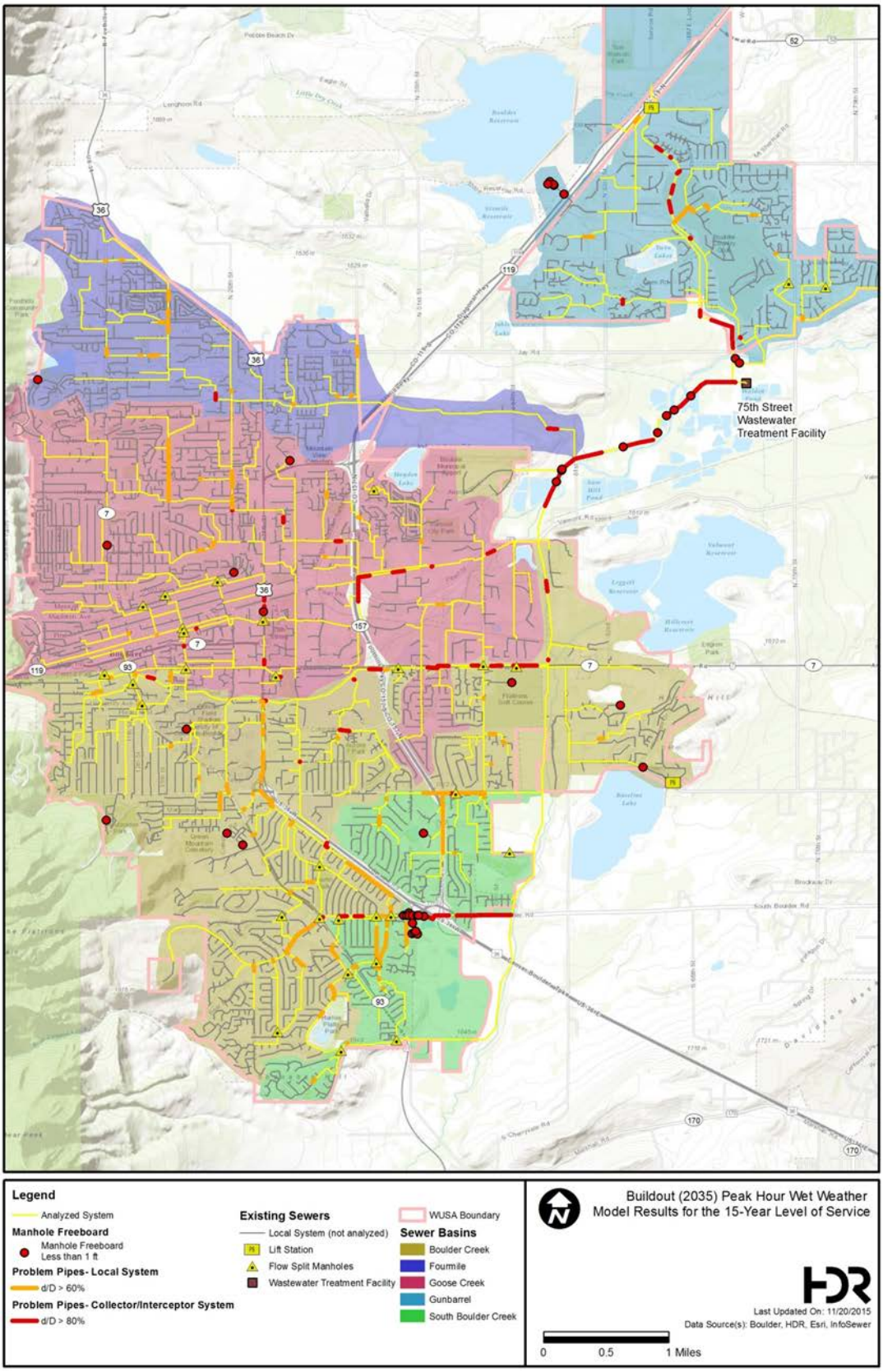


Figure 6-5. Buildout (2035) Peak Hour Wet Weather Model Results for the 20-Year Level of Service

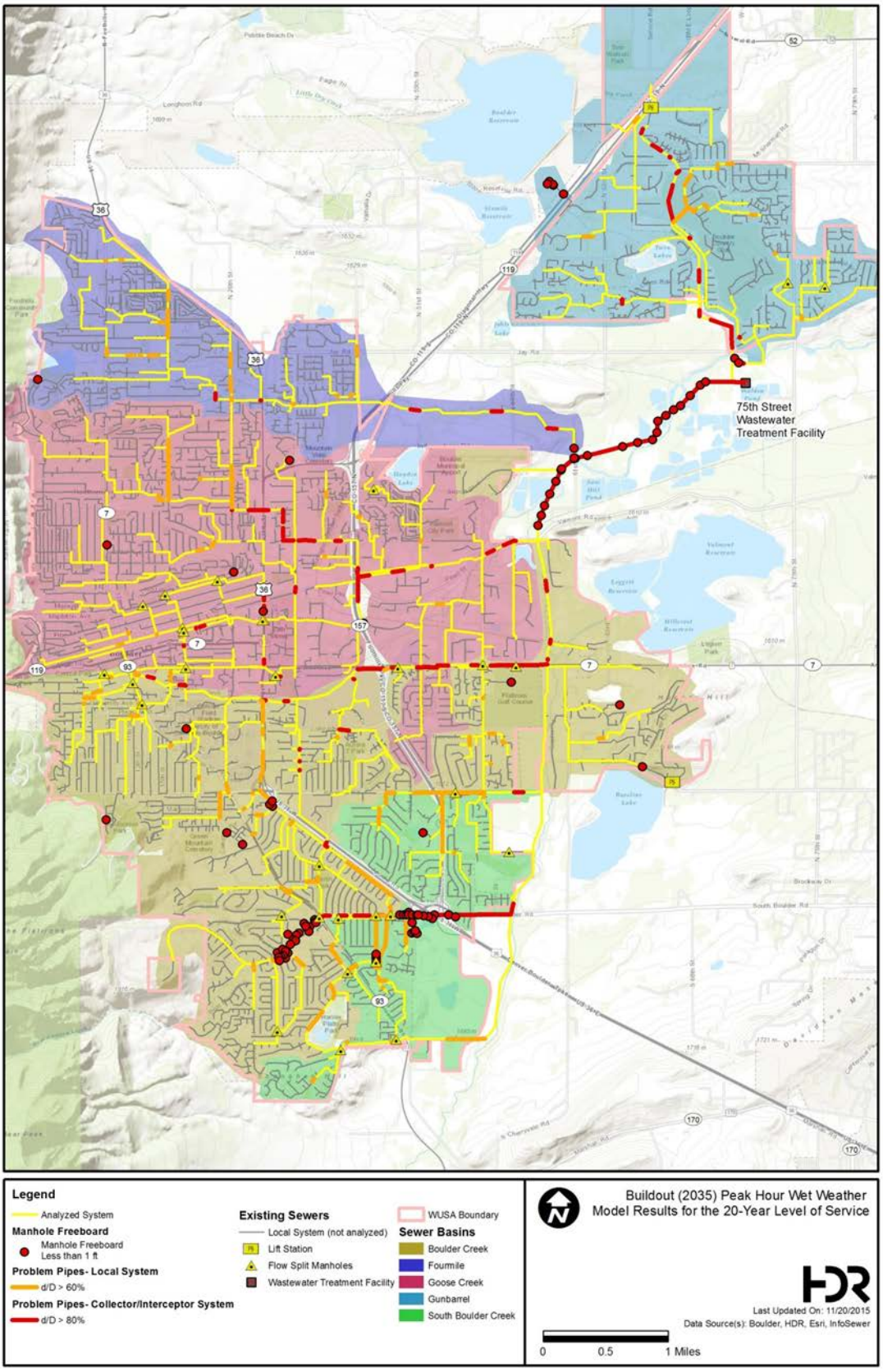


Figure 6-6. Buildout (2035) Peak Hour Wet Weather Model Results for the 25-Year Level of Service

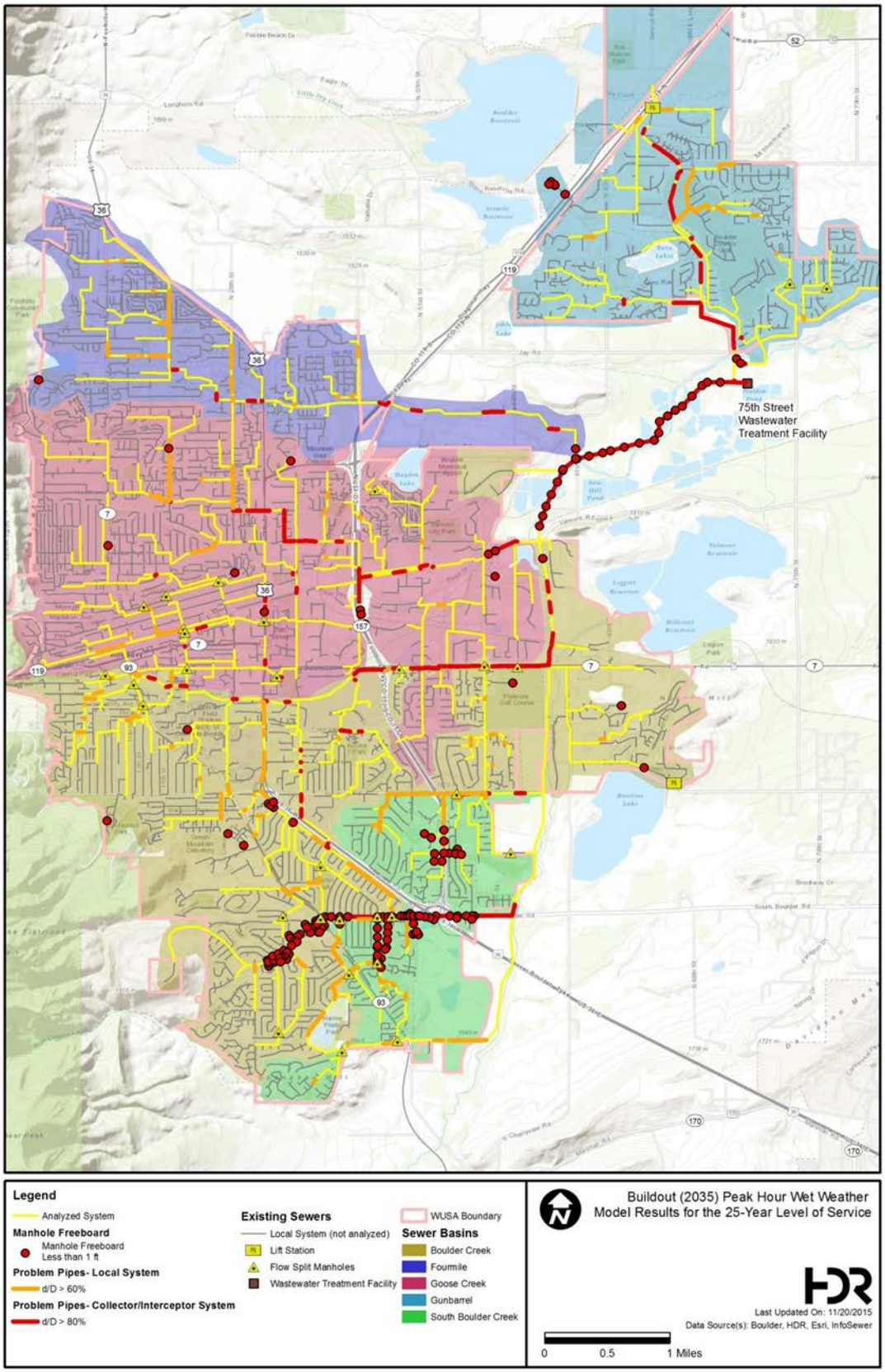
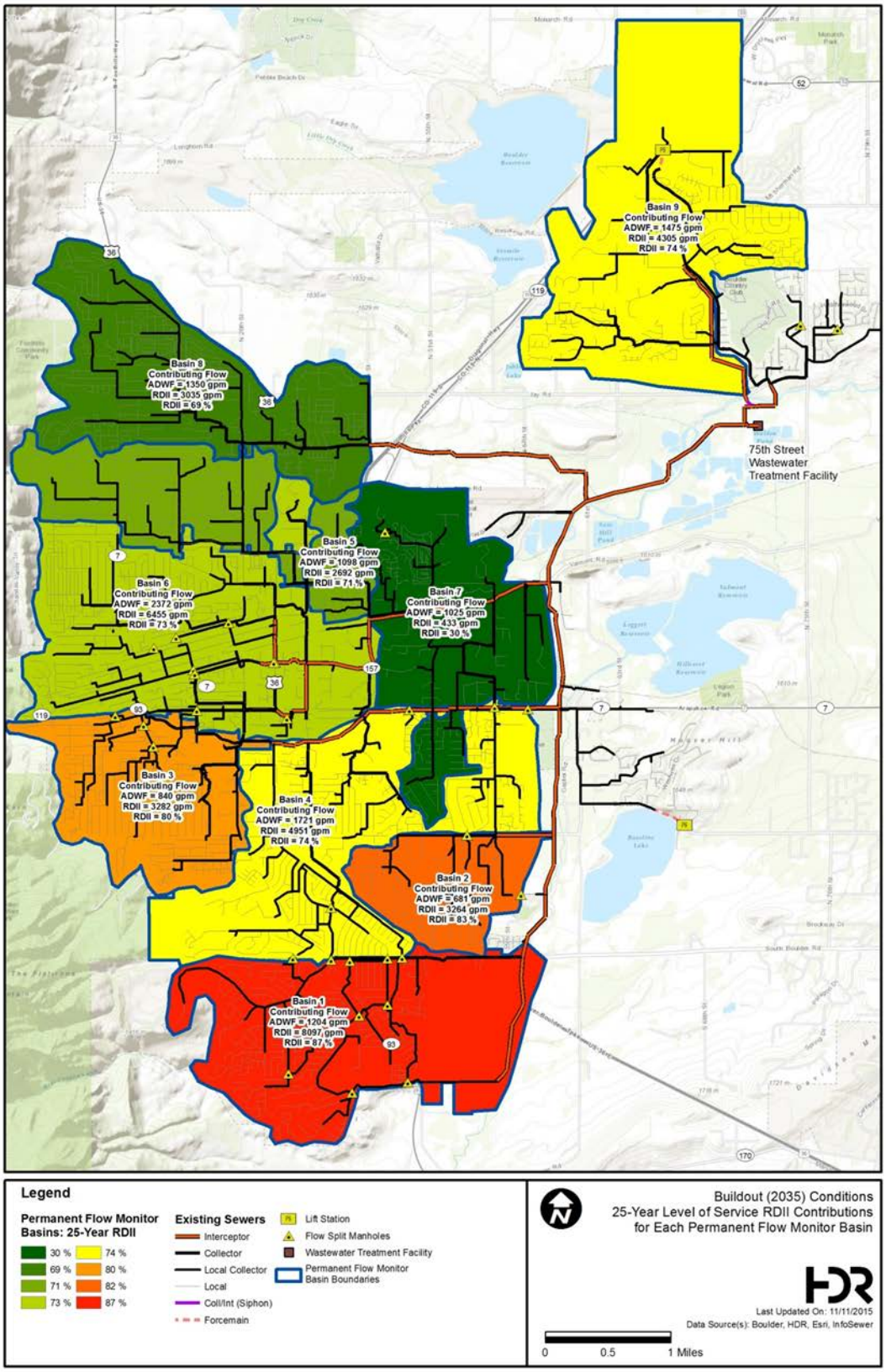


Figure 6-7. Buildout (2035) RDII Loadings Per Permanent Flow Monitoring Basin for the 25-Year Level of Service



6.2 Capacity-Limited Identification and Characterization

The collection system pipes with identified capacity limitations, established from the model results, were examined to identify likely hydraulic issues under the various flow scenarios. Table 6-2 summarizes pipes in the analyzed collection system with identified hydraulic limitations. A capacity-limited identification and characterization process was completed to better understand the nature and extent of these issues. This process is described in the following sections.

Table 6-2. Summary of Pipes with Modeled Hydraulic Limitations under Buildout Flow Projections in the Analyzed Collection System

Buildout Model Flow Scenario	Number of Pipes with Hydraulic Limitations	Total Length of Pipe with Hydraulic Limitations (miles)	Total Length of Pipe with Hydraulic Limitations (as a Percent of Total Analyzed System Length)	Number of Surcharged Manholes (Less than 1 foot of Freeboard)
15-Year Level of Service PHWWF	288	12.6	10%	41
20-Year Level of Service PHWWF	391	17.9	14%	99
25-Year Level of Service PHWWF	500	23.1	18%	176

6.2.1 Problem Identification

The hydraulic problems were separated into three categories for characterization and prioritization: Type A, Type B, and Type C. These three categories are defined as follows:

- **Type A:** A series of under capacity pipes that are hydraulically connected to one another. For Type A hydraulic problems, the system wide criteria is a modeled peak wet weather flow level exceeding 80 percent d/D and includes the interceptor, collector, local collector, and local systems.
- **Type B:** Isolated under capacity pipes that are not hydraulically connected to other problem locations. For Type B hydraulic problems, the system wide criteria is a modeled peak wet weather flow level exceeding 80 percent d/D and includes the interceptor, collector, local collector, and local systems.
- **Type C:** Under capacity pipes that are part of the local collector and local systems that can be either isolated or hydraulically connected to other problem pipes. For Type C hydraulic problems, the modeled peak wet weather flow level criteria is between 60 and 80 percent d/D and includes only the local collector and local systems.

Type C problems were placed in a separate category because they apply to local collector and local system pipes that are just above their hydraulic capacity criteria and, while modeling indicates they are hydraulically restricted, they do not have the same level of priority or risk as the Type A and Type B categories. In addition, the accuracy of the data that are used to identify these potential capacity restrictions may outweigh the precision provided by the hydraulic model. These Type C restrictions will likely require further assessment with flow monitoring and pipe invert validation.

Type A problems account for 50 percent of the problem pipes or a total of 247 pipes with a cumulative length of approximately 12.8 miles. Type B problems account for 25 percent of the problem pipes or a total of 125 pipes with a cumulative length of approximately 3.9 miles. Type C problems account for the remaining 25 percent of problem pipes or a total of 128 pipes with a cumulative length of approximately 6.3 miles.

Type A and Type B problem areas will have system improvement recommendations developed and estimates of capital cost prepared. Type A capacity limitations will be identified as recommendations for capital improvements. Type B capacity limitations should be further validated through additional localized flow monitoring and invert survey to verify capacity constraints and, if still valid, further capital project recommendations may be necessary. Type C capacity limitations reflect a series of pipes that should be monitored via CCTV or localized flow monitoring and, if necessary based on actual upstream growth, considered for isolated upsizing at a later time. Many of the Type C problems are expected to be addressed through decreased RDII contribution as the local systems are rehabilitated.

Figure 6-8 shows the Type A and Type B problem areas and Figure 6-9 shows the Type C problem areas. A total of 12 Type A capacity-limited areas, or groups, were identified based on the relative proximity of the problem pipes and hydraulic connectivity. The most extensive Type A capacity-limited areas are in permanent flow monitor basins 1, 2, 3, and 4 and correspond to the basins receiving the greatest RDII loadings (Figure 6-7). Each Type A capacity-limited group is identified by the sewer basin it is located in followed by an identification number. These capacity-limited groups are discussed in the following sections.

Figure 6-8. Type A and Type B Problem Locations: Buildout Peak Hour Wet Weather Flows for 15, 20, and 25-Year Levels of Service

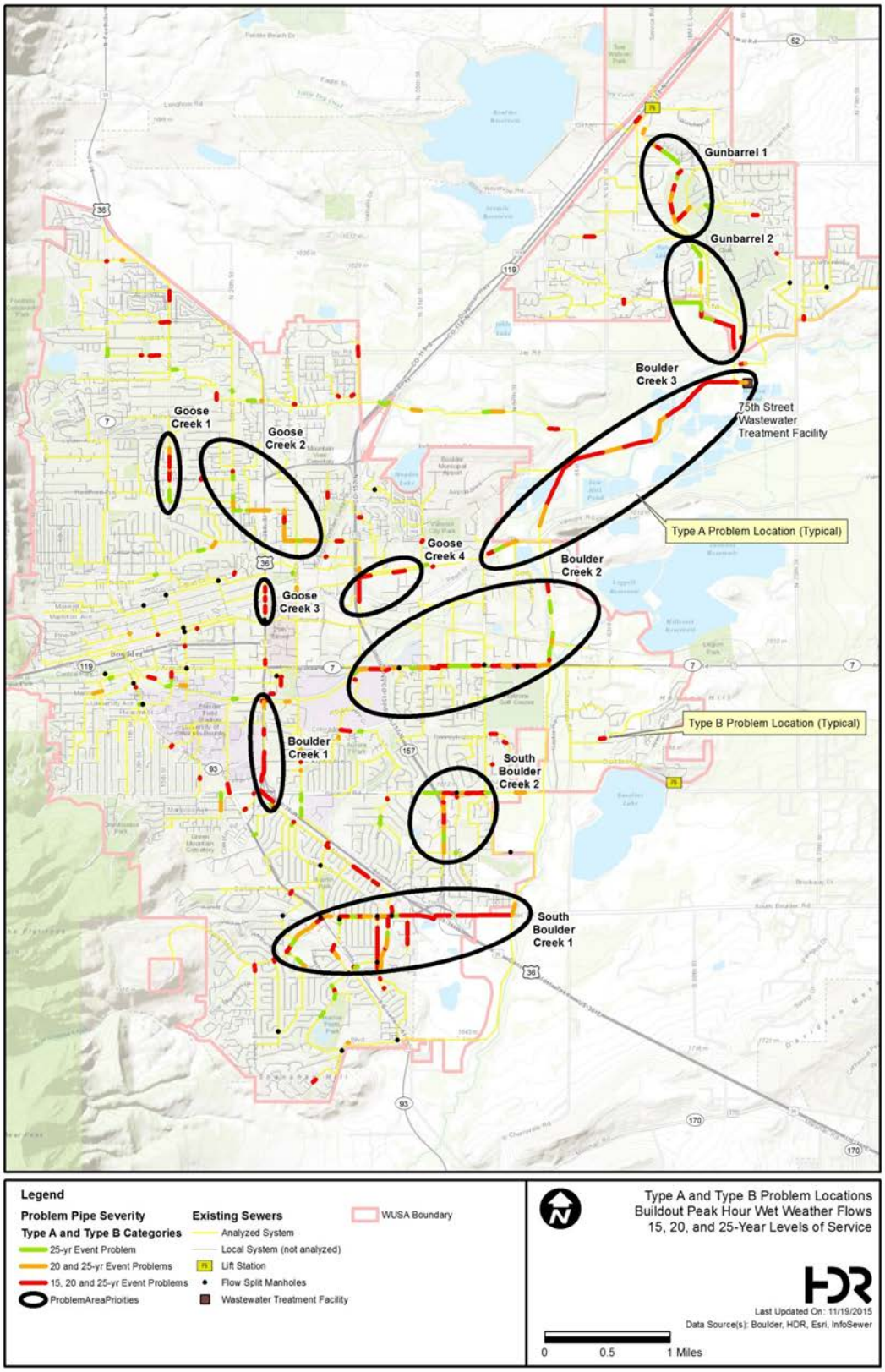
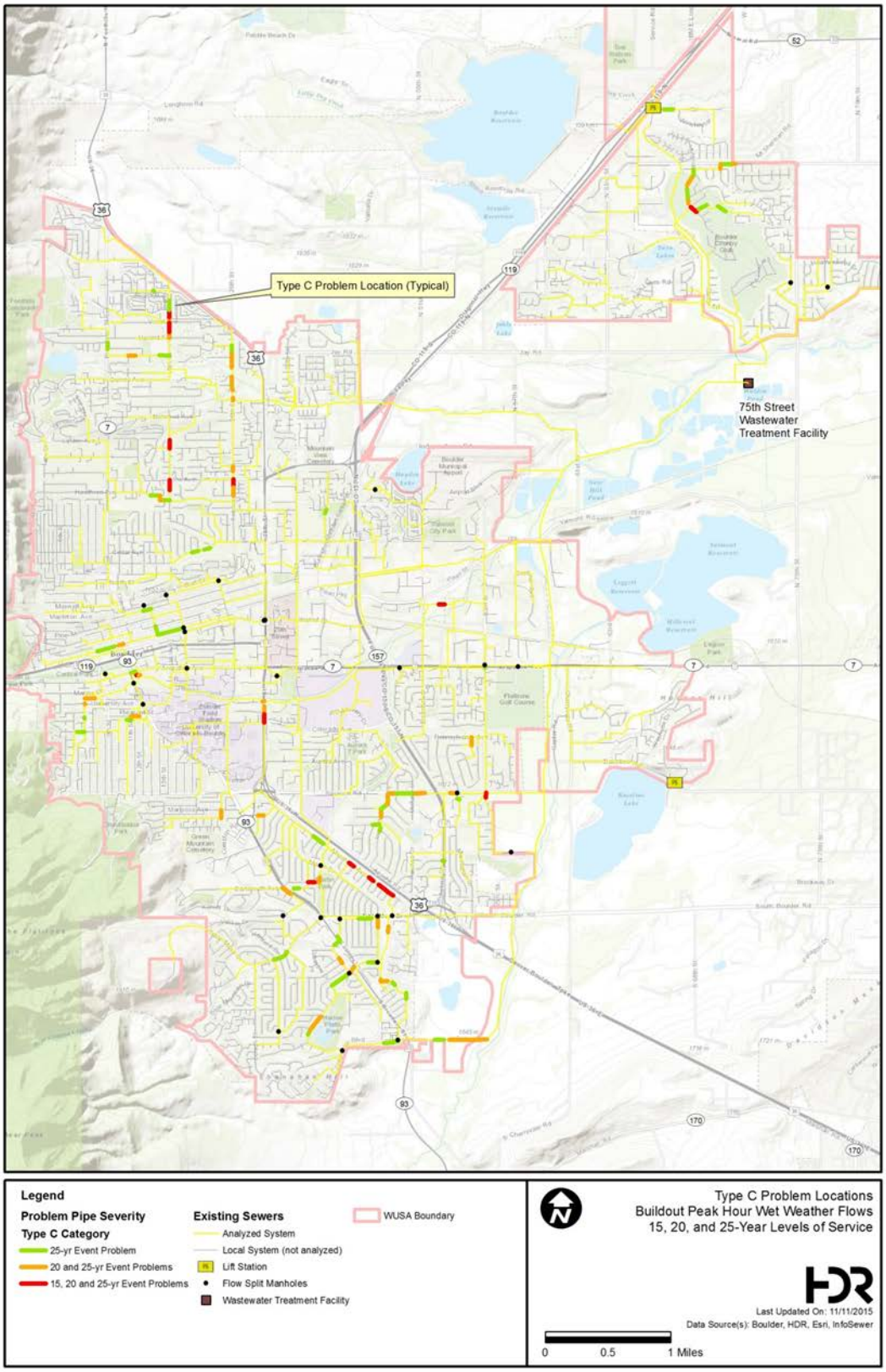


Figure 6-9. Type C Problem Locations: Buildout Peak Hour Wet Weather Flows for 15, 20, and 25-Year Levels of Service



6.2.2 Problem Characterization – Type A Problem Locations

As previously defined, the criteria for a Type A hydraulic limitation is based on sewers with a peak wet weather flow level exceeding 80 percent d/D. Type A locations were characterized using a set of descriptive categories to better understand the nature, extent, and hydraulics of the issues for the eventual development of improvements. Table 6-3 identifies the descriptive categories and what they entail in helping to define the capacity-limited groups. Table 6-4 through Table 6-14 characterize each of the problem groups using the descriptive categories. Figure 6-8 references these locations.

Table 6-3. Capacity Limitation Characterization Categories and Definitions

Location:	Identifies the sewer basin, major street intersection(s) or adjacent feature(s).
Pipe Classification:	Identifies if the pipes are categorized as local, local collector, collector or interceptors. If the system is an interceptor or collector that is located along a creek corridor, the manhole lid condition (sealed or un-sealed) will be noted.
Diameter Range:	Summarizes the range in pipe diameters.
Material Types:	Summarizes the pipe material types.
Install/Rehab Date:	Identifies the average or predominant installation date of the pipes and also notes if segments have been recently rehabilitated through the O&M program. This information is extracted from the city's GIS.
Problem Extent (Buildout with 15-Year Level of Service):	Summarizes the total length of Type A problem pipe under buildout wet weather 15-year level of service flow scenario.
Problem Extent (Buildout with 20-Year Level of Service):	Summarizes the total length of Type A problem pipe under buildout wet weather 20-year level of service flow scenario.
Problem Extent (Buildout with 25-Year Level of Service):	Summarizes the total length of Type A problem pipe under buildout wet weather 25-year level of service flow scenario.
Manhole SSO Risk (Buildout, 25-Year Level of Service):	Summarizes the number of manholes that have less than 1 foot of freeboard under the buildout wet weather 25-year level of service flow scenario.
Estimated Number of Services:	Identifies the number of sewer services connected to the problem pipes.
Calibration Confidence:	Identifies the calibration confidence in the vicinity of the problem area based on the results from the dry weather calibration. A qualitative ranking from low to medium to high is assigned to each problem area depending on accuracy of model versus meter flow. Capacity-limited areas not in the vicinity of a calibration flow meter are assigned a medium calibration confidence ranking. The calibration confidence ranking represents model confidence during the dry weather scenarios only since the permanent flow meter calibration was based on dry weather. Because of this, only the dry weather portion of the total flow and associated flow difference between permanent flow meter and model is represented during wet weather flow which establishes the greatest potential for capacity problems.
Data Confidence:	Summarizes the number of manhole inverts that did not have survey or as-built data and were therefore interpolated for modeling purposes. Data confidence of 100% indicates that all manhole invert data was obtained from as-built or survey data and was not adjusted as part of the network validation process.
Accessibility:	Identifies if the problem pipes are generally located in roadways, creek/stream corridors or other alignment conditions.
Comments:	Provides a brief problem assessment considering the characterization findings for each category.

Table 6-4. Capacity Limitation Characterization: Boulder Creek 1

BOULDER CREEK 1	
Location:	Boulder Creek Sewer Basin - Colorado Ave and 28th St
Pipe Classification:	Local Collector, Interceptor
Diameter Range:	8-21 inch diameter
Material Types:	VC
Install/Rehab Date:	Install: varies (Unknown – 1976) / Rehab: varies (none, 2005, 2006, 2012, 2013)
Problem Extent (Buildout ADWF):	1,906 feet
Problem Extent (Buildout with 15-Year Level of Service):	2,629 feet
Problem Extent (Buildout with 20-Year Level of Service):	2,851 feet
Problem Extent (Buildout with 25-Year Level of Service):	3,020 feet
Manhole SSO Risk (Buildout, 25-Year Level of Service):	4
Estimated Number of Services:	1
Data Confidence:	80 percent (3 of 15 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	Medium
Accessibility:	Highway, Major Arterial Road
Comments:	Most of the problem pipes in this group run north to south on 28th St and have relatively shallow slopes which are causing deep pipe flow. There is a fairly high total length of problem pipe. Existing dry weather flows are causing problems in potentially older pipe constructed of vitrified clay.

Table 6-5. Capacity Limitation Characterization: Boulder Creek 2

BOULDER CREEK 2	
Location:	Boulder Creek Sewer Basin - Arapahoe Ave and Foothills Pkwy to Old Tale Rd; South Boulder Creek corridor
Pipe Classification:	Local Collector, Collector/Interceptor, Interceptor
Diameter Range:	12-36 inch diameter
Material Types:	VC, PVC, RC
Install/Rehab Date:	Install: varies (Unknown – 1957, 1991, 2007) / Rehab: none
Problem Extent (Buildout ADWF):	635 feet
Problem Extent (Buildout with 15-Year Level of Service):	3,787 feet
Problem Extent (Buildout with 20-Year Level of Service):	6,137 feet
Problem Extent (Buildout with 25-Year Level of Service):	9,268 feet
Manhole SSO Risk (Buildout, 25-Year Level of Service):	0
Estimated Number of Services:	8
Data Confidence:	80 percent (6 of 30 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	High
Accessibility:	Highway, Major Arterial Road
Comments:	The problem pipes run west to east along Arapahoe Ave west of Foothills Pkwy to Old Tale Rd. There is a high total length of problem pipe and areas of relatively shallow slopes. Construction will have major traffic impacts as the roadway is a heavily traveled commuter route.

Table 6-6. Capacity Limitation Characterization: Boulder Creek 3

BOULDER CREEK 3	
Location:	Boulder Creek Sewer Basin - Valmont Rd and 61st St to WWTF
Pipe Classification:	Interceptor along Boulder Creek Corridor (manholes sealed)
Diameter Range:	30-60 inch diameter
Material Types:	VC, RC, DI
Install/Rehab Date:	Install: varies (unknown – 1966) / Rehab: varies (none, 2003)
Problem Extent (Buildout ADWF):	0 feet
Problem Extent (Buildout with 15-Year Level of Service):	8,605 feet
Problem Extent (Buildout with 20-Year Level of Service):	12,677 feet
Problem Extent (Buildout with 25-Year Level of Service):	13,265 feet
Manhole SSO Risk (Buildout, 25-Year Level of Service):	2, plus surcharging in several sealed manholes
Estimated Number of Services:	0
Data Confidence:	100 percent (0 of 32 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	Medium
Accessibility:	Major Road, Creek Corridor
Comments:	The influent sewer to the WWTF is expected to flow full during significant wet weather events. Construction access would be very difficult in this area. However, this project is highlighted as a top priority due to the constant occurrence of SSOs during even marginal rainfall events. Addressing this section of interceptor is one of the main environmental compliance goals of the city.

Table 6-7. Capacity Limitation Characterization: Goose Creek 1

GOOSE CREEK 1	
Location:	Goose Creek Sewer Basin – 19th Street from Kalmia Ave to Grape Ave
Pipe Classification:	Local Collector, Collector/Interceptor
Diameter Range:	8-15 inch diameter
Material Types:	VC
Install/Rehab Date:	Install: varies (unknown – 1959) / Rehab: varies (none, 2005, 2011)
Problem Extent (Buildout ADWF):	0 feet
Problem Extent (Buildout with 15-Year Level of Service):	886 feet
Problem Extent (Buildout with 20-Year Level of Service):	1,339 feet
Problem Extent (Buildout with 25-Year Level of Service):	1,832 feet
Manhole SSO Risk (Buildout, 25-Year Level of Service):	1
Estimated Number of Services:	5
Data Confidence:	80 percent (2 of 10 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	Medium
Accessibility:	Minor Road
Comments:	The problem pipes in this group run north to south along 19th Street. The problem pipe sections appear to be at or over capacity for their size.

Table 6-8. Capacity Limitation Characterization: Goose Creek 2

GOOSE CREEK 2	
Location:	Goose Creek Sewer Basin – Folsom St/Glenwood Dr/Valmont Rd
Pipe Classification:	Local Collector, Collector/Interceptor
Diameter Range:	10- 15 inch diameter
Material Types:	VC
Install/Rehab Date:	Install: varies (unknown – 1969; 1971, 1979, 1983) / Rehab: none
Problem Extent (Buildout ADWF):	30 feet
Problem Extent (Buildout with 15-Year Level of Service):	274 feet
Problem Extent (Buildout with 20-Year Level of Service):	3,097 feet
Problem Extent (Buildout with 25-Year Level of Service):	4,228 feet
Manhole SSO Risk (Buildout, 25-Year Level of Service):	0
Estimated Number of Services:	14
Data Confidence:	71 percent (6 of 21 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	High
Accessibility:	Local and Major Roads
Comments:	The general direction of the in this problem run is from the northwest to the southeast, with problem pipes running north to south and west to east along Folsom St, Glenwood Dr, along the border of private properties, and Valmont Rd. Construction accessibility may be difficult along the major roads and private properties. These are older pipes constructed of vitrified clay. There is a high total length of problem pipe and modeling shows that pipe surcharging along this stretch may be significant.

Table 6-9. Capacity Limitation Characterization: Goose Creek 3

GOOSE CREEK 3	
Location:	Goose Creek Sewer Basin – 28th Street from Pine St to Walnut St
Pipe Classification:	Collector/Interceptor
Diameter Range:	24 inch diameter
Material Types:	RC
Install/Rehab Date:	Install: unknown / Rehab: 2008
Problem Extent (Buildout ADWF):	0 feet
Problem Extent (Buildout with 15-Year Level of Service):	622 feet
Problem Extent (Buildout with 20-Year Level of Service):	622 feet
Problem Extent (Buildout with 25-Year Level of Service):	622 feet
Manhole SSO Risk (Buildout, 25-Year Level of Service):	1
Estimated Number of Services:	2
Data Confidence:	66 percent (1 of 3 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	Medium
Accessibility:	Highway
Comments:	The problem pipes in this group run north to south along 28th Street. The problem pipe sections have a relatively shallow slope. Construction accessibility may be difficult.

Table 6-10. Capacity Limitation Characterization: Goose Creek 4

GOOSE CREEK 4	
Location:	Goose Creek Sewer Basin – Foothills Pkwy and Pearl St
Pipe Classification:	Interceptor
Diameter Range:	21-30 inch diameter
Material Types:	RC
Install/Rehab Date:	Install: varies (1956, 1967, 1972, 1980, 1987) / Rehab: none
Problem Extent (Buildout ADWF):	487 feet
Problem Extent (Buildout with 15-Year Level of Service):	1,999 feet
Problem Extent (Buildout with 20-Year Level of Service):	1,999 feet
Problem Extent (Buildout with 25-Year Level of Service):	2,067 feet
Manhole SSO Risk (Buildout, 25-Year Level of Service):	2
Estimated Number of Services:	3
Data Confidence:	70 percent (3 of 10 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	High
Accessibility:	Local Road, Highway
Comments:	The problem pipes in this group run south to north and then east to west along Foothills Pkwy and Pearl St. There is a single segment 21” diameter pipe restriction along this predominantly 30” pipe run. The problem pipe sections have a relatively shallow slope. There are pipes north of Pearl Street that are constructed with RFM pipes that have a high structural failure potential. Construction accessibility may be difficult.

Table 6-11. Capacity Limitation Characterization: Gunbarrel 1

GUNBARREL 1	
Location:	Gunbarrel Sewer Basin – Boulder and Left Hand Ditch; Idylwild Tr/Boulder Country Club
Pipe Classification:	Local Collector, Collector/Interceptor
Diameter Range:	12-21 inch diameter
Material Types:	VC
Install/Rehab Date:	Install: varies (unknown, 1965) / Rehab: varies (none, 2003)
Problem Extent (Buildout ADWF):	207 feet
Problem Extent (Buildout with 15-Year Level of Service):	1,914 feet
Problem Extent (Buildout with 20-Year Level of Service):	3,188 feet
Problem Extent (Buildout with 25-Year Level of Service):	4,173 feet
Manhole SSO Risk (Buildout, 25-Year Level of Service):	0
Estimated Number of Services:	5
Data Confidence:	80 percent (3 of 15 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	High
Accessibility:	Ditch Corridor, Open Space, Golf Course, Local Street
Comments:	The problem pipes in this area are showing stress due to increasing flows from growth in the northern part of the Gunbarrel sewer basin. There is a high total length of problem pipe in this area. The problem pipes run north to south along the ditches as well as along Idylwild Tr and across the Boulder Country Club golf course. The problem pipes along the collector/interceptor have a shallow slope. Construction accessibility would need to be coordinated with the Ditch Company and Boulder Country Club.

Table 6-12. Capacity Limitation Characterization: Gunbarrel 2

GUNBARREL 2	
Location:	Gunbarrel Sewer Basin - Boulder Supply Canal north of Jay Rd
Pipe Classification:	Collector/Interceptor, Interceptor along Canal
Diameter Range:	15-24 inch diameter
Material Types:	CC, VC
Install/Rehab Date:	Install: varies (1971 – 1976) / Rehab: none
Problem Extent (Buildout ADWF):	0 feet
Problem Extent (Buildout with 15-Year Level of Service):	2,065 feet
Problem Extent (Buildout with 20-Year Level of Service):	2,562 feet
Problem Extent (Buildout with 25-Year Level of Service):	5,241 feet
Manhole SSO Risk (Buildout, 25-Year Level of Service):	0
Estimated Number of Services:	3
Data Confidence:	43 percent (8 of14 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	High
Accessibility:	Open Space, Canal Corridor
Comments:	The problem pipes in this area run along irrigation ditches upstream of the Gunbarrel siphon and are comprised of the north to south 24” interceptor and a west to east 15” collector/interceptor. There is a high total length of problem pipe with a relatively shallow slope.

Table 6-13. Capacity Limitation Characterization: South Boulder Creek 1

SOUTH BOULDER CREEK 1	
Location:	South Boulder Creek Sewer Basin – Table Mesa Dr, South Boulder Rd, S 46th St,
Pipe Classification:	Local Collector, Collector/Interceptor
Diameter Range:	8-30 inch diameter
Material Types:	VC, RC, CI, PVC
Install/Rehab Date:	Install: varies (unknown, 1961, 1971, 1984, 1988, 2013) / Rehab: varies (none, 2005, 2008, 2013)
Problem Extent (Buildout ADWF):	1,535 feet
Problem Extent (Buildout with 15-Year Level of Service):	10,293 feet
Problem Extent (Buildout with 20-Year Level of Service):	14,557 feet
Problem Extent (Buildout with 25-Year Level of Service):	16,600 feet
Manhole SSO Risk (Buildout, 25-Year Level of Service):	65
Estimated Number of Services:	23
Data Confidence:	High (15 of 72 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	High
Accessibility:	Local and Major Roads, Highway
Comments:	The problem pipes in this area are the collector/interceptor system running west to east along Table Mesa Dr and South Boulder Rd as well as four local collectors discharging into it. There are capacity issues along the entire length of pipe. The SSO risk increases for the higher frequency scenarios where the pipe profile abruptly changes from a near 4% slope to a less than 1% slope near Table Mesa Dr and Moorhead Ave. There are several potential SSO locations indicated by the model for all model scenarios and the majority of the problem lines may experience SSOs for the 25-year level of service. There is a high total length of problem pipe and construction accessibility may be difficult.

Table 6-14. Capacity Limitation Characterization: South Boulder Creek 2

SOUTH BOULDER CREEK 2	
Location:	South Boulder Creek Sewer Basin – Foothills Pkwy, Baseline Rd
Pipe Classification:	Local Collector, Collector/Interceptor
Diameter Range:	8-24 inch diameter
Material Types:	VC, PVC, RPM
Install/Rehab Date:	Install: varies (unknown, 1957, 1973, 1978, 1987, 1989, 1990) / Rehab: none
Problem Extent (Buildout ADWF):	805 feet
Problem Extent (Buildout with 15-Year Level of Service):	2,783 feet
Problem Extent (Buildout with 20-Year Level of Service):	4,770 feet
Problem Extent (Buildout with 25-Year Level of Service):	6,563 feet
Manhole SSO Risk (Buildout, 25-Year Level of Service):	9
Estimated Number of Services:	5
Data Confidence:	85 percent (3 of 20 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	High
Accessibility:	Local and Major Roads, Highway
Comments:	The problem pipes in this area are the local collector running south to north along Foothills Pkwy and the collector/interceptor running west to east along Baseline Rd. Capacity issues exist where the collector/interceptor flattens at the upstream of the intersection of Baseline Rd and Foothills Pkwy. There are capacity issues along the entire length of pipe. There are pipes along Baseline Rd that are constructed with RFM pipes that have a high structural failure potential. There is a high total length of problem pipe and construction accessibility may be difficult.

6.2.3 Problem Characterization – Type B Problem Locations

As previously defined, Type B problem locations have the same capacity criterion as Type A problems, however, Type B problems are relatively isolated and are not hydraulically connected to other problem locations. Type B problems often result from isolated flat pipe slopes limiting the capacity of single pipe segments. Figure 6-8 shows the Type B problem locations.

6.2.4 Problem Characterization – Type C Problem Locations

As previously defined, Type C problems are isolated stretches of sewer in the local collector and local systems where peak wet weather flow levels fall between 60 and 80 percent d/D. For the majority of these sewers this threshold is only marginally exceeded. Figure 6-9 shows these locations.

Type C sewers are under stress for the model scenarios, but are not significant enough to constitute their own capital improvement projects. Type C areas are locations where CCTV and localized flow monitoring and invert survey are recommended to validate the problem extent. Based on the results from the capacity validation activities and actual upstream growth, they could be considered for upsizing if necessary.

6.3 Remaining Capacity Analysis

An analysis was also performed to determine the remaining capacity in the existing sewers after buildout ADWF loadings and the 25-year level of service RDII is applied to the model. The results of this analysis, based on the problem identification hydraulic criteria on the analyzed system, are

presented in Table 6-15 (total number of pipes) and Table 6-16 (total length of pipes) as well as in Figure 6-10. The results presented in these tables and the figure are based on the buildout modeled flow divided by the full flow capacity (q/Q), which generally correspond with the results based on the d/D ratio.

Assuming d/D and q/Q to be roughly equivalent, interceptor and collector pipes with a q/Q less than 80 percent (excess capacity greater than 20 percent) and local collector and local pipes with a q/Q less than 60 percent (excess capacity greater than 40 percent) were assumed to have a remaining flow capacity available to support future growth while still providing for conveyance of a 25 year storm level of RDII. For the collector/interceptor system, about 637 pipes in the analyzed system with a total pipe length of 28.2 miles have available remaining capacity. For the local collector systems, about 1,617 pipes in the analyzed system with a total pipe length of 67.6 miles have available remaining capacity.

For comparison, the remaining capacity in the analyzed system for existing conditions was also mapped (Figure 6-11). Comparing Figure 6-10 to Figure 6-11 illustrates where there is capacity today versus in the future as anticipated development occurs.

Table 6-15. Buildout Peak Hour Wet Weather 25-Year Level of Service Capacity Analysis - Remaining Capacity Summary by Number of Pipes for the Analyzed System

Sewer Classification	Remaining Capacity[1] (Number of Pipe Segments)						Number of Analyzed Pipes with Available Remaining Capacity (Sum of Bold/Italicized Values)
	Surcharged Pipe	*< 20 %*	*20 – 40 %*	*40 – 60 %*	*60 – 80 %*	*80 – 100%*	
Collector/ Interceptor	192	93	**108**	**140**	**166**	**223**	**637**
Local Collector	156	67	117	**227**	**450**	**940**	**1,617**
Total	348	160	225	367	616	1,163	**2,254**

[1] Remaining capacity is calculated as: 100 x (Full Flow Capacity – 25-year modeled peak flow)/Full Flow Capacity; Values that are bold and italicized are the number of pipes that have available capacity for the 25-year event in accordance with the problem identification hydraulic criteria.

Table 6-16. Buildout Peak Hour Wet Weather 25-Year Level of Service Capacity Analysis- Remaining Capacity Summary by Length of Pipe in Miles for the Analyzed System

Sewer Classification	Excess Capacity[1] (Length of Pipe In Miles)						Length of Analyzed Pipes with Available Remaining Capacity (Sum of Bold/Italicized Values)
	Surcharged Pipe	*< 20 %*	*20 – 40 %*	*40 – 60 %*	*60 – 80 %*	*80 – 100%*	
Collector/ Interceptor	10.0	4.7	**5.5**	**6.7**	**6.6**	**9.4**	**28.2**
Local Collector	5.7	3.4	5.2	**9.5**	**19.3**	**38.8**	**67.6**
Total	15.7	8.1	10.7	16.2	26.0	48.2	**95.8**

[1] Remaining capacity is calculated as: 100 x (Full Flow Capacity – 25-year modeled peak flow)/Full Flow Capacity; Values that are bold and italicized are the length of pipes that have available capacity for the 25-year event in accordance with the problem identification hydraulic criteria.

Figure 6-10. Buildout Peak Hour Wet Weather Capacity Analysis - Remaining Capacity to the 25-Year Level of Service

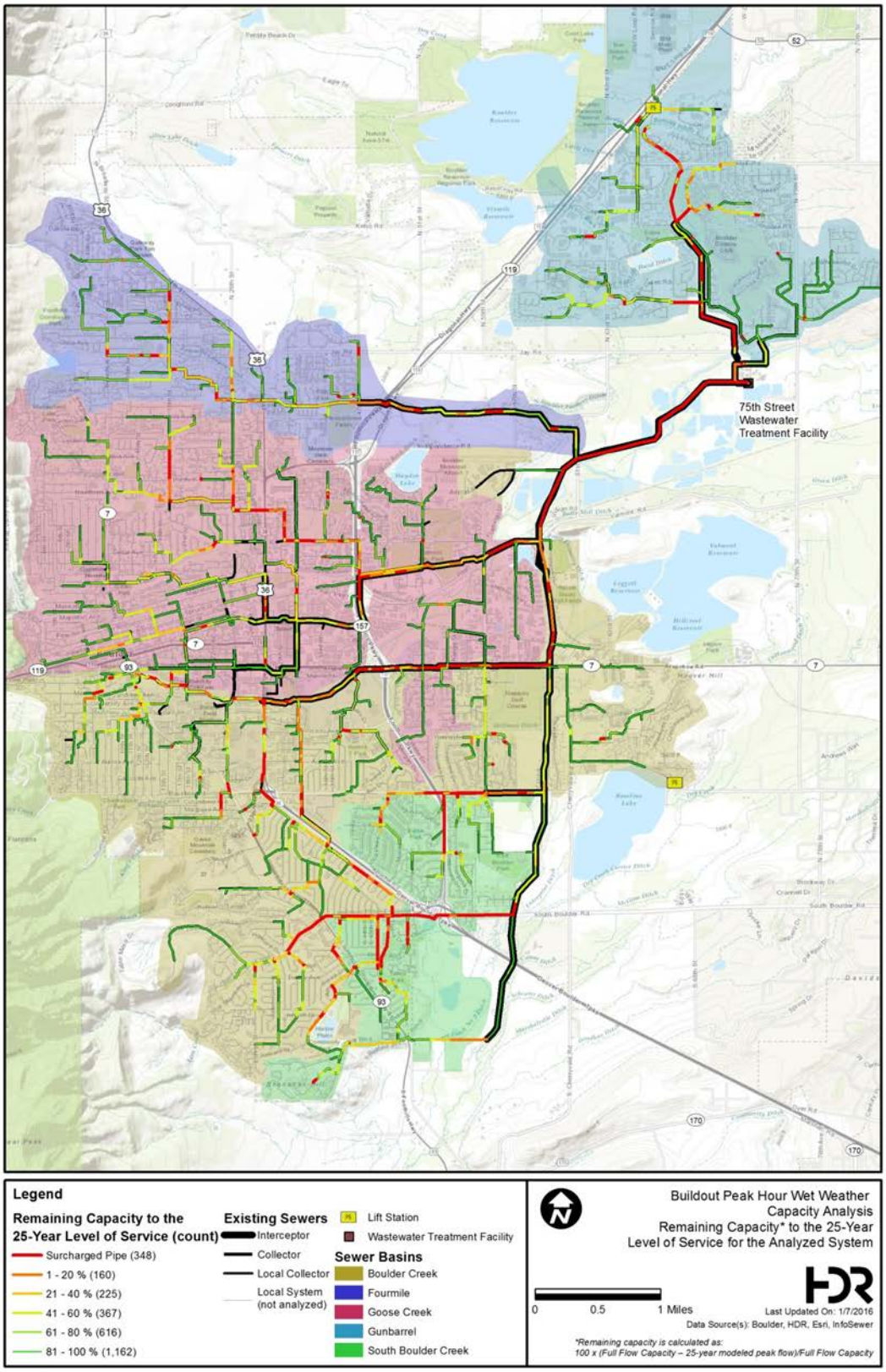
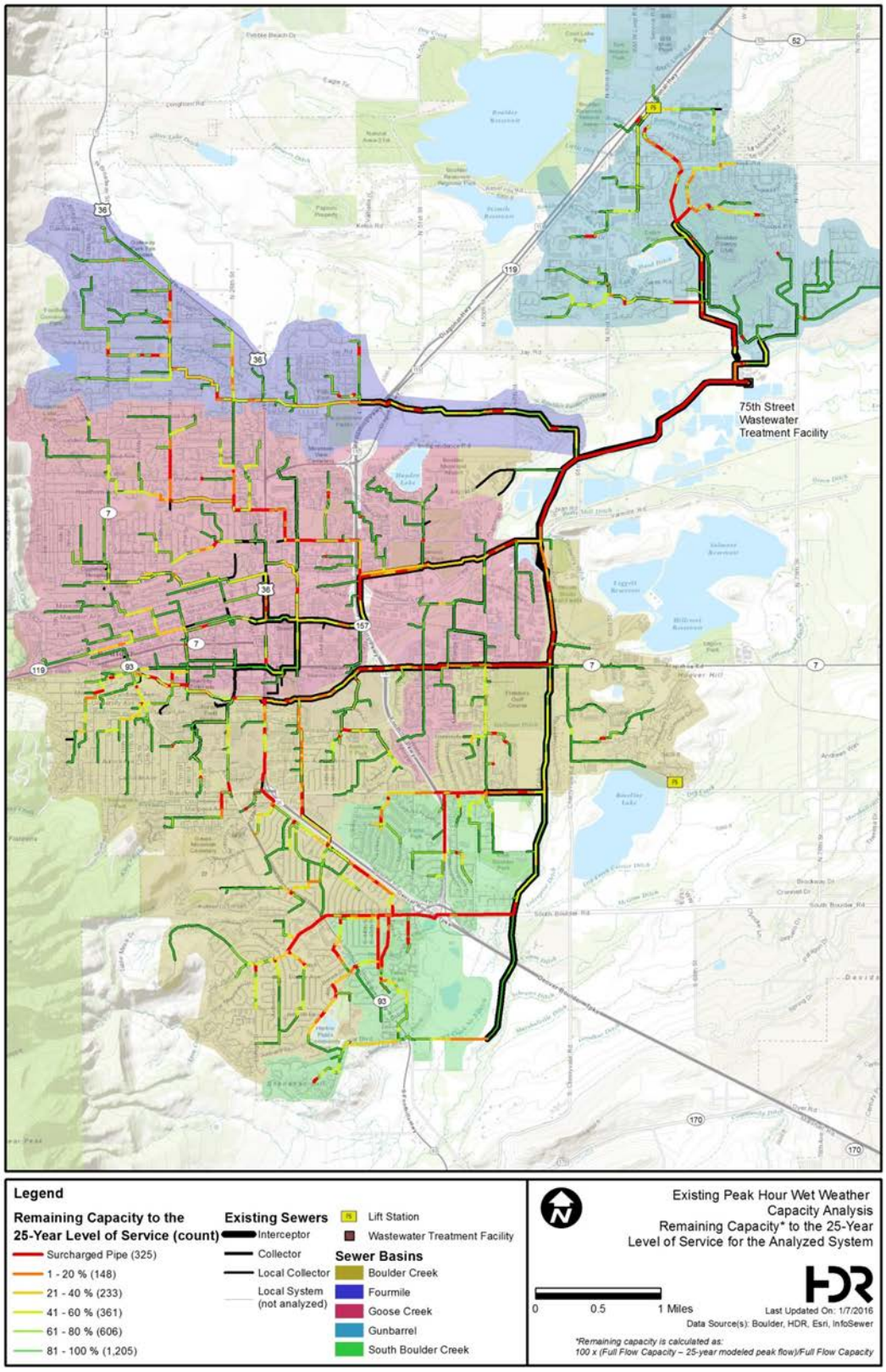


Figure 6-11. Existing Peak Hour Wet Weather Capacity Analysis - Remaining Capacity to the 25-Year Level of Service



7 Capital Project Recommendations

This section documents the capital project recommendations and planning-level opinion of probable construction costs in association with the city's 2016 WWCSMP. These recommendations are developed from the updated master plan model described in Section 3- Dry Weather Model Update and Calibration , Section 4- RDII Response and Level of Service Assessment, and Section 5-Wet Weather Flow Generation and Model Calibration, as well as the collection system capacity analysis described in Section 6- Collection System Capacity Analysis and Capacity Limitations Identification. The basis of these recommendations are the buildout conditions flow projections for BSF, the calibrated BI allowances, and the RDII allowances associated with the 15-, 20-, and 25-year levels of service.

7.1 Improvement Recommendations

In Section 6- Collection System Capacity Analysis and Capacity Limitations Identification, the hydraulic problems were separated into three categories; Type A, Type B, and Type C. Type A problems consist of a series of hydraulically connected problem pipes with modeled 25-year peak wet weather flow levels exceeding 80 percent d/D for the interceptor/collector, local collector, and local systems. Type B problems are isolated hydraulic restrictions that are not hydraulically connected to other problem locations with modeled 25-year peak wet weather flow levels exceeding 80 percent d/D for the interceptor/collector, local collector, and local systems. Type C problems are under capacity pipes with modeled 25-year peak wet weather flow levels between 60 and 80 percent d/D that are part of the local collector and local systems that can be either isolated or hydraulically connected to other problem pipes.

For this project, capacity issues for both Type A and Type B problem areas are resolved with increases in pipe diameter and have system improvement recommendations developed and estimates of capital cost prepared. Alternatives to pipe replacement and upsizing can be considered through the preliminary design phase of the recommended improvements. Modifications to upstream flow split manholes, if feasible, are recommended in the near-term to utilize the capacity of the existing system in areas which are experiencing existing hydraulic restrictions. The exception to pipe upsizing is the recommended Boulder Creek parallel interceptor at the downstream end of the system.

Type A capacity limitations are identified as recommendations for capital improvements. Type B capacity limitations should be further validated through additional localized flow monitoring and invert survey to verify capacity constraints and, if still valid, further capital improvements may be necessary. Type C capacity limitations reflect a series of pipes that should be inspected via CCTV or with localized flow monitoring and, if necessary based on actual upstream growth and additional flow, considered for necessary upsizing at a later time. In areas of the system with little upstream growth and future additional flow, some of the Type C problems may be addressed through decreased RDII contribution as the local and local collector systems are rehabilitated.

7.1.1 Recommended Improvement Priority

The recommended improvements were grouped into three tiers to establish implementation priority:

- Tier 1 projects address Type A problems and have the highest priority.

- Tier 2 projects also address Type A problems but have lower priority compared to Tier 1.
- Tier 3 projects address Type B problems which have the lowest priority.

The improvement priorities were assigned based on a number of qualitative factors including the observed performance of the system during high flow events, the level of service provided by the current system, extent of the problem, potential for SSOs and service lateral backups, and relative benefit over other improvement projects. The relative benefit takes into account the amount of pipe replaced compared to the extent of the problem remedied. These factors are summarized in the problem characterization tables in Section 6- Collection System Capacity Analysis and Capacity Limitations Identification.

7.1.2 Reinforced Plastic Mortar Pipes

A review of the GIS data indicates that some pipes within the system are reinforced plastic mortar (RPM) pipe. The product name of RPM is Flextran and the material is a thin-walled fiberglass-based pipe that was installed in the early to mid 1970s. Flextran RPM pipes have been known to experience deterioration and/or be susceptible to structural failure over time in collection systems around the country. The city knows that these pipes need to be lined with a structural liner or replaced. According to the GIS data 13 pipes within the system are constructed with RPM (Figure 7-1). These pipes should be lined with cured in place pipe, replaced or abandoned as soon as feasible due to the structural failure potential. These pipes are located in the Goose Creek 4 and South Boulder Creek 1 Type A problem areas.

Figure 7-1. Reinforced Plastic Mortar (RPM) pipes in the Existing Collection System

7.1.3 Type A Problem Improvements

Type A problem locations were characterized using a set of descriptive categories to better understand the nature, extent, and severity of the problems for the eventual development of improvements. Improvement recommendations for Type A problem locations are developed for each problem area to correct these hydraulic issues. Pipe improvement recommendations are developed to convey the flow conditions during the buildout 25-year wet weather scenario to allow for future system loading conditions in addition to alleviating existing hydraulic problems.

Using the model, improvements developed for the Type A alternatives were verified by checking that the hydraulic problems were remedied and the analysis criteria was met for each of the buildout flow scenarios. Improvements considered during this project were pipe replacements with the exception of the Boulder Creek Interceptor parallel. Figure 7-2 depicts and Table 7-1 summarizes the Type A improvements with the original and replacement pipe sizes.

Multiple factors were considered in developing each improvement recommendation. Although each problem area had unique constraints and required a different set of improvements, a number of common themes were followed:

- To minimize capital expenditures, the existing infrastructure was used to the maximum extent possible.
- Improvements were developed to address each problem area starting at the downstream end and working upstream. This process ensures that only hydraulically deficient pipes were addressed, as opposed to pipes that have adequate capacity but experience surcharging due to downstream bottlenecks.
- Capacity improvements were only extended far enough downstream so that the capacity criteria were met. This could result in a larger pipe discharging into a smaller pipe if that smaller pipe has sufficient capacity to carry the upstream flow due to increased pipe slope.

Table 7-1 lists each Type A problem area with a relative ranking (low, medium, high) for each of the priority factors based on a comparison between problem areas. In addition, discussions were held with the city regarding model results and areas where they have seen hydraulic capacity issues. Tier 1 or 2 is assigned in the last column depending on the overall outcome of the priority factor ranking, as well as observations made by the city, with the number of categories containing more high rankings reigning. Figure 7-2 depicts the Type A improvements by their Tier 1 or Tier 2 improvement priority.

Each Type A improvement project recommendations should be confirmed using localized flow monitoring and complete invert survey during preliminary design. The hydraulic model should be updated and improvement sizing and their extents confirmed prior to final design.

Figure 7-2. Type A Improvement with Original and Replacement Pipe Sizes

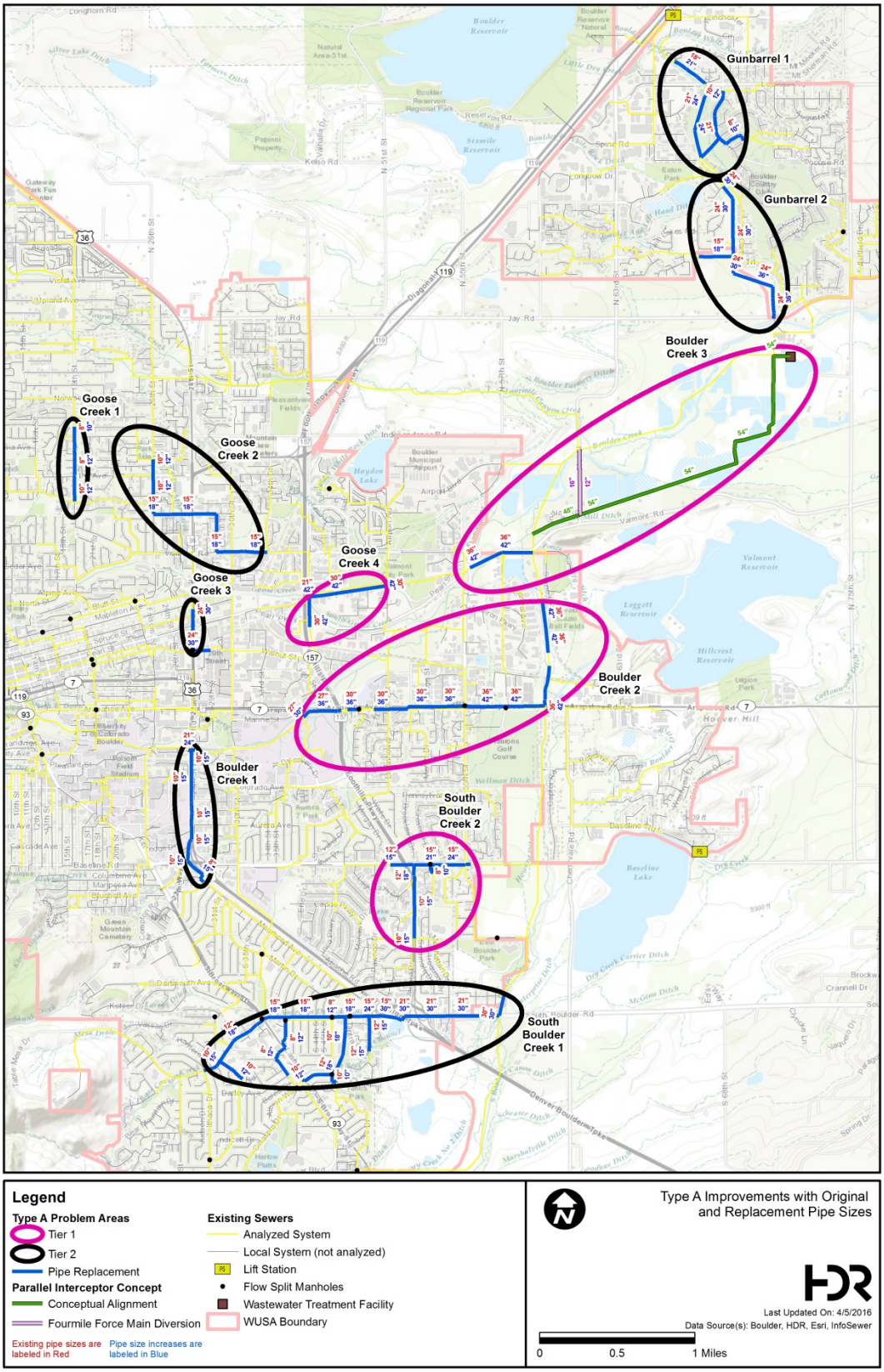


Table 7-1. Type A Improvement Summary with Original and Replacement Pipe Sizes

Problem Location	Existing Pipe Diameter(s)	Recommended Diameter(s)	Project Extents: Pipe Length per Diameter Size
Boulder Creek 1	8-, 10-, and 12-inch	12-inch	324 feet
		15-inch	4,586
		24-inch	208
Boulder Creek 2	27-, 30-, and 36-inch	30-inch	262 feet
		36-inch	4,687 feet
		42-inch	5,861 feet
Boulder Creek 3	36-inch	12-inch	2,210 feet
		16-inch	2,210 feet
		42-inch	2,216 feet
		48-inch	1,750 feet
		54-inch	10,788 feet
Goose Creek 1	8-, and 10-inch	10-inch	363 feet
		12-inch	2,176 feet
Goose Creek 2	10-, and 15-inch	12-inch	1,866 feet
		18-inch	5,197 feet
Goose Creek 3	24-inch	24-inch	272 feet
		30-inch	1,673 feet
Goose Creek 4	21-, and 30-inch	42-inch	4,016 feet
Gunbarrel 1	8-, 10-, 12-, 18-, and 21-inch	8-inch	37 feet
		10-inch	1,111 feet
		12-inch	1,278 feet
		15-inch	784 feet
		21-inch	1,877 feet
		24-inch	2,308 feet
Gunbarrel 2	15-, and 24-inch	18-inch	1,194 feet
		30-inch	3,585 feet
		36-inch	2,007 feet
South Boulder Creek 1	8-, 10-, 12-, 15-, 18-, 21-, and 30-inch	10-inch	109 feet
		12-inch	5,229 feet
		15-inch	3,017 feet
		18-inch	7,076 feet
		21-inch	377 feet
		24-inch	375 feet
		30-inch	5,295 feet
South Boulder Creek 2	8-,10-,12-,15-, and 24-inch	10-inch	619 feet
		12-inch	24 feet
		15-inch	2,891 feet
		18-inch	417 feet

Table 7-1. Type A Improvement Summary with Original and Replacement Pipe Sizes

Problem Location	Existing Pipe Diameter(s)	Recommended Diameter(s)	Project Extents: Pipe Length per Diameter Size
		21-inch	1,326 feet
		24-inch	447 feet
		30-inch	156 feet

Table 7-2. Type A Improvement Priority Ranking

Problem Location	Level of Service	Problem Extent	RPM Pipes	SSO Risk	Lateral Backup Risk	Construct-ability	Observed Problem	Relative Benefit	Priority Tier
Boulder Creek 1	15-, 20-, and 25-Year	High	N/A	Medium	Medium	High	Low	Low	Tier 2
Boulder Creek 2	15-, 20-, and 25-Year	High	N/A	Low	High	Low	Medium	High	Tier 1
Boulder Creek 3	15-, 20-, and 25-Year	High	N/A	High	Low	Low	High	High	Tier 1
Goose Creek 1	15-, 20-, and 25-Year	Medium	N/A	Medium	Medium	Medium	Low	Low	Tier 2
Goose Creek 2	15-, 20-, and 25-Year	High	N/A	Low	High	Low	High	Medium	Tier 2
Goose Creek 3	15-, 20-, and 25-Year	Low	N/A	Medium	Medium	Low	Low	Low	Tier 2
Goose Creek 4	15-, 20-, and 25-Year	Medium	High	Medium	Medium	Low	High	High	Tier 1
Gunbarrel 1	15-, 20-, and 25-Year	High	N/A	Low	Medium	High	Medium	Low	Tier 2
Gunbarrel 2	15-, 20-, and 25-Year	High	N/A	Low	Medium	High	Medium	Low	Tier 2
South Boulder Creek 1	15-, 20-, and 25-Year	High	N/A	High	High	Low	Medium	Medium	Tier 2
South Boulder Creek 2	15-, 20-, and 25-Year	High	High	High	Medium	Low	High	High	Tier 1

7.1.4 Type B Problem Improvements

Type B problems identified in TM 4.1 – Collection System Capacity Analysis and Capacity Limitations Identification were addressed with pipe replacements, upsizing, or, in cases where there is a reverse slope pipe, re-grading until the pipe met capacity criteria under 25-year buildout peak hour wet weather conditions. No alternatives to pipe replacement, upsizing, or regrading reversed slope pipes were developed. Figure 7-3 depicts Type B improvements recommendations with the original and replacement pipe sizes. Type B improvement costs are addressed as one lump sum in the cost estimate section. These pipe deficiencies and improvements should be verified before any design is begun. Type B capacity limitations should be further validated through additional localized flow monitoring and invert survey to verify capacity constraints and, if still valid, further capital improvements may be necessary.

7.1.5 Type C Problem Improvements

Type C problems are isolated stretches of sewer in the local collector and local systems where peak wet weather flow levels fall between 60 and 80 percent d/D. For the majority of these sewers this threshold is only marginally exceeded. Figure 7-4 shows these locations.

Type C sewers are under stress for the model scenarios, but are not significant enough to constitute their own capital improvement projects. Type C areas are locations where CCTV and localized flow monitoring and invert survey are recommended to validate the problem extent. Based on the results from the capacity validation activities and actual upstream growth, they could be considered for upsizing if necessary. In areas of the system with little upstream growth and future additional flow, some of the Type C problems may be addressed through decreased RDII contribution as the local and local collector systems are rehabilitated. Neither pipe improvement alternatives nor costs were developed for Type C problems.

Figure 7-3. Type B Improvement with Original and Replacement Pipe Sizes

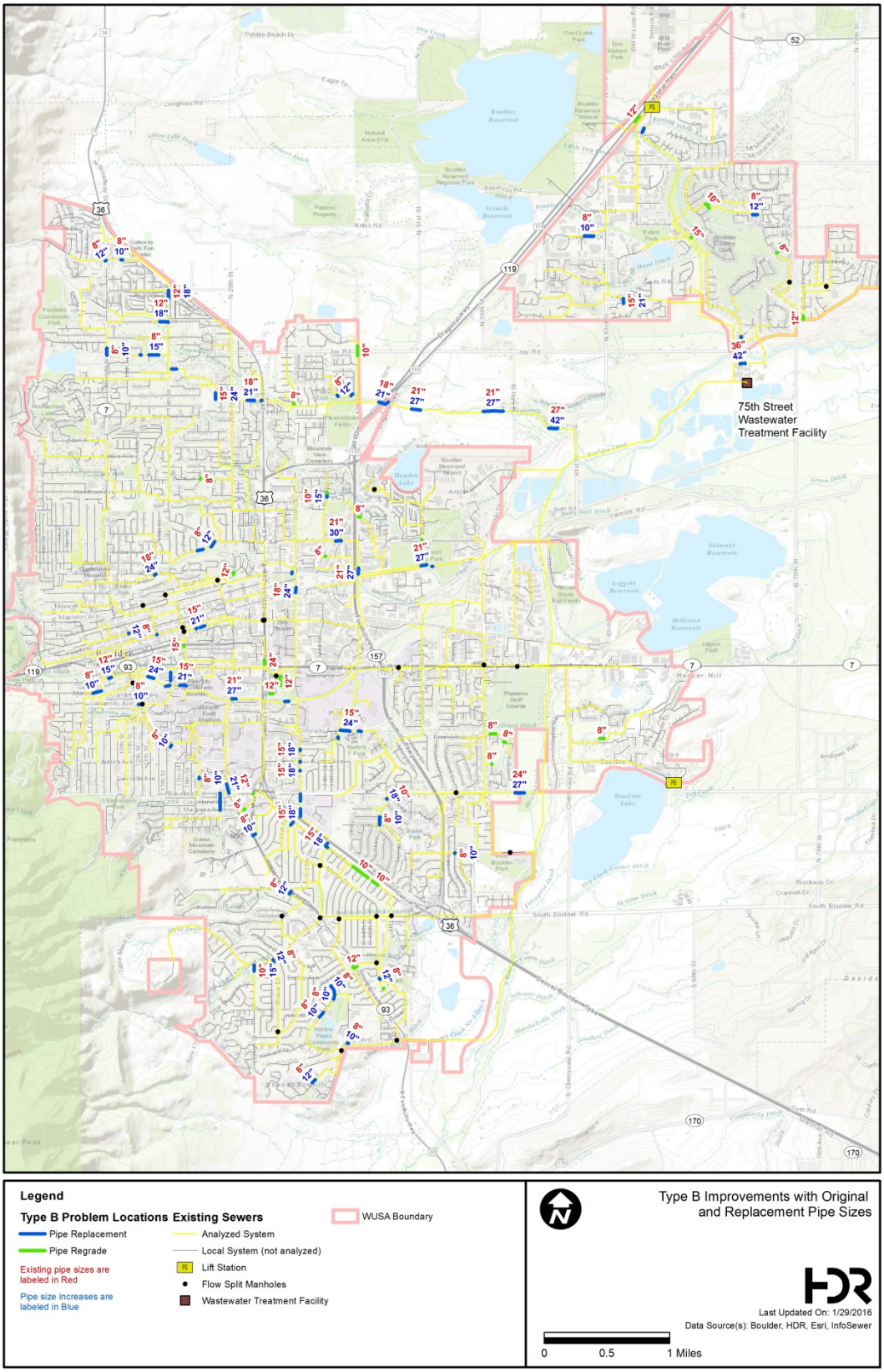
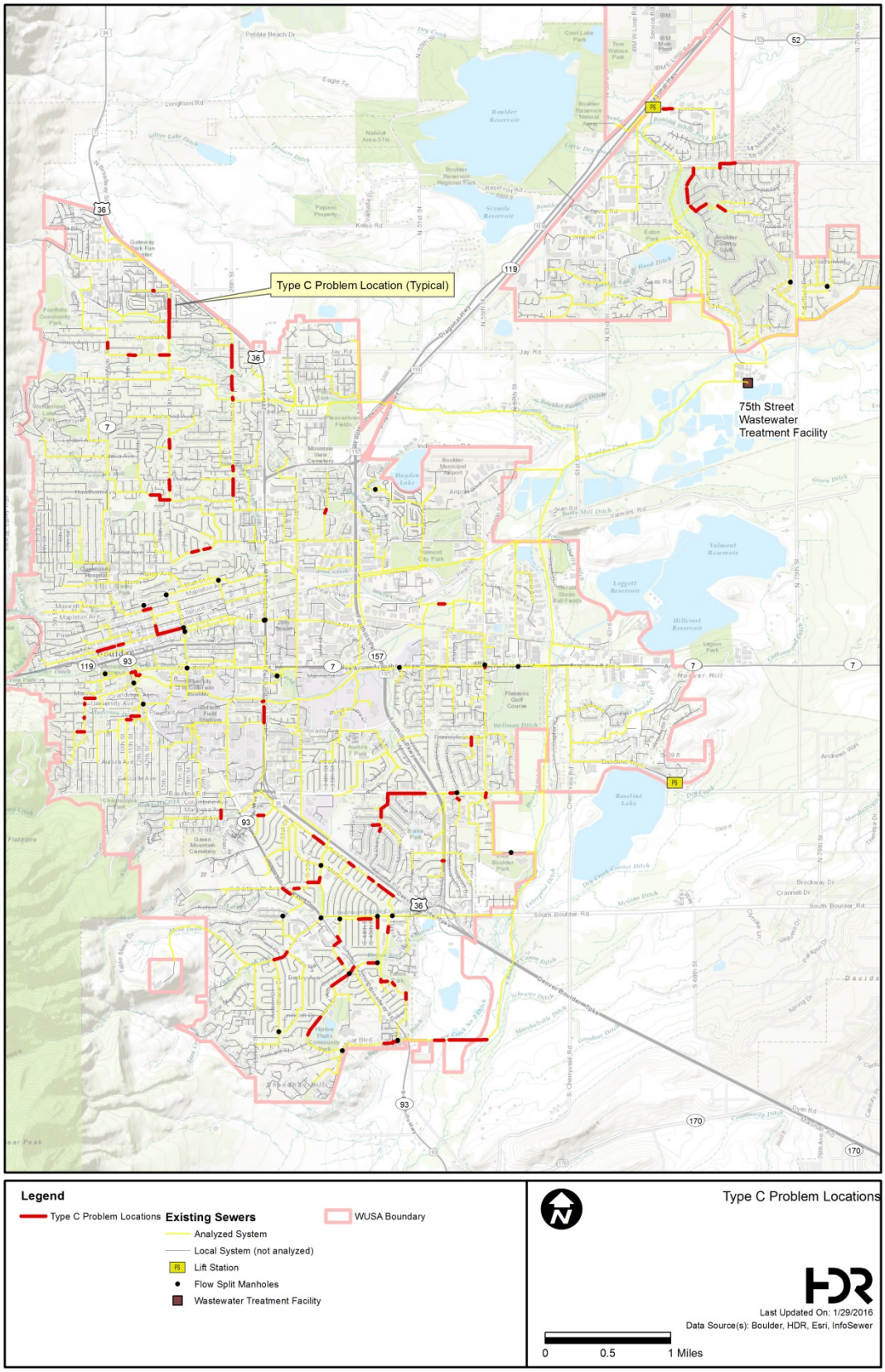


Figure 7-4. Type C Problem Locations



7.2 Boulder Creek Interceptor Capacity

The city has observed that the Boulder Creek Interceptor is reaching capacity during wet weather events and has experienced surcharging and SSOs during rainfall events less than a 15-year reoccurrence interval. Modeling confirms this observation in that the Boulder Creek Interceptor is under capacity for all modeled events, including portions of the interceptor under existing ADWF conditions. One of the main environmental compliance goals of the city is addressing this section of interceptor. Therefore, the Boulder Creek Interceptor parallel improvement project is recommended as a Type A Tier 1 improvement. Through modeling under the 25-year buildout peak hour wet-weather condition scenario, a 48-inch transitioning into a 54-inch parallel interceptor improvement is recommended to accommodate the 70 mgd flow from the Goose Creek, Boulder Creek, Fourmile Creek, and South Boulder Creek basins.

Of the 70 mgd total interceptor flow, 7 mgd is from the Fourmile Creek basin. The flow from the Fourmile Creek basin would need to be routed to the parallel interceptor via a diversion along 61st Street. Challenges of this diversion include:

- Passing under Boulder Creek
- Construction along 61st Street.
- The diversion sewer bucking grade going south away from Boulder Creek

These challenges would result in a likely siphon lift station and force main to pass the 7 mgd flows under Boulder Creek to minimize depth along 61st Street. The force main is recommended to be two parallel 12-inch and 16-inch diameter pipes to balance flows through the force mains between dry and wet weather conditions as well as handle the range of existing and future flows. Duel force mains also provide the advantage of operational redundancy during maintenance periods and maintaining scour velocity during dry-weather flow periods.

7.3 Construction Costs

Itemized opinion of probable construction cost (OPCC) estimates were developed for each recommended Type A improvement project with an anticipated level of accuracy of +50% to –30% (order-of-magnitude cost estimates). Type B improvement project costs are provided as a lump sum to be considered for use in monitoring and verifying capacity problems and improvement of confirmed issues. These cost estimates were prepared with the use of costing spreadsheets and model layouts typical of a master plan, with applying topography and system requirements to overall horizontal and vertical pipe layout. Cost estimates were not prepared to the detail of site specific information, constructability issues, or equipment details. The cost estimate worksheets are included in Appendix A for reference.

The estimates include capital construction costs and estimated land acquisition costs. Unit costs were obtained from Front Range bid tabs, RSMeans® Site Work and Landscape Cost Data, and equipment suppliers. Unit costs for pipeline and manhole construction include material, excavation, and backfill. Surface restoration was developed as a separate cost item. Minor utility relocations were accounted for as a percentage of the total construction cost. Quantities for pipes, manholes, and related improvements were obtained from the project GIS and hydraulic model based on the capacity analysis.

The wastewater utility modeling identified project areas (Type A) and pipes (Type B) that would have to be removed and replaced, augmented, or regraded. This information was broken down per

problem type (Type A or Type B), problem area (Type A), pipe diameter, manhole diameter, and improvement bury depths. The costs were developed based on the factors these quantities along with the stated assumptions below. All estimates are escalated to 2015 dollars and equate to an Engineering News Record, Construction Cost Index of 10,092.

Each heading is discussed in the order presented in the Budget Cost estimate sheets.

Insurance and Bonding – 10 percent of Pipe Improvement Subtotal costs for contractor insurance and bonding.

Mobilization – 6 percent of Pipe Improvement Subtotal costs for contractor equipment mobilization and staging setup. Mobilization was reduced for Boulder Creek 3 due to economy of scale.

Traffic Control – 5 percent of Pipe Improvement Subtotal costs for required traffic control during improvement construction. Traffic control was reduced for Boulder Creek 3 due to alignment being in a non-urban location.

Utility Relocation – 5 percent of Pipe Improvement Subtotal costs for temporary relocation of utilities (water, gas, electric, communications, etc.) encountered during improvement construction. Utility relocation was reduced for Boulder Creek 3 due to alignment being in a non-urban location.

Dewatering – 6 percent of Pipe Improvement Subtotal costs for dewatering of open trenches due to pipe alignments elevations determined to be at or below the mapped 8 foot groundwater table or within the 100-year flood plain.

Bypass Pumping – 12 percent of Pipe Improvement Subtotal costs for temporary routing of wastewater flows for pipes removed in the active system. Where possible, parallel pipes should be temporarily established to keep the active system in service and reduce or avoid parallel pipes until the new pipe is put into service. Bypass pumping was assigned a lump sum for Boulder Creek 3 based on discussion with the city based on the 61st Street Interceptor project.

Removal and Disposal – Cost based on pipe diameter of existing pipe and manhole to be removed and disposed.

Connect to Existing System – Reflects the number and cost of connecting to existing main lines that remain to the proposed new/replacement manholes.

Pipe – Shows the cost per diameter and depth of each replacement pipe segment within the problem area. The pipes are shown as “diameter in inches.depth to invert in feet”, i.e. 12.10 is a 12 inch diameter pipe with an average invert depth of 10 feet. Pipe cost has been developed utilizing contractor budget pricing for pipe equal to and greater 18 inch in diameter based on Vylon PS46 and A2000 PVC pipe. The cost of pipe below 18 inch diameter is based on 2008 Boulder Asset Management unit cost data using SDR 35 PVC pipe escalated to 2015 costs. The pipe costs reflect differences in excavation, bedding, and backfill quantities per pipe diameter and depth. This cost includes controlled fill placement over pipe but does not include final surface treatment. Existing Type B pipe was calculated to have an average depth to pipe of 10.5 feet and therefore pipe costs are based on the specified pipe diameter with a pipe depth of 12 feet (costs are based on every 2 feet of depth).

Service Taps – Cost to connect existing wastewater service lines to new wastewater main lines. This cost is sensitive to depth and is based on the 4 inch pipe cost from the pipe cost

section above. The service lines replacement was assumed to be an average length of 25 feet in order to extend it to the edge of the right-of-way. Type B service taps were based on the average pipe depth of 11 feet. The number of service lines/taps was obtained from the city's GIS data.

Stream/Road Crossing – Stream and road crossings are difficult to estimate based on unknown costs for permitting, stream flow rates, surrounding improvements and channel confinement among other factors. For this budget level cost estimate, sewers crossing streams were assumed to be cased with a casing pipe diameter 18" greater than the carrier pipe diameter. Unit costs are based on inch-diameter/100 lineal feet for the casing pipe.

Surface Restoration – Cost to restore surface to final condition, landscaped or hard paved. Assumes subgrade has been placed to appropriate elevation and density. The three surface restoration types assume a 12 foot surface restoration width regardless of the pipe diameter or depth. Asphalt depth was assumed to be 6 inches.

Manholes – Cost to replace manholes based on manhole type and diameter. Manhole depth was assumed to be a standard 10 feet.

Design Contingency – Type A Design Contingency is 30 percent, typical for budget planning efforts based on the detail of design data. Type B Design Contingency is 35% due to the averaging and combining of improvements. In addition, this allows for Type B projects to be extended some to address their confirmed project extents. Type B improvement project budget should be first used to confirm and then address any problems.

Engineering Design and Construction Administration – This cost is a standard 20 percent cost, typical for this level of budget planning.

7.4 Implementation Plan

Table 3 summarizes the implementation priorities as developed in Section 2 along with the opinions of probable construction costs. Itemized capital cost estimate worksheets are included in Appendix A. Based on discussion with the city, the Type A problems were prioritized accordingly. Table 3 presents these capital improvement costs in order of established priority.

Table 7-3. Existing Sewer System Summary – Modeled Elements

Problem Priority	Improvement ID	Improvement Location	Improvement Size (inches)	Total Improvement Length (feet)	Capital Cost
Tier 1	Boulder Creek 3	Valmont Rd and 61st St to WWTP	12 (FM),16 (FM),42, 48, 54, and 7 mgd Firm Lift Station	19,174	$19,673,000
Tier 1	South Boulder Creek 2	Foothills Pkwy, Baseline Rd	10, 12, 15, 18, 21, 24, 30	5,880	$3,497,000
Tier 1	Boulder Creek 2	Arapahoe Ave and Foothills Pkwy to Old Tale Rd; South Boulder Creek corridor	30, 36, 42	10,810	$12,605,000
Tier 1	Goose Creek 4	Foothills Pkwy and Pearl St	42	4,016	$2,584,000
				TIER 1 TOTAL	**$38,359,000**
Tier 2	Goose Creek 1	19th Street from Kalmia Ave to Grape Ave	10, 12	2,539	$1,292,000
Tier 2	South Boulder Creek 1	Table Mesa Dr, South Boulder Rd, S 46th St	10, 12, 15, 18, 21, 24, 30	21,478	$17,370,000
Tier 2	Boulder Creek 1	Colorado Ave and 28th St	12, 15, 24	5,118	$4,298,000
Tier 2	Goose Creek 3	28th Street from Pine St to Walnut St	24, 30	1,945	$1,250,000
Tier 2	Goose Creek 2	Folsom St/Glenwood Dr/Valmont Rd	12, 18	7,063	$4,004,000
Tier 2	Gunbarrel 1	Boulder and Left Hand Ditch; Idylwild Tr/Boulder Country Club	8, 10, 12, 15, 21, 24	7,395	$4,388,000
Tier 2	Gunbarrel 2	Boulder Supply Canal north of Jay Rd	18, 30, 36,	6,786	$5,467,000
				TIER 2 TOTAL	**$38,069,000**
				TIER 3 TOTAL1	**$18,299,000**
				TOTAL ALL PROJECTS TOTAL	**$94,727,000**

[1]Tier 3 cost reflect Type B improvements

7.5 Capital Project Tier I Fact Sheets

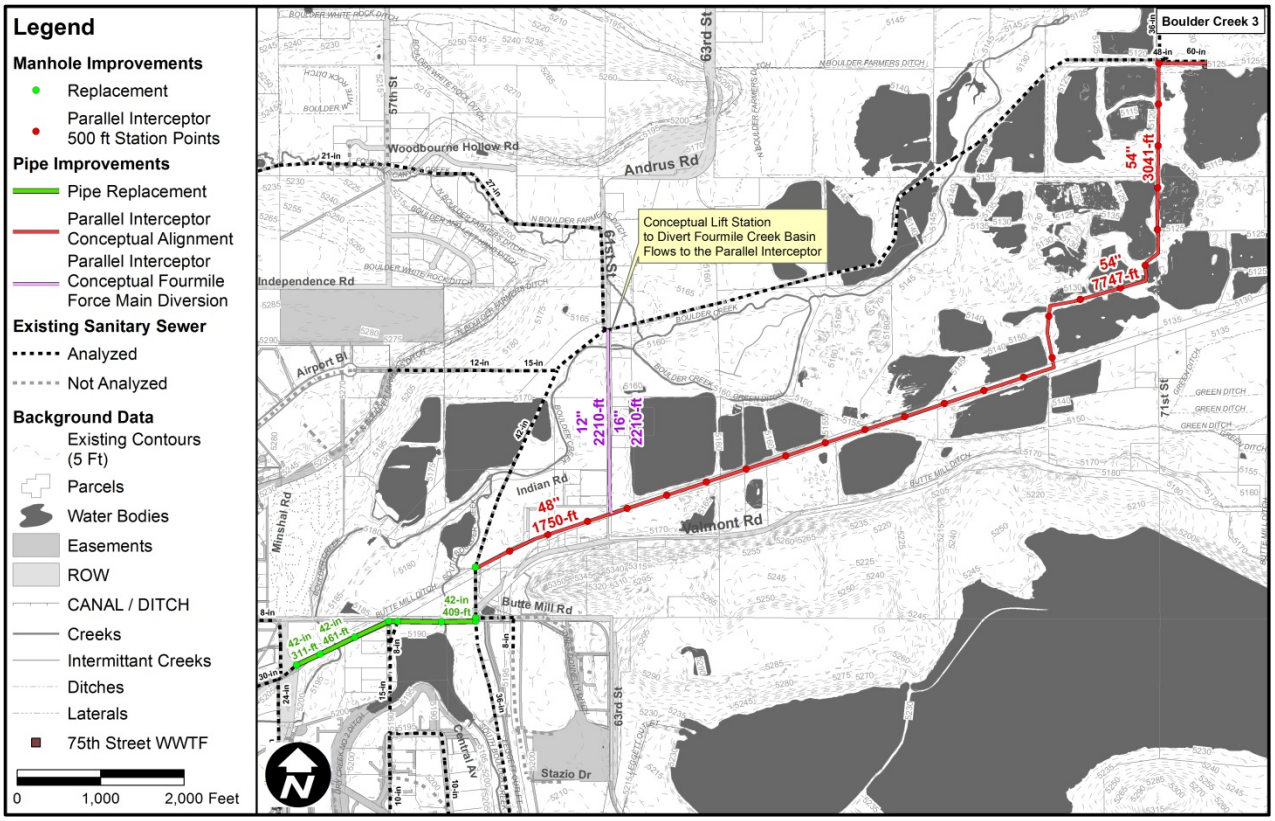
Fact sheets were developed to provide details regarding each of the Tier 1 improvement areas. These fact sheets provide the problem area ID, improvement location and alignment, technical data for initiating the design process, land ownership and acquisition needs, probable implementation issues, and an estimate of the capital construction costs. Flow triggers are included for the interceptor improvements to provide a flow rate when the capacity of the interceptor is reached according to the established capacity limitation criteria, and when improvements should be designed. The improvement plan map shown in the fact sheets identifies the recommended pipe size and lengths and general manhole locations.

The Data Confidence category within the fact sheets refers to the percentage of interpolated invert elevations needed to complete the modeling effort; specific information regarding this category is included in the problem characterization tables in Section 6. Similarly, the Calibration Confidence refers to how well model results matched the permanent flow meter data. *It is recommended that projects with a Medium confidence level in the Calibration category and confidence levels below 70 percent in the Data category be refined through data surveys and/or temporary flow monitoring before they are included in the Utilities' 6-year CIP project list to validate the project elements.*

This section includes fact sheets that provide details for each of the Type A (Tier 1 and Tier 2) improvement areas. These fact sheets are organized by their established priority.

Table 7-4. Boulder Creek 3 Capital Project Tier I Fact Sheet

Improvement Location:	**Valmont Rd and 61st St to WWTP**
Problem ID:	**Boulder Creek 3 (Tier 1 Priority Level)**

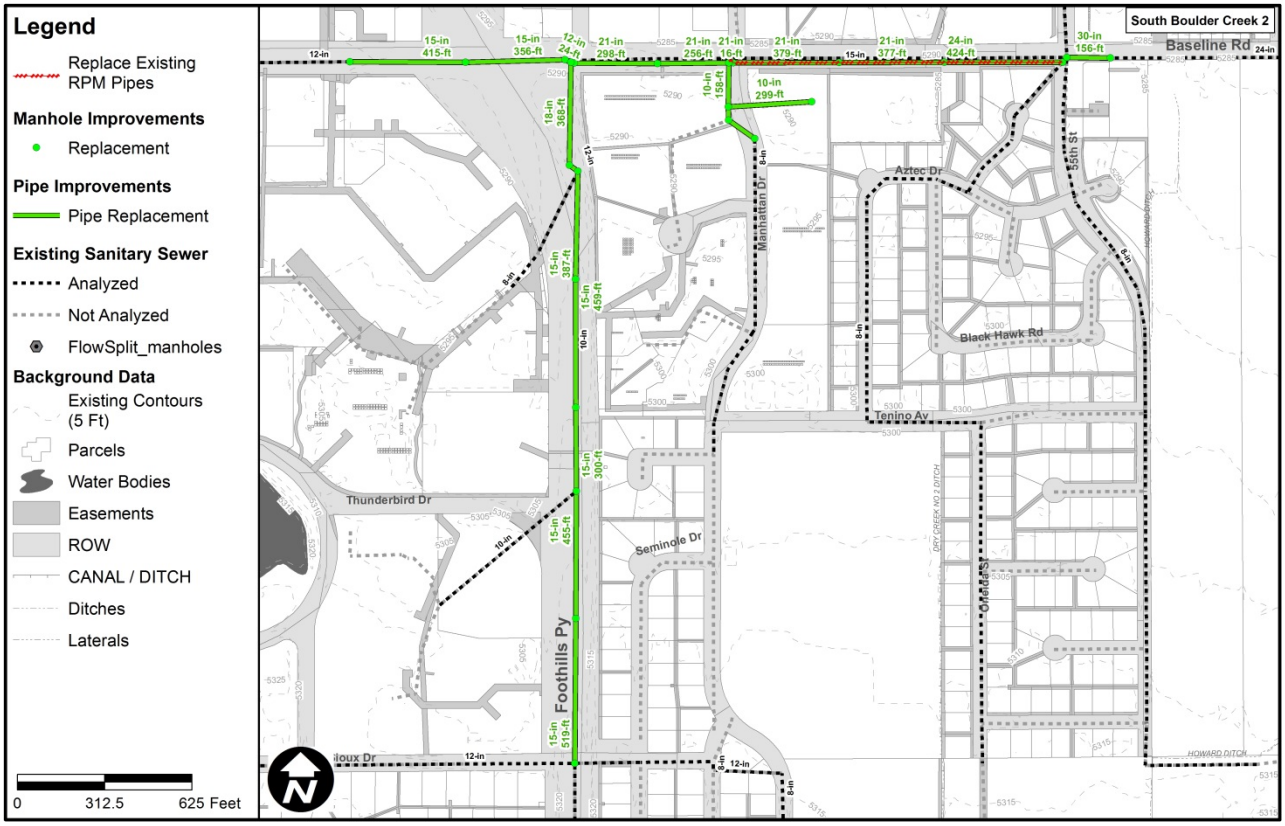


Improvement Description	• Replace 2,216 feet of existing interceptor pipe from 36-inch diameter to 42-inch diameter. • Construct 1,750 feet of 48-inch diameter and 10,788 feet of 54-inch diameter parallel interceptor pipe. • Plug and abandon existing interceptor to the north of the new parallel interceptor. • Construct new 7 mgd firm lift station to divert flows from the Fourmile Creek basin to the new parallel interceptor. • Construct 2,210 feet of parallel 16-inch and 12-inch diameter force main along 61st Street
Technical Data:	The entire system is required to convey buildout dry weather and 25-year level of service wet weather flows to the established analysis criteria. Expected buildout 25-year peak flow ranges from 13,849 gpm in the Valmont Road interceptor (from the Goose Creek basin) to 43,687 gpm in the parallel Boulder Creek interceptor (after receiving Boulder Creek flow).
Data Confidence:	100% (0 of 32 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	High

Flow Trigger:	9,870 gpm on 30-inch line along Valmont Rd
Land Ownership:	ROW purchase will be necessary for the parallel interceptor as the alignment does not follow an established road or easement.
Implementation Issues:	• Dewatering will be required along the entire alignment. • Constructability issues due to alignment around existing gravel pits and potentially along a railroad ROW • Surface treatment of primarily open space with some asphalt pavement.
Estimated Capital Cost:	$19,673,000

Table 7-5. South Boulder Creek 2 Capital Project Tier I Fact Sheet

Improvement Location:	**Foothills Pkwy, Baseline Rd**
Problem ID:	**South Boulder Creek 2 (Tier 1 Priority Level)**

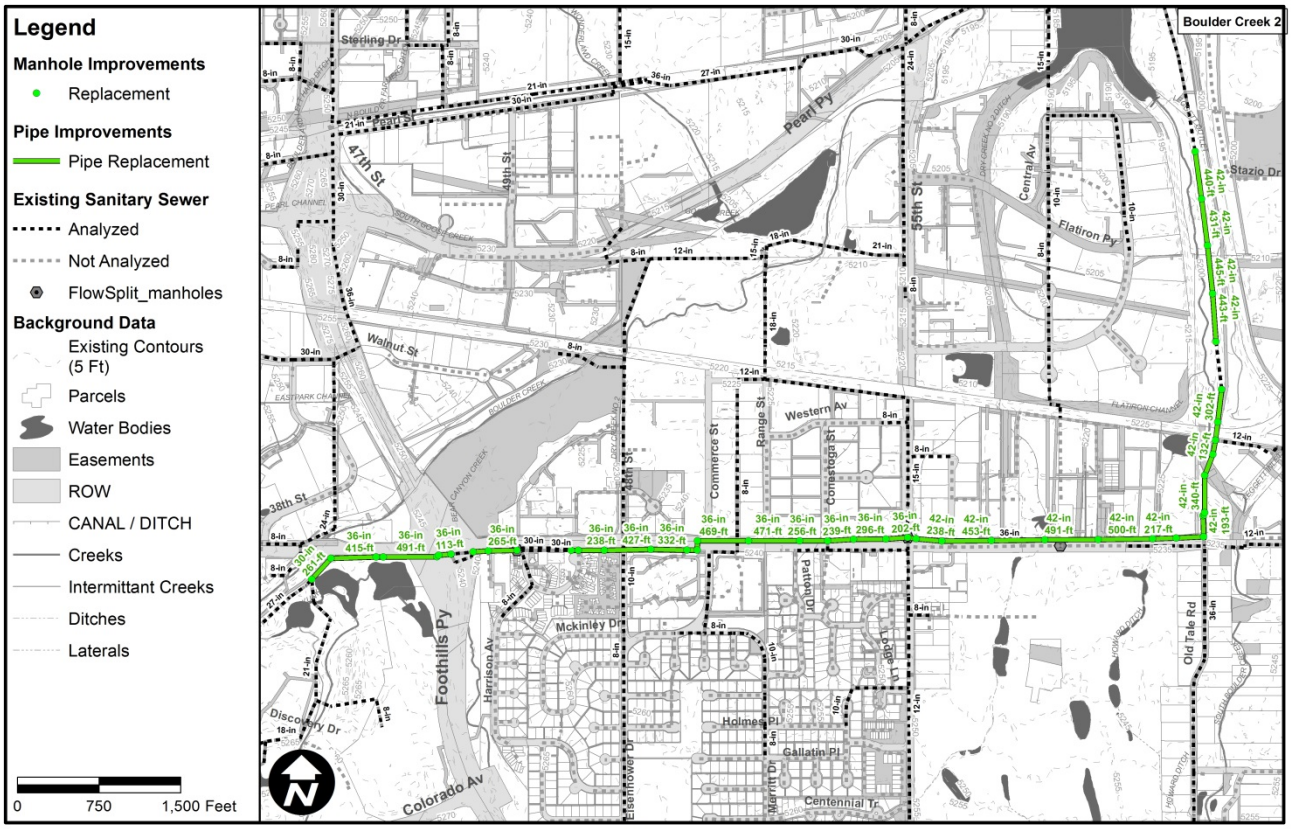


Improvement Description	• Replace 619 feet of existing local collector pipe from 8-inch diameter to 10-inch diameter. • Replace 2,120 feet of existing pipe from 10-inch diameter to 15-inch diameter. • Construct 24 feet of 12-inch diameter pipe connection so that only one sewer line needs to be upsized. • Replace 771 feet of existing local collector pipe from 12-inch diameter to 15-inch diameter. • Replace 405 feet of existing local collector pipe from 12-inch diameter to 18-inch diameter. • Replace 12 feet of existing collector/interceptor pipe from 15-inch diameter to 18-inch diameter. • Replace 1,326 feet of existing collector/interceptor pipe from 15-inch diameter to 21-inch diameter (7 feet of which is RPM pipe). • Replace 447 feet of existing collector/interceptor pipe from 15-inch diameter to 24-inch diameter (424 feet of which is RPM pipe). • Replace 156 feet of existing pipe from 24-inch diameter to 30-inch diameter.

Technical Data:	The entire system is required to convey buildout dry weather and 25-year level of service wet weather flows to the established analysis criteria. Expected buildout 25-year peak flow ranges from 12 gpm in the local collector pipes to 3,583 gpm in the collector/interceptor pipes.
Data Confidence:	85% (3 of 20 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	High
Flow Trigger:	750 gpm on 12-inch line along Baseline Rd; 600 gpm on 10-inch line along Foothills Pkwy
Land Ownership:	Construction is limited to Foothills Pkwy, Baseline Rd, and Manhattan Dr ROWs and land presently owned by the city. No land ownership issues should be present.
Implementation Issues:	• Constructability issues due to highway and major roads will slow rate of construction. • Requires a crossing of three canals: West Valley Split Flow, 55th Street Split Flow, and Dry Creek Ditch No. 2. • Surface treatment of asphalt pavement.
Estimated Capital Cost:	$3,497,000

Table 7-6. Boulder Creek 2 Capital Project Tier I Fact Sheet

Improvement Location:	**Arapahoe Ave and Foothills Pkwy to Old Tale Rd; South Boulder Creek Corridor**
Problem ID:	**Boulder Creek 2 (Tier 1 Priority Level)**

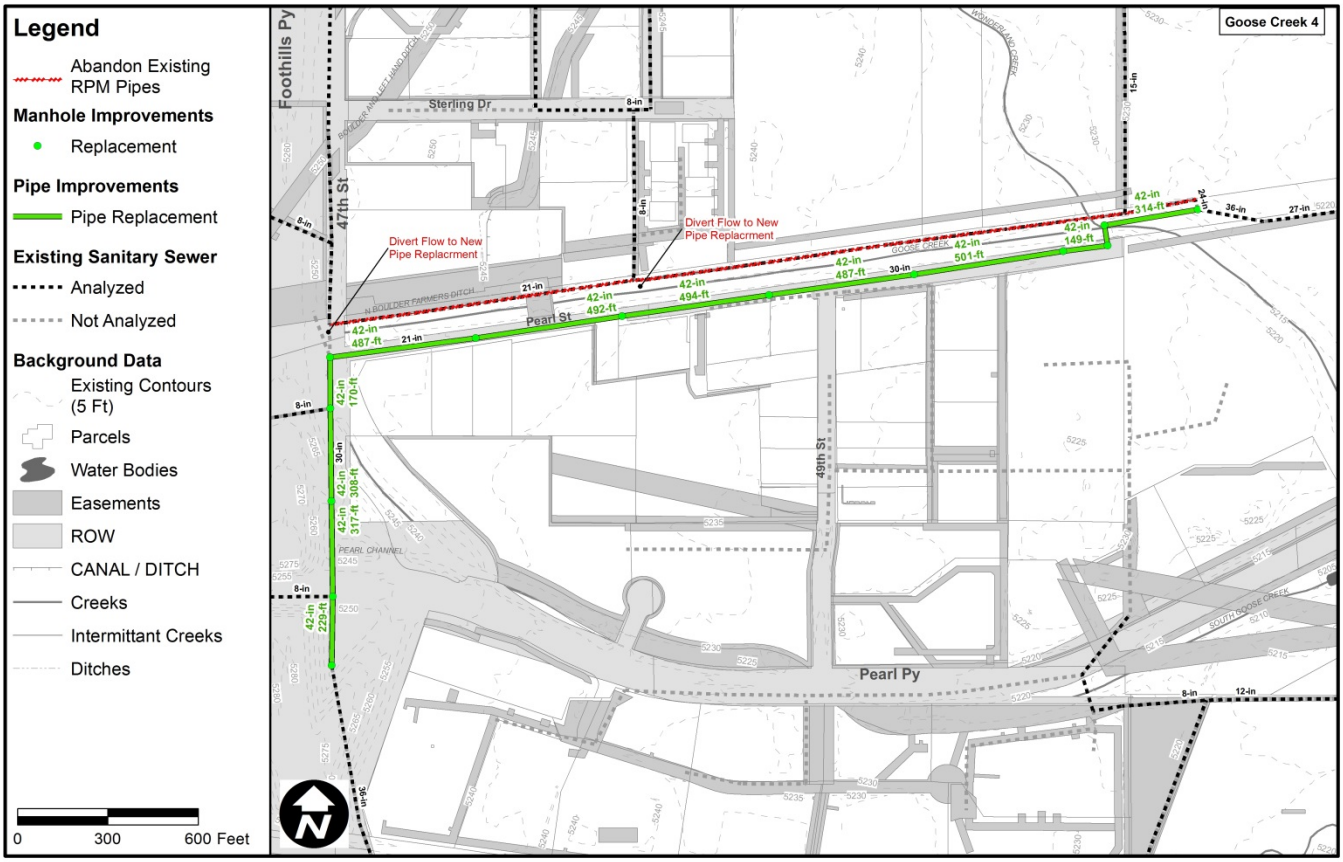


Improvement Description	• Replace 262 feet of existing collector/interceptor pipe from 27-inch diameter to 30-inch diameter. • Replace 973 feet of existing collector/interceptor pipe from 27-inch diameter to 36-inch diameter. • Replace 3,714 feet of existing collector/interceptor pipe from 30-inch diameter to 36-inch diameter. • Replace 5,861 feet of existing collector/interceptor pipe from 36-inch diameter to 42-inch diameter.
Technical Data:	The entire system is required to convey buildout dry weather and 25-year level of service wet weather flows to the established analysis criteria. Expected buildout 25-year peak flow ranges from 2,017 gpm to 4,108 gpm in the collector/interceptor pipes.
Data Confidence:	80% (6 of 30 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	High
Flow Trigger:	9,330 gpm on 27-inch line along Arapahoe Ave

Land Ownership:	Construction is limited to Arapahoe Ave. ROW, utility ROW, and land presently owned by the city. No land ownership issues should be present.
Implementation Issues:	• Constructability issues due to highway and major roads will slow rate of construction. • Depending on depth of groundwater present in vicinity of replacement pipe, dewatering may be required. • Requires crossing Arapahoe Ave. • Requires crossing Foothills Pkwy. • Bypass pumping of large volumes of sewage. • Surface treatment of primarily asphalt pavement with some open space.
Estimated Capital Cost:	$12,605,000

Table 7-7. Goose Creek 4 Capital Project Tier I Fact Sheet

Improvement Location:	**Foothills Pkwy and Pearl St**
Problem ID:	**Goose Creek 4 (Tier 1 Priority Level)**

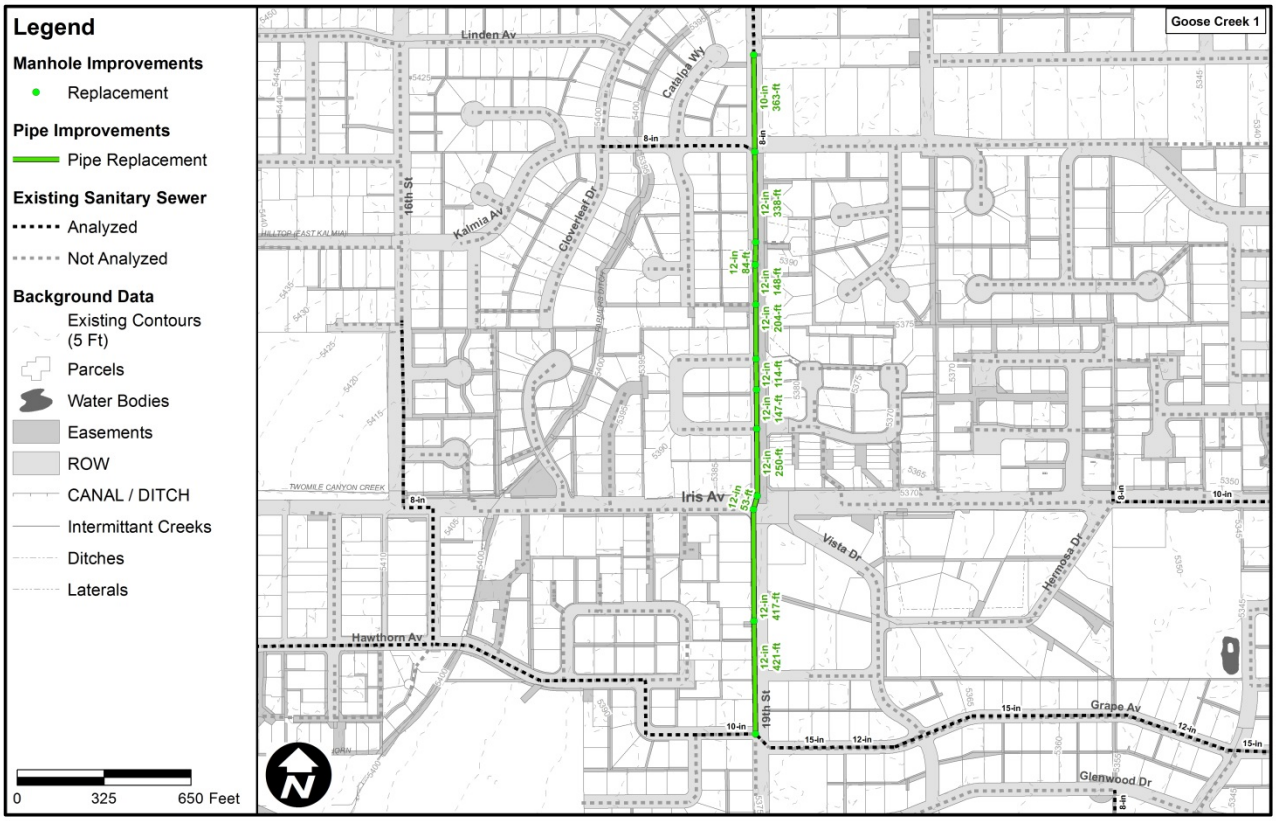


Improvement Description	• Replace 487 feet of existing collector/interceptor pipe from 21-inch diameter to 42-inch diameter. • Replace 3,529 feet of existing collector/interceptor pipe from 30-inch diameter to 42-inch diameter. • Abandon existing RPM pipes and divert flow south to new replacement pipe.
Technical Data:	The entire system is required to convey buildout dry weather and 25-year level of service wet weather flows to the established analysis criteria. Expected buildout 25-year peak flow ranges from 8,650 gpm to 8,876 gpm in the collector/interceptor pipes.
Data Confidence:	70% (3 of 10 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	High
Flow Trigger:	4,300 gpm on 30-inch line at the intersection of Pearl Pkwy and Foothills Pkwy
Land Ownership:	Construction is limited to Foothills Pkwy and Pearl St ROWs and land presently owned by the city. No land ownership issues should be present.

Implementation Issues:	• Dewatering will be required. • Constructability issues due to road construction. • Requires crossing Foothills Pkwy. • Requires crossing North Goose Creek • Bypass pumping of large volumes of sewage.
Estimated Capital Cost:	$2,584,000

Table 7-8. Goose Creek 1 Capital Project Tier I Fact Sheet

Improvement Location:	**19th Street from Kalmia Ave to Grape Ave**
Problem ID:	**Goose Creek 1 (Tier 2 Priority Level)**

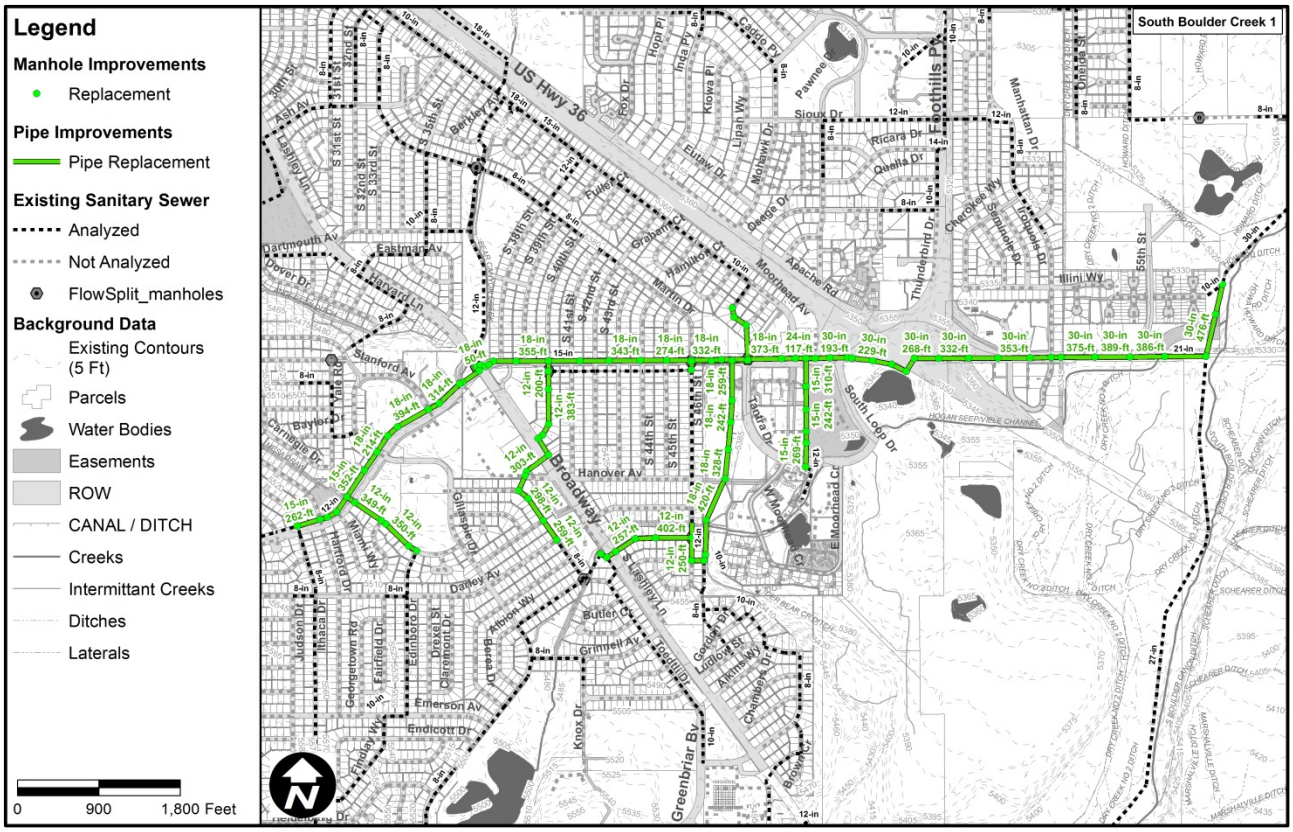


Improvement Description	• Replace 363 feet of existing local collector pipe from 8-inch diameter to 10-inch diameter. • Replace 1,338 feet of existing local collector pipe from 8-inch diameter to 12-inch diameter. • Upsize 838 feet of existing local collector pipe from 10-inch diameter to 12-inch diameter.
Technical Data:	The entire system is required to convey buildout dry weather and 25-year level of service wet weather flows to the established analysis criteria. Expected buildout 25-year peak flow ranges from 319 gpm to 631 gpm in the local collector pipes.
Data Confidence:	80% (2 of 10 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	Medium
Flow Trigger:	230 gpm on 8-inch line along 19th St
Land Ownership:	Construction is limited to 19th Street ROW along local streets

Implementation Issues:	• Depending on depth of groundwater present in vicinity of replacement pipe, dewatering may be required. • Constructability issues due to road construction. • Bypass pumping required.
Estimated Capital Cost:	$1,292,000

Table 7-9. South Boulder Creek 1 Capital Project Tier I Fact Sheet

Improvement Location:	**Table Mesa Dr, South Boulder Rd, S 46th St**
Problem ID:	**South Boulder Creek 1 (Tier 2 Priority Level)**

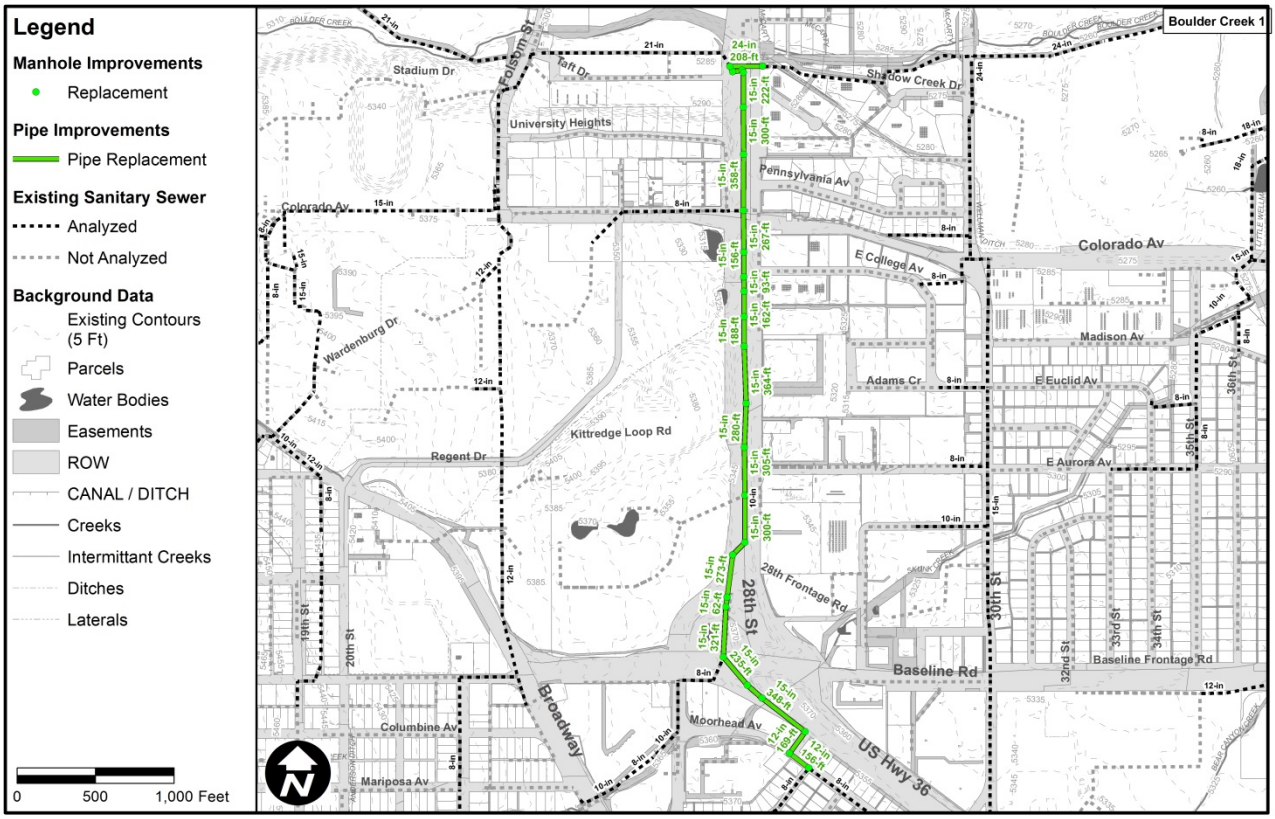


Improvement Description	• Replace 109 feet of existing local collector pipe from 8-inch diameter to 10-inch diameter. • Replace 2,863 feet of existing local collector pipe from 8-inch diameter to 12-inch diameter. • Replace 2,366 feet of existing local collector pipe from 10-inch diameter to 12-inch diameter. • Replace 616 feet of existing local collector pipe from 10-inch diameter to 15-inch diameter. • Replace 2,401 feet of existing local collector pipe from 12-inch diameter to 15-inch diameter. • Replace 1,500 feet of existing local collector pipe from 10-inch diameter to 18-inch diameter. • Replace 2,469 feet of existing local collector pipe from 12-inch diameter to 18-inch diameter. • Replace 3,107 feet of existing collector/interceptor pipe from 15-inch diameter to 18-inch diameter.

	• Replace 377 feet of existing local collector pipe from 10-inch diameter to 21-inch diameter. • Replace 375 feet of existing collector/interceptor pipe from 15-inch diameter to 24-inch diameter. • Replace 549 feet of existing collector/interceptor pipe from 15-inch diameter to 30-inch diameter. • Replace 354 feet of existing collector/interceptor pipe from 18-inch diameter to 30-inch diameter. • Replace 3,576 feet of existing collector/interceptor pipe from 21-inch diameter to 30-inch diameter. • Replace and re-grade 816 feet of 30-inch diameter collector/interceptor pipe (slope adjustment). • Plug 10 inch line at an existing flow diversion to only upsize on stretch of sewer main
Technical Data:	The entire system is required to convey buildout dry weather and 25-year level of service wet weather flows to the established analysis criteria. Expected buildout 25-year peak flow ranges from 5 gpm in the local collector pipes to 9,290 gpm in the collector/interceptor pipes.
Data Confidence:	79% (15 of 72 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	High
Flow Trigger:	2,040 gpm on 12-inch line along Table Mesa Dr, 210 gpm on 8-inch line along Toedtli Dr; 270 gpm on 8-inch line at Broadway Ave at the Viele Lake Canal crossing
Land Ownership:	Construction is limited to Table Mesa Dr, US Hwy 36, Foothills Pkwy,Yale Rd, S 40th St, Toedtli Dr, Whitney Pl, 48th St, Brookfield Dr, Ingram Ct, and 46th St ROWs, utility easements, land presently owned by the city, and private parking lots.
Implementation Issues:	• Depending on depth of groundwater present in vicinity of replacement pipe, dewatering may be required. • Large area of construction impacting several roadways. • Constructability issues due to highway and major roads will slow rate of construction. • Requires crossing Bear Canyon Creek, Viele Lake Canal at three locations, and Anderson Extension Ditch at seven locations. • Requires crossing Broadway at three locations. • Requires crossing US Hwy 36. • Requires crossing Foothills Pkwy. • Bypass pumping of large volumes of sewage. • Requires crossing Tantra Dr.
Estimated Capital Cost:	$17,370,000

Table 7-10. Boulder Creek 1 Capital Project Tier I Fact Sheet

Improvement Location:	**Colorado Ave and 28th St**
Problem ID:	**Boulder Creek 1 (Tier 2 Priority Level)**

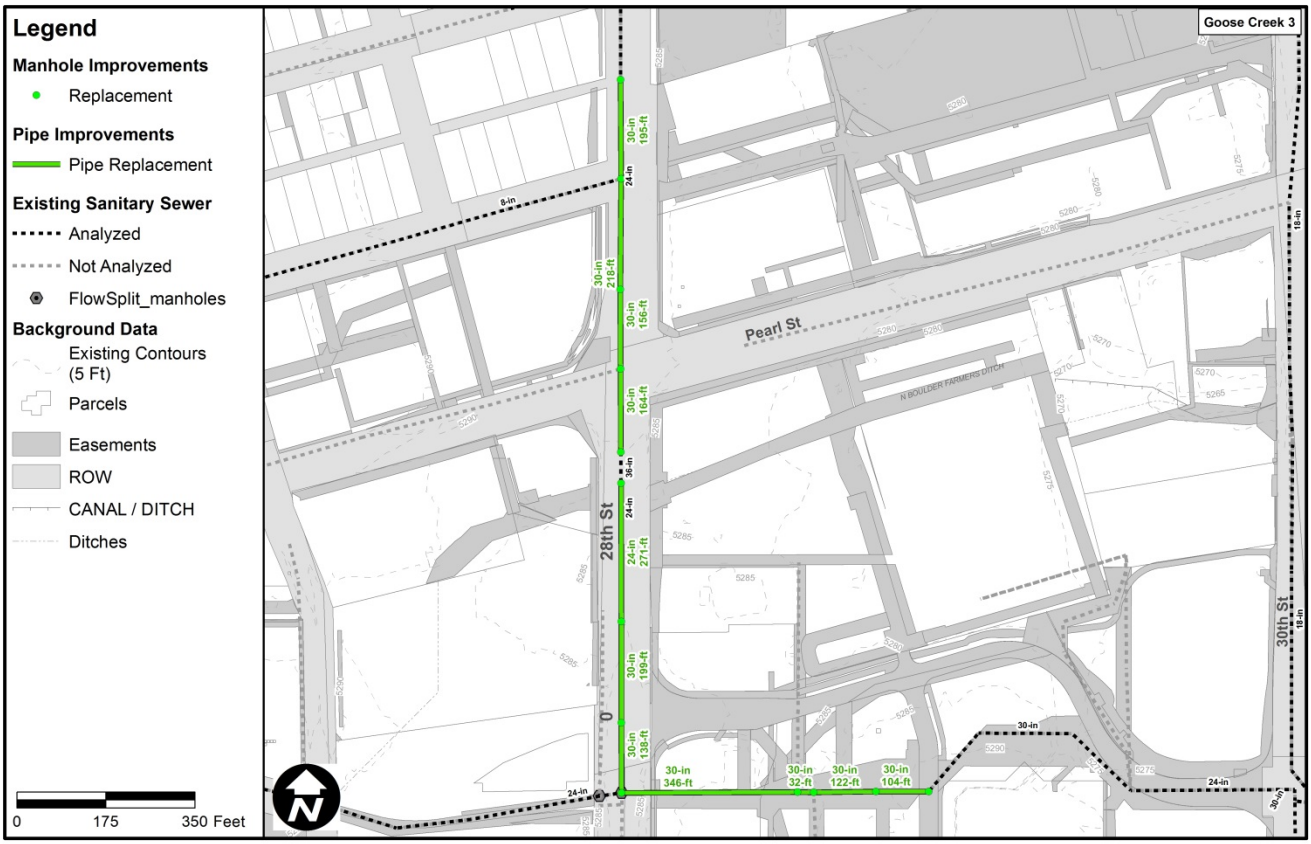


Improvement Description	• Replace 324 feet of existing local collector pipe from 8-inch diameter to 12-inch diameter. • Replace 472 feet of existing local collector pipe from 8-inch diameter to 15-inch diameter. • Replace 4,114 feet of existing local collector pipe from 10-inch diameter to 15-inch diameter. • Replace 208 feet of existing pipe from 21-inch diameter to 24-inch diameter.
Technical Data:	The entire system is required to convey buildout dry weather and 25-year level of service wet weather flows to the established analysis criteria. Expected buildout 25-year peak flow ranges from 639 gpm to 5,250 gpm in the local collector pipes.
Data Confidence:	80% (3 of 15 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	Medium
Flow Trigger:	230 gpm on 8-inch line along Moorhead Ave
Land Ownership:	Construction is limited to Moorhead Ave, Moorhead Frontage Rd, US Highway 36, and 28th Frontage Rd ROWs. No land ownership issues should be present.

Implementation Issues:	• Depending on depth of groundwater present in vicinity of replacement pipe, dewatering may be required. • Constructability issues due to highway and major roads will slow rate of construction. • Requires construction under Colorado Avenue Creek and along US Highway 36. • Bypass pumping of large volumes of sewage. • Requires construction under Skunk Creek. • Surface treatment of concrete and asphalt pavement.
Estimated Capital Cost:	$4,298,000

Table 7-11. Goose Creek 3 Capital Project Tier I Fact Sheet

Improvement Location:	**28th Street from Pine St to Walnut St**
Problem ID:	**Goose Creek 3 (Tier 2 Priority Level)**

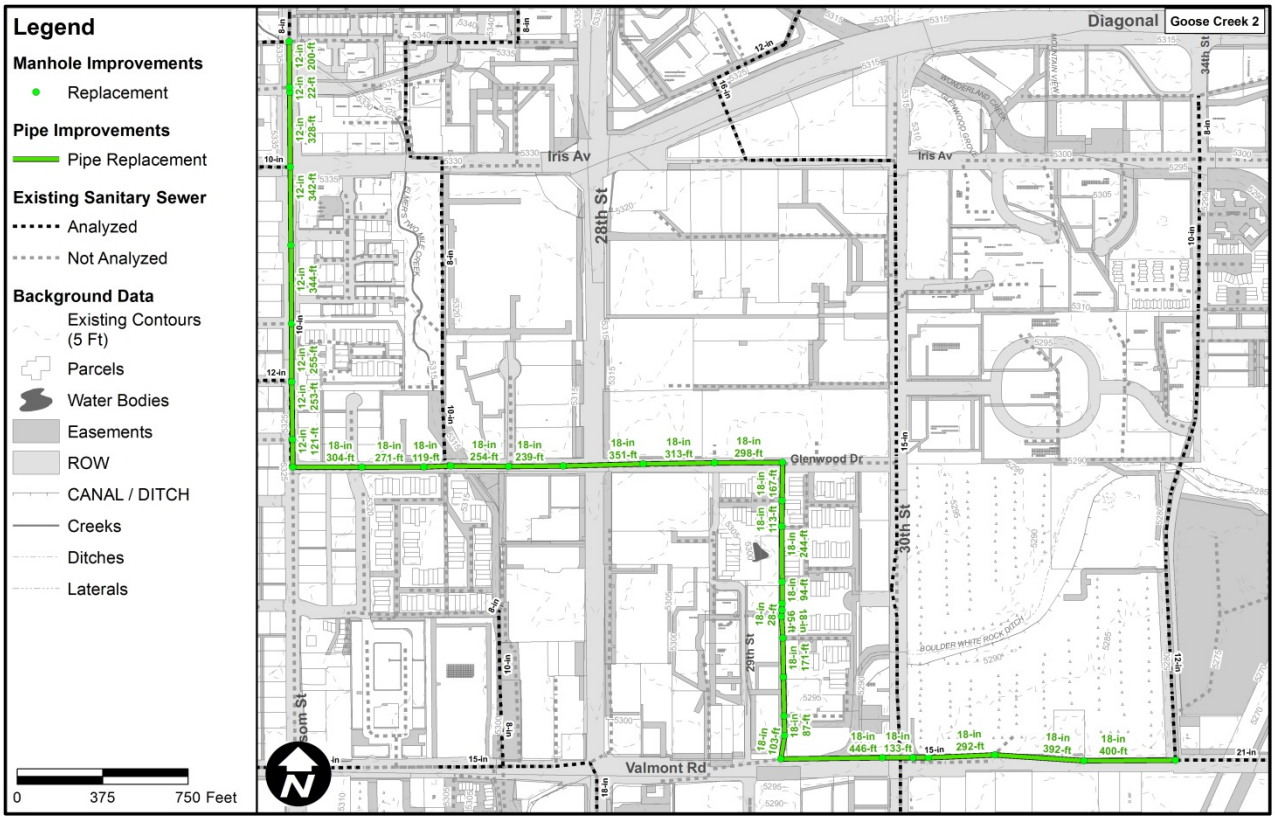


Improvement Description	• Replace and re-grade 272 feet of 24-inch diameter collector/interceptor pipe (slope adjustment). • Replace 1,673 feet of existing collector/interceptor pipe from 24-inch diameter to 30-inch diameter.
Technical Data:	The entire system is required to convey buildout dry weather and 25-year level of service wet weather flows to the established analysis criteria. Expected buildout 25-year peak flow ranges from 2,106 gpm to 2,961 gpm in the collector/interceptor pipes.
Data Confidence:	66% (1 of 3 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	Medium
Flow Trigger:	3,150 gpm on 24-inch line along 28th St
Land Ownership:	Construction is limited to 28th Street ROW and utility easements across privately owned parking lots. Access to the utility easements across privately owned parking lots should be accessible but may require special permission from owners.

Implementation Issues:	• Constructability issues due to highway and major roads will slow rate of construction. • Bypass pumping required. • Surface treatment of concrete and asphalt pavement.
Estimated Capital Cost:	$1,250,000

Table 7-12. Goose Creek 2 Capital Project Tier I Fact Sheet

Improvement Location:	**Folsom St/Glenwood Dr/Valmont Rd**
Problem ID:	**Goose Creek 2 (Tier 2 Priority Level)**

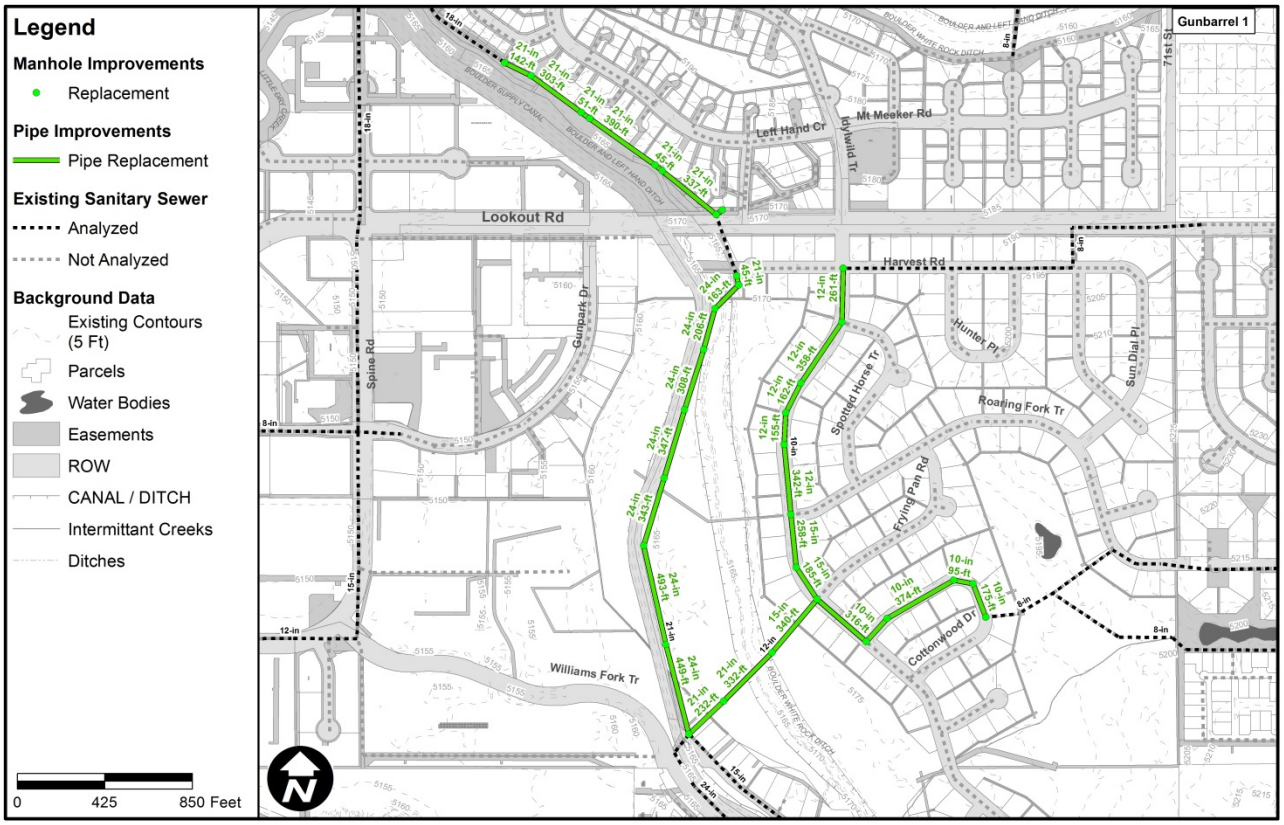


Improvement Description	• Replace 1,866 feet of existing local collector pipe from 10-inch diameter to 12-inch diameter. • Replace 5,197 feet of existing collector/interceptor pipe from 15-inch diameter to 18-inch diameter.
Technical Data:	The entire system is required to convey buildout dry weather and 25-year level of service wet weather flows to the established analysis criteria. Expected buildout 25-year peak flow ranges from 443 gpm in the local collector pipes to 2,986 gpm in the collector/interceptor pipes.
Data Confidence:	71% (6 of 21 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	High
Flow Trigger:	440 gpm on 10-inch line along Folsom St
Land Ownership:	Construction is limited Folsom St, Glenwood Dr, and Valmont Rd ROWs and utility easements across private property boundaries. Access to the utility easements across private property should be accessible but may require special permission from owners.

Implementation Issues:	• Depending on depth of groundwater present in vicinity of replacement pipe, dewatering may be required. • Constructability issues due to highway and major roads will slow rate of construction. • Requires crossing 28th St. • Requires crossing Elmer's Twomile Creek at two locations. • Requires crossing White Rock Ditch. • Bypass pumping required. • Surface treatment of open space, concrete and asphalt pavement.
Estimated Capital Cost:	$4,004,000

Table 7-13. Gunbarrel 1 Capital Project Tier I Fact Sheet

Improvement Location:	**Boulder and Left Hand Ditch; Idylwild Tr/Boulder Country Club**
Problem ID:	**Gunbarrel 1 (Tier 2 Priority Level)**

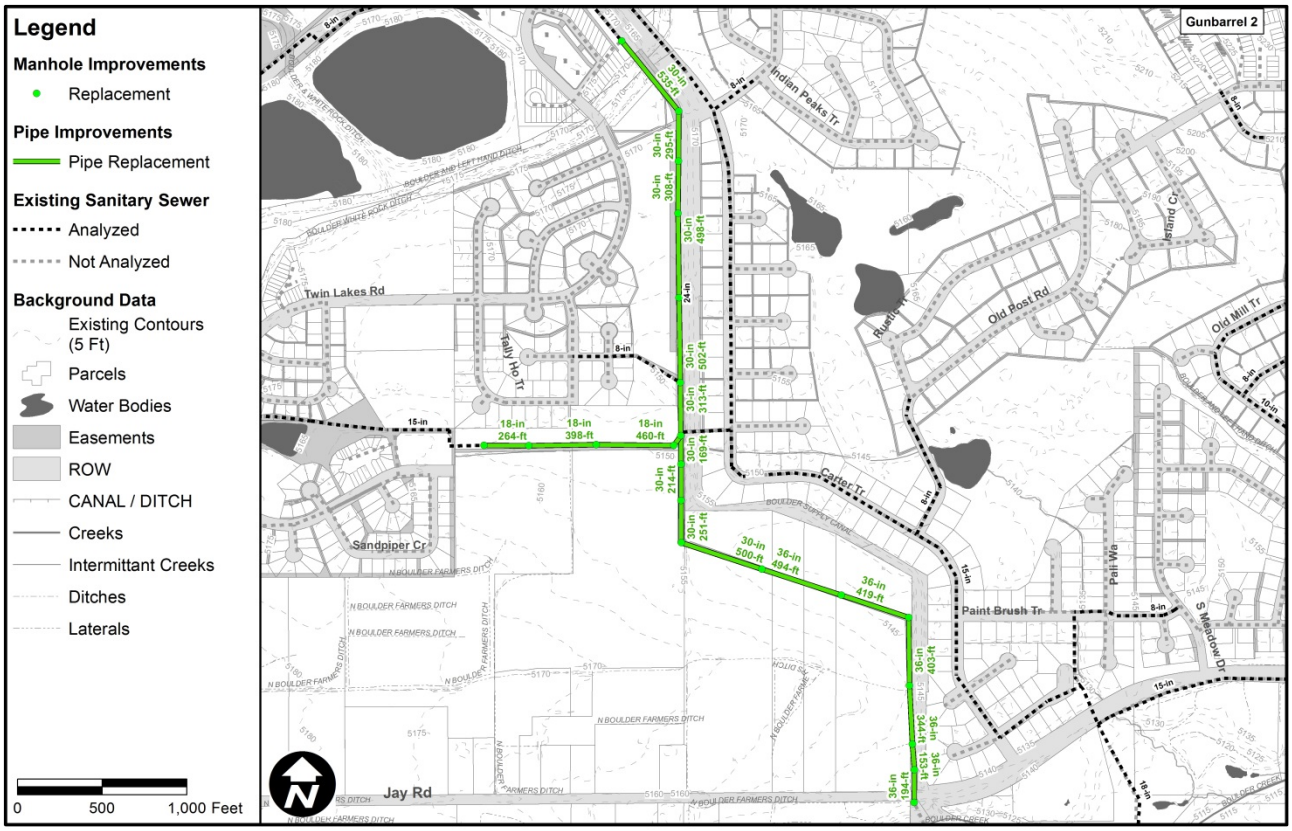


Improvement Description	• Replace and re-grade 37 feet of 8-inch diameter local collector pipe (slope adjustment). • Replace 1,111 feet of existing local collector pipe from 8-inch diameter to 10-inch diameter. • Replace 1,278 feet of existing local collector pipe from 10-inch diameter to 12-inch diameter. • Replace 784 feet of existing local collector pipe from 12-inch diameter to 15-inch diameter. • Replace 564 feet of existing local collector pipe from 12-inch diameter to 21-inch diameter. • Replace 1,268 feet of existing collector/interceptor pipe from 18-inch diameter to 21-inch diameter. • Replace and re-grade 45 feet of 21-inch diameter collector/interceptor pipe (slope adjustment). • Upsize 2,308 feet of existing pipe from 21-inch diameter to 24-inch diameter.

Technical Data:	The entire system is required to convey buildout dry weather and 25-year level of service wet weather flows to the established analysis criteria. Expected buildout 25-year peak flow ranges from 61 gpm in the local collector pipes to 2,265 gpm in the collector/interceptor pipes.
Data Confidence:	80% (3 of 15 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	High
Flow Trigger:	380 gpm on 10-inch line along Idylwild Tr; 1,160 gpm on 18-inch line along the ditch
Land Ownership:	Construction is along Idylwild Tr and Cottonwood Dr ROWs, along ditch corridors, through a golf course, and through residential properties. Special permission from landowner will be required and may involve purchase of ROW.
Implementation Issues:	• Constructability issues due to canal corridor. • Constructability issues due to private residential property. • Constructability issues due to golf course. • Requires crossing White Rock Ditch at two locations. • Requires crossing Lefthand Ditch at two locations. • Bypass pumping of large volumes of sewage. • Surface treatment of primarily open space and asphalt pavement. • Coordination issues and construction disturbance due to adjacent golf course.
Estimated Capital Cost:	$4,388,000

Table 7-14. Gunbarrel 2 Capital Project Tier I Fact Sheet

Improvement Location:	**Boulder Supply Canal north of Jay Rd**
Problem ID:	**Gunbarrel 2 (Tier 2 Priority Level)**



Improvement Description	• Replace 1,194 feet of existing collector/interceptor pipe from 15-inch diameter to 18-inch diameter. • Replace 3,585 feet of existing collector/interceptor pipe from 24-inch diameter to 30-inch diameter. • Replace 2,007 feet of existing collector/interceptor pipe from 24-inch diameter to 36-inch diameter.
Technical Data:	The entire system is required to convey buildout dry weather and 25-year level of service wet weather flows to the established analysis criteria. Expected buildout 25-year peak flow ranges from 1,357 gpm to 5,752 gpm in the collector/interceptor pipes.
Data Confidence:	43% (8 of14 pipes in the corresponding pipe run adjusted)
Calibration Confidence:	High
Flow Trigger:	3,590 gpm on 24-inch line along the ditch
Land Ownership:	Construction along a ditch corridor and across private property. If utility ROW exists in canal corridor, then no land ownership issues should be present along these segments. However, where the alignment crosses private property, sewer either may need to be realigned to follow the ditch corridor or ROW may need to be purchased.

Implementation Issues:	• Constructability issues due to ditch corridors. • Requires crossing Jay Rd. • Requires crossing Lefthand Ditch. • Requires crossing Boulder Farmers Ditch. • Requires crossing a perennial stream at two locations (name unknown). • Requires crossing a perennial stream (different from above, name unknown). • Bypass pumping of large volumes of sewage. • Surface treatment of primarily open space with some asphalt pavement.
Estimated Capital Cost:	$5,467,000

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8 Collection System Maintenance Review

The review and recommendations for the collection system operations and maintenance (O&M) procedures from the 2009 WWCSMP were not revised for this 2016 WWCSMP. This section therefore remains as published in the 2009 WWCSMP.

This section presents the findings of the Gravity Systems Maintenance Program Review and identifies the increases in service level that the city may need to implement to comply with trends currently evolving in the wastewater collection system industry. The purposes of this analysis were:

1. to examine the current state of Boulder's operations and maintenance (O&M) practices; and
2. to develop an estimation of increases in service level due to trends in the regulatory environment in the western region.

HDR's analysis is comprised of data collection and review, interviews, and telephone conversations with city staff. Data was collected during an on-site visit on December 18 and 19, 2007. The staff members who were interviewed are knowledgeable in Boulder's collection system O&M practices. This analysis assesses the current programs employed by the City of Boulder's Utility Maintenance group.

8.1 Background

The first sewer mains were installed in 1895 upon the creation of the utility in the city. Data stored in the GIS database indicate the oldest pipes where installed in the 1940s. It is not accurately known how many miles of sewers were installed between 1895 and 1940 or if any of these pipes are currently active. The utility does not have installation dates for all of its assets, but has made an assumption on installation date based on age of the developments where the assets are located. Based on these numbers, nearly 1/3 of the system is over 50 years old.

For purposes of this analysis, assumptions for probable changes in the regulatory environment in Colorado will be based on examples recently set in the west. The State of California has developed the Waste Discharge Requirements (WDR) regulation and Arizona has developed Rule C305. These regulations for sanitary sewer systems are similar in content to the Capacity, Management, Operations, and Maintenance (CMOM) regulation proposed but never implemented by the U.S. Environmental Protection Agency (EPA). Even though CMOM was never implemented, the EPA does support such state requirements and has enforced even stricter provisions to reduce or eliminate spills under the provisions of the Clean Water Act.

The WDR contains requirements for monitoring, reporting, developing and implementing Sewer System Management Plans (SSMPs). This regulation affects all municipal sewer agencies in the state with more than one mile of collection system and regulates the discharge of sanitary sewer overflows (SSOs).

The WDR defines an SSO as any overflow, spill, release, discharge, or diversion of untreated or partially treated wastewater from a sanitary sewer system, including:

- Overflows or releases of untreated or partially treated wastewater that reach waters of the United States;

- Overflows or releases of untreated or partially treated wastewater that do not reach waters of the United States; and
- Wastewater backups into buildings and on private property caused by blockages or flow conditions within the publicly owned portion of a sanitary sewer system.

8.2 Project Approach

HDR evaluated City of Boulder's Utility Maintenance performance based on industry knowledge of new regulations in the west. The city was evaluated as to whether they would be in regulatory compliance. Recommendations for improvement were made for areas where the city would not be in compliance, or where it was felt that business processes should be changed to meet standard industry practices. This analysis is a means of examining systemic factors that have contributed to or caused a gap between the current and future desired state of the system as outlined in the compliance requirements. The analysis process includes an in-depth analysis of the factors that have created the current state and lays the groundwork for improvement planning. This approach ensures that the system improvement process does not jump from identifying the problem areas to proposing and implementing solutions without first understanding the conditions that created the current state.

HDR conducted the analysis in accordance with the following guidelines:

- The research team gathered information and used it to develop desired system performance baselines (or levels of service) that are formed on the indicators mentioned in the analysis;
- The team identified the gaps between the current and future system performance level, and developed a problem statement that summarizes the underlying issues that must be addressed to progress towards full compliance;
- The team developed a root-cause analysis to determine the factors that are crucial for improvement; and
- These factors were then used to develop specific goals, and objectives for the improvement plan to satisfy the goals associated with any future state regulation.

8.3 Sewer System Management Plan

A critical requirement of California's WDR is to prepare a plan and a schedule to properly manage, operate, and maintain all parts of Boulder's sanitary sewer system in order to reduce, prevent, and mitigate SSOs. The WDR requires collection system managers to develop and implement the SSMP document and revise and update it every two years.

This section discusses the elements of the general WDR and HDR's opinion of Boulder's current performance status. Only the sections of the WDR relating to O&M of the system will be evaluated.

8.3.1 Operation and Maintenance Program - Organization and Staffing

Staff

The Utility Maintenance Group has three two-person cleaning crews, two rodding crews and one hydro flushing crew. There is also one three-person construction crew and two

one-person CCTV vans and crews. Classifications and positions that support the operations and maintenance programs are as follows:

Wastewater Maintenance Supervisor (1) – Supervises all collection system activities

Maintenance Person IV (1) –This position is the construction crew lead and performs tasks related to the maintenance and repair of the sewer system. This position is the equipment operator for the construction crew.

Maintenance Person III (4) – One of the positions in this classification is on the construction crew and performs tasks related to sewer repairs. The other three positions are the operator's of the two-person maintenance crews. One operates a hydro flushing truck and the other two operate the mechanical rodding equipment.

Maintenance Person II (2) – One of these positions is a crew member on the construction crew and the other is a crew member on one of the rodding crews. These positions perform semi-skilled functions in the maintenance and repair of the sewer system.

Maintenance Person I (2) – These positions are entry-level helpers on maintenance crews. One is a helper on a rodding truck and the other on the hydro flush truck.

TV Operator I (2) – The TV operator positions are one-man crews that videotape and record the condition of 8" to 15" sewer pipes throughout the system.

Types of Crews

As mentioned above, there are three two-person cleaning crews, one three-person construction crew, and a one-person television crew. Crews work Monday through Friday, from 7am to 3:30pm.

The construction crew typically performs manhole maintenance, sewer repairs, and confined space entry. These repairs are based on referrals from the maintenance crews or from the television crew. These are typically issues that either need immediate attention or projects that are too small to warrant inclusion on a CIP.

There are two different types of maintenance crews. There are two mechanical rodding crews and one hydro flushing crew. The hydro flushing crew handles hot spots related to grease twice a year. The remainder of the year that crew cleans the rest of the system. Boulder's goal is to clean the entire system every 18 months. The two mechanical rodding crews handle root related maintenance issues. It is Boulder's goal to rod the entire system every three years.

There is one, one-person CCTV crew. Currently the CCTV crew televises the entire system of pipes, less than 16 inches in diameter every 7-9 years. Having a one-man crew may pose safety issues for crews working in the street. It may also be less efficient due to the time spent setting up traffic control and CCTV equipment.

Workday

The city's operations and maintenance personnel work five 8-hour days per week, Monday through Friday. The current work order and time management procedures and systems do not allow for a performance assessment.

Productivity

There are no performance measures in place to benchmark productivity of cleaning crews to industry averages for daily production averages per crew. There are no benchmarks established for daily production goals. There are goals established for how frequently the entire system is cleaned. Using the frequency of entire system cleanings and approximating the number of days crews are out cleaning, in general, flushing crews seem to be more productive than industry standards, while rodding appears below average.

8.3.2 Maintain an Up-to-Date Map of the Sanitary Sewer System

Assessment

The city currently has two sources for maps of the system. One is paper map books that crews use in the field for navigating to their work orders. The city also maintains all system assets in GIS and this is used for planning functions. There is missing data in the GIS database that the city is working to complete. Some examples of these are missing installation dates, diameters, materials, and invert and manhole rim elevations. As city crews visit these locations, they are attempting to capture the data to update their database.

The Computerized Maintenance Management System (CMMS) software for generating work orders and managing data is not tied to the GIS system. The CMMS will be addressed further in the following section.

Recommendations

Only one asset database should be maintained for the system and this should be the system that is used for all maintenance activities related to the sanitary sewer system. Maintaining two systems is time consuming and updates may not always be made to both depending on desired use of the group responsible for data maintenance.

Completion of the GIS database should be made a priority. The current practice of correcting discrepancies by submitting a Utility Field Report to the supervisor or planner helps to ensure that the existing GIS database is continually checked against reality.

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8.3.4 Routine and Preventive Maintenance

Assessment

Boulder's maintenance program includes cleaning their trouble areas or hot-spots locations every six months, as well as maintenance of the sanitary sewer system whenever an O&M related problem occurs. The city uses both hydro flushing and mechanical rodding equipment to clean and remove debris from the sewer system. Boulder's goal is to hydro flush the entire system every 18 months and to mechanically rod the entire system every three years. This means every pipe in the system is maintained an average of once per year. The city proactively maintains their buried sewer assets, thus helping to avoid any maintenance problems or SSOs that could result in a threat to the public health and/or a loss of human life. The following sections present findings and suggestions should be considered to refine the preventive maintenance program.

COMPUTERIZED MAINTENANCE MANAGEMENT SYSTEM

The current system, Utility Maintenance Management System (UMMS), was built by a board member who still maintains and upgrades the system. UMMS houses asset and some maintenance information for water, stormwater, and sewer assets. Maintenance information collected by field crews and stored in the UMMS includes coded values that categorize manhole problems, the operator's assessment of a pipe's overall condition, and the specific location and type of problem in a pipe. This system is not currently integrated with GIS. CCTV data is collected and entered into the system, and the system has the ability to collect some simplistic findings. As CCTV operators televise sections of pipe events such as lateral tie-ins are recorded as well as significant structural defects are mentioned, but not rated. When events such as blockages or SSOs occur, the Utilities Program Planner maps them in GIS, which is a separate database from UMMS, though the UMMS spill data is frequently exported and joined to the GIS spill points. Also, only "serious" events, such as SSOs, are documented, not general maintenance findings.

Recommendations

UMMS should be updated and more closely integrated with the GIS system, or a new GIS-based CMMS system should be implemented specifically for the sanitary sewer system. This will be discussed further in the following section. UMMS has the ability to generate and track work orders, but since it was created to work with several different utilities, it lacks some of the planning tools that a CMMS geared just for the wastewater

industry would include. At a minimum, it should be able to collect maintenance findings by asset and support geographical work scheduling.

UMMS should be updated to store condition data which would be collected on maintenance and inspection visits. Currently, maintenance crews are identifying the pipeline cleaned and recording the type of maintenance performed, but not recording condition findings. This should be corrected by capturing the findings in UMMS. Condition findings should be code-based and not text-based.

The city should have all data, such as trouble area cleaning records, root treatment, and others, entered into the UMMS. This database should be the one source for all maintenance-related issues and should be integrated with GIS software for data management and development of work orders. CMMS software should be integrated with GIS in producing map-based work orders so field activities can be planned and performed using the most up-to-date data. Also, planners could query and link data from UMMS to GIS for analysis and long-term planning.

A detailed service request or work order form should be created and provided to crews who maintain the sewer system assets. The work order would be specific to the type of work being performed and would collect code-based findings for each asset maintained. This code-based data would be captured in UMMS and used for planning future maintenance activities and could also be used for analyzing trends in the system or identifying problem spots or grease dischargers.

The city should provide training to staff in the effective usage of GIS and CMMS software.

CLEANING PROGRAM

The existing collection system pipes are cleaned on a routine basis to minimize the risk of having an SSO, maintain capacity, and to minimize system deterioration and odor generation. An analysis of the last 5 years of SSOs shows the primary causes of SSOs in the city are grease buildup from commercial and residential sources, and root intrusion. Cleaning is performed on pipes that have documented grease problems at a frequency of every six months. Pipes with a documented root problem are placed on the chemical root program. Pipes without a documented maintenance-related condition get cleaned at a lower frequency as will be discussed in the following sections.

Hydro flushing is a cleaning method using high pressure water to remove grease, sand, sludge, and many other obstructions from sewer lines. Mechanical rodding is another cleaning method commonly used in the city to clean sewer lines. This form of cleaning is specifically targeted at the removal of roots from the system but is also used for the penetration of solid blockages. This equipment uses blades that spin on a heavy-duty cable or rod, used for cutting through roots from trees and bushes or other types of debris. The city also contracts with an outside service provider for the application of chemical root inhibitor. Annually between five and eight miles of pipelines are chemically treated for roots.

Each segment of the collection system is hydro flushed once every 18 months and mechanically rodded once every three years. Segments of the system known to have hydraulic problems, or “Hot Spots”, are cleaned more frequently. These areas are typically cleaned on 6 month cycles in May and November. “Hot Spots” are generally

near the point where a restaurant discharges into the system. In 2007 the city cleaned approximately 22,000 feet of pipe on each of its “Hot Spot” cycles. Interviews with staff and planning personnel confirmed that once a pipe was placed on a “Hot Spot”, there was next to no chance of it ever coming off.

Recommendations

The system is currently being cleaned, on average, once per year, and the City’s cleaning program has resulted in a reduction of SSOs. By comparing this to industry best management practices, this frequency is considered over-cleaning, and it is possible to realize similar effectiveness while cleaning less. The city is currently cleaning the entire system on what is normally considered an accelerated cleaning schedule, which is a frequency of less than once every two years. This is considered a high level of service, but also means that crews are most likely cleaning clean pipe. Additionally, there are studies that show that cleaning practices such as hydro-flushing and mechanical rodding can actually cause structural damage to a pipe and reduce the service life of a pipe. Hydro flushing and mechanical cleaning should only be performed to remove roots, grease, or other debris when needed.

As mentioned in the CMMS section, the city should move to code-based collection of findings and collection of this data should be stored in an upgraded CMMS. Over the next few cleaning cycles, data could be collected and, most likely, more accurate cleaning frequencies could be developed for the individual line segments. This would allow the city to ease away from such an aggressive system-wide cleaning program. This same methodology can be used for collection of cleaning findings on the current “Hot Spot” schedule. Once the scheduled cleaning is run through several more times, the data collected will help identify the optimal cleaning frequencies which will most likely lessen the cleaning workload. This data collected would allow for a periodic reevaluation of the cleaning frequencies. The schedule can be level loaded throughout the year for all pipes in the system to provide steady work for crews throughout the year.

As the city implements the above two recommendations, they will likely modify their cleaning schedule to only clean pipes when they are in need of cleaning. This will result in a reduction of the net feet cleaned per year. Instead of downsizing, the utility should look at moving resources to the repair crew or creating a second repair crew. As will be discussed in the following section, the CCTV crew should be generating repair work that city crews could be repairing. Additionally, as the city does less cleaning they may want to consider transitioning from using mechanical rodding equipment to combination jet rodder units. This can be accomplished by replacing one of the mechanical rodders with a combination jet rodder during the next replacement cycle. The combination units are more versatile and more effective.

Large diameter sewer cleaning is an area where there is liability in the future from a regulatory perspective. The probability of a sewer overflow from a large diameter sewer is very small; however, the consequence can be very large. In California, the EPA has required cities such as San Diego and Los Angeles to have a program in place to either clean large diameter sewers periodically or inspect large diameter sewers to determine if cleaning is necessary. The city currently does not inspect pipes that are larger than 15” in diameter and rarely cleans pipes that are larger than 18” in diameter. It is recommended that the city develop a contingency plan to inspect large diameter sewers

over the next 10 years to identify the large diameter sewers that have maintenance or structural issues. Condition assessment of large diameter pipes will most likely require the purchase of new equipment capable of large diameter inspections or should be contracted out to a qualified company.

The majority of maintenance issues in large diameter sewers are the accumulation of debris. This condition is usually exacerbated by flat slopes. Due to the exorbitant cost of large diameter inspections, the city should perform an analysis of flow conditions in large diameter sewers to identify the most likely candidates for maintenance defects. This should be used in conjunction with Boulder's CIP prioritization methodology for identifying structural defects. Together, this priority list would be used to create a risk-based inspection program of only the large diameter sewers that either have a higher probability of maintenance or structural issues or have an elevated consequence of failure, such as near high profile public facilities. The program should then be expanded or contracted based on the findings from the initial inspections.

INSPECTION PROGRAM

Utility Maintenance staff performs inspections on all pipes and manholes on a routine basis. These inspections are either visual, to determine the integrity of manholes, or Closed Circuit Television (CCTV) inspections of the distributed assets. Inspection of the entire collection system using CCTV is currently able to be completed approximately every nine years. The CCTV crew inspects sewers less than 16" in diameter. The data collected from CCTV inspections is used to document the condition of the system and plan long-term CIP projects. Additionally, the data is used to identify areas requiring special or immediate maintenance attention, such as blockages or structural damage. When issues arise, maintenance activities are scheduled to repair the damaged segment or relieve the blockage. CCTV video data is stored in a database so that maintenance staff can review it if necessary.

Recommendations

The city does not currently have a defect coding system for their CCTV program. They currently have one CCTV crew that notes the defect and what it is but it isn't coded and there is no place to document the severity. It is recommended that the city move to an industry recognized defect coding system. This will enable the city to collect consistent records if there is turn-over on the CCTV crew as well as becoming a standard for contractors. Should there ever be a need for CCTV inspections to be done by outside contractors; the data collected would be in the same format as Boulder's data. Additionally, collection of code-based defects and severity data allow for the evaluation of the condition of the system as well as the development of long-term CIPs. These coding systems are typically built into the newer inspection software. The current CCTV van is 10 years old and the city is about to purchase a new inspection van and equipment. The city should identify the coding system that they intend to use prior to making the investment in the new equipment and including the coding system in their specifications.

One such coding system is the Pipeline Assessment Certification Program (PACP). This is a sewer condition coding system and certification program developed by National Association of Sewer Service Companies (NASSCO). The program was developed for

the purposes of standardizing the way condition data is classified and how CCTV inspection results are managed. Regardless of whether the city chooses a certification program or another recognized classification program, training should be provided initially and periodically to the CCTV crews as well as to any other personnel who might need to use the software or operate the equipment.

Currently the CCTV data is used to identify CIP projects to be contracted out, or it identifies areas that need to be repaired immediately because they are near the point of catastrophic failure. Once a defect coding system is implemented, a full range of projects could be identified that could be repaired by city crews before they reach the catastrophic failure point.

CCTV crews should be used for quality control (QC) on maintenance and repair activities. Quality control on cleaning operations should consist of random evaluation of cleaning quality using CCTV inspection on a spot check basis within one week of sewer cleaning activities. This evaluation should be performed on at least 3 pipes per 100 pipes cleaned per cleaning crew. At current production levels, this would account for approximately 1.25% of the CCTV crew's workload. This can include tandem cleaning and CCTV activities where CCTV crews provide instant feedback to cleaning crews by monitoring cleaning effectiveness using CCTV during cleaning operations. This is a best management practice and can be considered to be both a quality assurance and quality control activity.

Additionally, as mentioned in the prior section, it is recommended that the city develop a contingency plan to inspect large diameter sewers over the next 10 years to identify the large diameter sewers that have maintenance or structural issues.

8.3.5 Rehabilitation and Replacement Program

Assessment

When identifying projects to address failing assets, the city has primarily been focusing on replacing assets once they reach a critical stage and has a near-term impact on system reliability. The city does not have a structured process to analyze the condition of assets to optimize the timing of repair, rehabilitation and replacement projects with a focus on minimizing the long-term cost of asset ownership.

Rehabilitation and replacement projects are identified in two ways. The first is through inspection or maintenance activities identifying structurally unsound pipe and the second is through the hydraulic model in order to identify capacity related issues.

The city currently does not have a formal project prioritization or ranking process for all projects. When inspection or maintenance activities identify pipes that require a significant capital improvement, the maintenance staff that has identified the problem notifies the Public Works Utility Project Management Staff of the need for a capital improvement project (CIP) to alleviate the problem. Once Project Management Staff has been notified, they assume responsibility for planning, scheduling, and implementing the CIP. A procedure for this process exists but it has not been formally documented in writing. This is a highly reactive means for identifying CIP needs and is not the best way to manage a system with better than 50% of its assets in excess of 50 years old.

In 2003, the city retained services of Brown and Caldwell to revise their Wastewater Collection System Master Plan (WWCSMP). As part of this project, the Hydraulic Model was revised. As a result of the modeling performed for the revised WWCSMP, capacity-based capital improvement needs were identified. These CIP needs have been categorized into four separate classes based on how immanent the need was. It was also recommended that the CIP budget be increased by 50% annually to accommodate these additional CIP needs that were not currently in the 5-year CIP plan.

Recommendations

The city should develop a standardized methodology to determine repair, rehabilitation, and replacement needs. With approximately 20 sewer line segments per mile, the city's sewer CCTV program quickly produces large amounts of data that should be analyzed in an objective manner for several purposes including capital planning. To assure consistent decision-making in the city's sewer repair, rehabilitation and replacement project identification process, it is very important that the city processes future CCTV data based on a formal decision process. It is a best practice to have a formal, reproducible repair, rehabilitation and replacement decision process that is documented in a decision flow diagram. This decision process would have decision guidelines that lead the person following the process to a preliminary decision about the pipe segment based on the type, severity and quantity of defects in the line segment. This can be done manually based on the decision flow diagram, or can be an algorithm developed from the diagram.

The city should be able to integrate the condition findings with the GIS. The city has a relatively complete GIS system. If sewer and manhole inspection and condition assessment data is collected by sewer and manhole asset number, city staff can display the results on the GIS system. This expedites and optimizes the groupings for staff and contractor sewer and manhole repair, rehabilitation and replacement projects.

If a backlog of capital improvement projects develops, it is a best practice to develop a formal project prioritization process to assure the highest risk and/or consequence assets are addressed to assure stakeholders that available resources are focused on the highest priority projects. Criteria that are often considered in prioritization programs include workplace safety, public safety, reliability of service for customers, regulatory compliance, environmental impacts, and discretionary or aesthetic concerns. Weighting factors could be applied to the different criteria to align priorities with the Boulder's mission and goals.

The development of code-based maintenance findings and CCTV inspections that have been centralized in one location should be leveraged to assist in the planning process.

8.3.6 Training

Assessment

The city encourages its staff to attend training courses. Wastewater Maintenance staff members are encouraged to obtain the highest level of Collection System Operator Certification available through the Colorado Department of Public Health and Environment. All WWTP operators keep up-to-date certification and registrations for their

various licenses and records are kept of training participation by all Utility Maintenance employees.

There is a formal safety training program and all staff members are required to participate. The safety program addresses the following topics; first aid/CPR, confined space entry, trenching and shoring, and defensive driving. Additional specialized trainings are available for field crews for topics such as specialized equipment operation training and asbestos cement pipe repair training.

The City also offers an in-house basic traffic control training annually, ensuring that all new employees are trained in this subject.

Recommendations

The city should develop a cleaning crew training program. The cleaning crew training program should have components that focus on improving both the cleaning work process and the cleaning information process. The training program should include the following:

- Conduct training on objectively assessing condition and defect severity of pipes based on maintenance activities. Use photos to train personnel on the difference between light, medium and heavy condition findings (or 1-5 code). Use other objective measures to assess the condition of a pipe.
- Conduct training to properly record the assessment on the work order form
- Conduct formal training in cleaning techniques for each type of equipment.
- Use CCTV while cleaning to provide feedback and training.
- The city may want to consider holding a “training academy” where a professional training service comes in and provides thorough equipment and cleaning training.
- Training should also be held for the CCTV coding system that the city chooses for their CCTV crews.

8.4 Design & Performance Provisions

Assessment

A key element in the efficient management of the collection system is the provision of well designed and installed sewers and pump stations. New facilities designed and installed with an emphasis on long-term sustainability can greatly reduce maintenance labor and expense. To facilitate this, the city has adopted a set of standards for all new facilities. Boulder’s standards are documented in the “Design and Construction Standards for Wastewater Collection Systems”. The “Design and Construction Standards for Wastewater Collection Systems” contain no provisions or information on planned or necessary acceptance inspections.

Recommendations

The city should amend the “Design and Construction Standards for Wastewater Collection Systems” to incorporate guidelines for the acceptance inspection of facilities. These inspections include:

Developer Work – This includes all new pipelines, manholes, and smaller pump stations.

Capital Projects – Larger pumping stations and sewer pipelines designed and contracted directly by the city.

The city should amend the "Design and Construction Standards for Wastewater Collection Systems" to incorporate SOPs for the testing of all new facilities. These SOPs should include provisions for testing requirements and acceptance criteria.

8.5 Overflow Emergency Response Program

Assessment

Currently the city responds to emergencies by sending out maintenance crews to the incident location. After hours, the wastewater standby employee is contacted. The spill is quickly assessed and resources are secured to mitigate the spill occurrence. During the mitigation process, the maintenance crews use visual, and sometimes CCTV, inspections to determine the nature and cause of the spill event.

Following an SSO, the CCTV crews will inspect and the section of sanitary sewer main where the stoppage occurred. The Wastewater Maintenance Supervisor, CCTV inspector, and Repair Crew Lead review the tape and attempt to determine the cause of the stoppage, and access any immediate maintenance concerns with the pipeline.

Response to all SSOs is guided by the Sanitary Sewer Overflow Response Plan. This document was put into place by the city in August of 2003. This plan is necessary to meet the requirements of the City of Boulder's Wastewater Treatment Plant Permit. The plan includes sections outlining the assessment of a spill, resolution, follow-up, and reporting.

Recommendations

The city's Overflow Emergency Response Program meets most of the requirements of California's WDR. The one recommendation for improvement would be to modify existing procedures executed in response to a spill. Current procedures of placing the problem asset on a list for root control treatment or submitting it to engineering as a potential CIPP should be modified to include the possibilities of increasing the maintenance frequency of the problem pipe, or placing it on the "hot-spot" program. If the asset is currently on one of these programs, the city should evaluate developing a cleaning frequency that is less than six months. Also, to be in compliance with the CWA, the city needs to develop a formal SSO tracking system.

8.6 Fats, Oils, and Grease (FOG) Control Program

One of the major causes of maintenance problems, blockages, and sanitary sewer overflows in the city's collection system is grease. The city addresses grease in the collection system through two programs: the sewer cleaning program and in the Industrial Pretreatment Program. The sewer cleaning program is discussed in earlier sections.

The purpose of the city's Pretreatment program is to ensure that commercial and residential entities are not contributing pollutants to the system. One of the pollutants is grease or oil in levels that would impact the operation of the city's collection system. The pretreatment program does not have a formal FOG program.

8.6.1 Installation of Grease Removal Devices

Assessment

The city's FOG program is governed by municipal code regulation with specific section relating to fats, oils, and grease. This code establishes a threshold for dischargers of 100 mg/l, or requires a plumbing device for FOG for those who exceed the threshold. Currently the municipal code refers to the International Plumbing Code for the design criteria of grease removal equipment. The municipal code has minimal requirement for grease removal equipment cleaning, which is every 6 months or as needed.

FOG producing facilities are not currently required to obtain permitting from the city. FOG producers are identified by Development Services. When applying for permits, applicants fill out a Business Environmental Questionnaire. If the facility generates wastewater, they are required to fill out an industrial waste survey. Any applicant determined to exceed the above mentioned discharge threshold is required to install grease removal equipment (GRE). There is an existing plan check system for restaurants during the initiation phase. Design approval is performed by the Development Review group. During construction, inspection of the GRE is performed by the plumbing inspector.

Recommendations

The FOG municipal code should be modified to require all new grease-producing facilities to install and maintain grease removal equipment (GRE). Any new or remodel of existing facilities that will have a kitchen, cooking equipment, or a food producing facility should contact the city to determine the need and size of the grease controlling device. Modifications should be made to the municipal code to allow for the development of a FOG program that can perform inspections and assess violations accordingly. According to California's WDR section vii of the SSMP, the following suggestions shall be included in the FOG ordinance:

- An implementation plan and schedule for a public education outreach program either through the local public newspaper, radio, television advertisements, flyers or newsletters that will promote proper disposal of FOG;
- A list of acceptable disposal facilities and/or additional facilities needed to adequately dispose of FOG generated within its service area;
- A legal authority to prohibit discharges to the sewer collection system and identify measures to prevent SSOs and blockages caused by FOG;
- A requirement to install grease removal devices such as an interceptor or trap, using the most current regulations and design standards (e.g. CPC), maintenance requirements, BMP requirements, record keeping and reporting requirements; and Authority to inspect the grease producing facilities, enforcement authorities, and enforcing penalties to the businesses that violate FOG control measures.

8.6.2 Inspection & Maintenance Program

Assessment

Currently, there are approximately 400 GRE facilities in the city. After design approval and inspection during construction, it then becomes the owner's responsibility to regularly inspect and maintain the GRE. Currently, the city does not have any staff dedicated to the inspection of the performance and maintenance of an existing GRE. The pretreatment program has responded reactively with additional site inspections, notices of violation, and issuing requirements for plumbing device installation following SSO events. Due to the lack of an inspection and maintenance program, the property owners may have not been maintaining their GREs. It is possible that food service establishments (FSE) may bypass their grease trap/interceptor and discharge directly into the sewer line.

Recommendations

The city should perform a business case for investment in a FOG prevention program. Development of a formal inspection program should be considered to be included in their FOG ordinance. The business case would evaluate the cost of a formal FOG program against the cost of maintenance and potential SSOs or blockages.

The first step in developing the FOG program would be the identification of all of the FSEs that would require grease removal equipment. There is a database that currently keeps this data, but it is incomplete. The database could be used as a starting point and added to over time. The FOG program would work with the operations group to identify grease hot-spots in the system and evaluate the businesses in the area to identify any that should have GREs. The city should develop a policy on how to handle existing FSEs that do not have GREs. Additionally, the FOG program needs to work with Development Services to ensure that all new food establishments are entered into the database.

Once data collection of the existing and new facilities is under way, the city can focus on developing an inspection schedule for the restaurants as well as recommending maintenance schedules for the facilities GREs. A report or a log should be prepared after each inspection. Depending on the findings of the inspection reports or logs, the facility will be issued a schedule that enables it to achieve compliance with the current regulations. If the facility fails to follow the regulations and/or FOG ordinance, a system of progressive discipline should be defined that will ultimately result in Boulder's ability to shut off the water of non-compliant FSEs.

8.7 Monitoring, Measurement, and Program Modifications

Assessment

The city uses a computerized maintenance management system for tracking its maintenance, repairs, and inspections of the sewer system. Additionally, it maintains separate GIS data documenting the locations of SSOs as well as repair and replacement projects. CCTV data is collected to monitor the condition of the system. Maintenance and structural issues are documented and the appropriate crew is assigned to perform the repair or to maintain the pipeline.

The city has developed several performance indicators for the maintenance of its sewer system. Boulder has set goals and developed performance measures to document what they are doing to maintain the wastewater collection system and to gauge how well it is being done. Performance measures are calculated annually and documented in the Utility Maintenance Division's annual report. The annual report also documents how the utility is performing against like size agencies in the area.

Currently modifications to the maintenance frequency of pipes in the system are performed in a reactive way. When CCTV crews identify a problem, there is an SSO or blockage, or a customer complaint is received, the Utility Maintenance Division responds to alleviate the problem. This may either be a one-time maintenance event or it may be the inclusion of the facility in the hot-spot program.

Recommendations

The city should assign a person to review the SSMP periodically to check its effectiveness and timeliness. This person can prepare regular progress reports documenting the effectiveness, potential changes, and summary of the program activities. Currently the city collects a large amount of data about maintenance activities in UMMS. The data is used now as documentation a maintenance event occurred and used to measure progress towards performance goals. As recommended in prior sections of this report, additional information could be gathered during maintenance events about the condition of the pipes. This data could be analyzed and modifications to maintenance activities could be optimized.

8.8 Program Audits and Communication Program

Assessment

California's WDR requires that an agency perform an audit of all programs associated with the SSMP every two years. The audit should identify any deficiencies in the SSMP programs and include the corrective steps to resolve the issues. The audit will help ensure the effectiveness of the SSMP implementation program. The audit should be conducted by a person other than a member of the agency's staff. The auditor should conduct random interviews of the staff in reviewing the SSMP performance.

Recommendations

An effective communication program can keep the city from missing the critical SSMP deadlines. The city should involve the key stakeholders and the public during the process of developing an SSMP avoiding any controversial discussions on its various elements.

8.9 Conclusions and Recommendations

In general, the city has the framework in place that will bring it into general compliance with the terms of the emerging regulations of the Western United States in the near future. Many of the recommendations made here are for the improvement of the maintenance of the utility. These are recommendations that incorporate best management practices and industry standards for the operation of the utility. The challenge for the city will be to implement these recommendations to improve the condition of the system. Below is a summary of the recommendations:

1. Maintain an Up-to-Date Map of the Sanitary Sewer System
    a. Completion of the GIS database should be made a priority. The current practice of correcting discrepancies by submitting a Utility Field Report to the supervisor or planner helps to ensure that the existing GIS database is continually checked against reality.
2. Computerized Maintenance Management System
    a. UMMS should be updated and more closely integrated with the GIS system, or a new GIS-based CMMS system should be implemented specifically for the sanitary sewer system. It should be able to collect maintenance findings by asset and support geographical work scheduling.
    b. UMMS should be updated to store condition data which would be collected on maintenance and inspection visits. The city should have all data, such as trouble area cleaning records, root treatment, and others, entered into the UMMS.
    c. A detailed service request or work order form should be created and provided to crews who maintain the sewer system assets. The work order would be specific to the type of work being performed and would collect code-based findings for each asset maintained.
    d. The city should provide training to staff in the effective usage of GIS and CMMS software.
3. Cleaning Program
    a. The system is currently being cleaned, on average, once per year, and the City's cleaning program has resulted in a reduction of SSOs. The city should move to code-based collection of findings and collection of this data should be stored in an upgraded CMMS. Over the next few cleaning cycles, data could be collected and, most likely, more accurate cleaning frequencies could be developed for the individual line segments.
    b. The utility should look at moving resources to the repair crew or creating a second repair crew. As will be discussed in the following section, the CCTV crew should be generating repair work that the city crews could be repairing. Additionally, as the city does less cleaning they may want to consider transitioning from using mechanical rodding equipment to combination jet rodder units.
    c. It is recommended that the city develop a contingency plan to inspect large diameter sewers over the next 10 years to identify the large diameter sewers that have maintenance or structural issues.
4. Inspection Program
    a. It is recommended that the city move to an industry recognized defect coding system. This will enable the city to collect consistent records if there is turn-over on the CCTV crew as well as becoming a standard for contractors. Training should be provided initially and periodically to the CCTV crews as well as to any other personnel who might need to use the software or operate the equipment.
    b. CCTV crews should be used for quality control (QC) on maintenance and repair activities. This evaluation should be performed on at least 3 pipes per 100 pipes cleaned per cleaning crew.
5. Rehabilitation and Replacement Program

a. The city should develop a standardized methodology to determine repair, rehabilitation, and replacement needs. To assure consistent decision-making in Boulder's sewer repair, rehabilitation and replacement project identification process, it is very important that the city processes future CCTV data based on a formal decision process. This can be done manually based on the decision flow diagram, or can be an algorithm developed from the diagram.

b. The city should be able to integrate the condition findings with the GIS.

c. When a backlog of capital improvement projects develops, it is a best practice to develop a formal project prioritization process to assure the highest risk and/or consequence assets are addressed to assure stakeholders that available resources are focused on the highest priority projects.

6. Training

   a. The city should develop a cleaning crew training program. The cleaning crew training program should have components that focus on improving both the cleaning work process and the cleaning information process. Training should also be held for the CCTV coding system that the city chooses for their CCTV crews.

7. Design & Performance Provisions

   a. The city should amend the "Design and Construction Standards for Wastewater Collection Systems" to incorporate guidelines for the acceptance inspection of facilities. The city should amend the "Design and Construction Standards for Wastewater Collection Systems" to incorporate SOPs for the testing of all new facilities.

8. Overflow Emergency Response Program

   a. The one recommendation for improvement would be to modify existing procedures executed in response to a spill. Current procedures of placing the problem asset on a list for root control treatment or submitting it to engineering as a potential CIPP should be modified to include the possibilities of increasing the maintenance frequency of the problem pipe, or placing it on the "hot-spot" program.

9. Installation of Grease Removal Devices

   a. The FOG municipal code should be modified to require all new grease-producing facilities to install and maintain grease removal equipment (GRE).

   b. Modifications should be made to the municipal code to allow for the development of a FOG program that can perform inspections and assess violations accordingly.

10. FOG Inspection & Maintenance Program

    a. The city should perform a business case for investment in a FOG prevention program. Development of a formal inspection program should be considered to be included in their FOG ordinance.

    b. The city should identify all of the FSEs that would require grease removal equipment. There is a database that currently keeps this data, but it is incomplete.

    c. The city should develop a policy on how to handle existing FSEs that do not have GREs. Additionally, the FOG program needs to work with Development Services to ensure that all new food establishments are entered into the database.

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9 References

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10 Appendices

Appendix A – Cost Estimate Worksheets

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Appendix A – Cost Estimate Worksheets

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Boulder WWCSMP
December 2008

System Improvement Recommendations
Detailed Cost Estimate

Improvement ID: *Boulder Creek 3*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)	LS		10%	$ 768,357
Mobilization (5%)	LS		5%	$ 384,179
Traffic Control (2%)	LS		2%	$ 153,671
Utility Relocation (2%)	LS		2%	$ 153,671
Subtotal				$ 1,459,879
Pipe Improvements				
Dewatering (6% of Pipe Improvements Cost)	LS		6%	$ 419,190
Bypass Pumping	LS		250,000	$ 250,000
Removal and Disposal				
8" to 36" pipe	LF	2,261	$ 19.37	$ 43,785
42" to 60" pipe	LF	400	$ 55.54	$ 22,216
Manholes	EA	13	$ 2,192.32	$ 28,500
Connect to Existing	EA	4	$ 1,242.31	$ 4,969
Pipe - Diameter.depth - (inches.feet)				
12.16	LF	2,210	$ 88.49	$ 195,572
15.16	LF	2,210	$ 107.15	$ 236,807
42.12	LF	419	$ 201.41	$ 84,391
42.14	LF	1,797	$ 214.30	$ 385,098
48.12	LF	1,750	$ 244.64	$ 428,124
54.12	LF	10,788	$ 313.84	$ 3,385,730
Service taps at various depths				
Depth 11.1' - 13'	EA	1	$ 1,301.39	$ 1,301
Stream/Road Crossing	in-dia/100ft	433	$ 4,345.73	$ 1,879,964
Surface Restoration				
Type 3 (Soil amendments, Grading, Seeding)	LF	15,182	$ 8.04	$ 122,041
Manholes				
60" Dia., pipe dia. 21" - 42", <15' depth	EA	9	$ 12,000.00	$ 108,000
72" Dia., pipe dia. 48" - 60", <15' depth	EA	4	$ 15,000.00	$ 60,000
Subtotal				$ 7,655,688
Other				
Lift Station	Firm MGD	7	$ 500,000.00	$ 3,400,000
Utility Relocation				
Water Line Relocation (5% of pipe length)	LF	959	$ 29.08	$ 27,884
Subtotal				$ 27,884
Subtotal Construction Costs				**$ 12,543,450**
Design Contingency (30%)				$ 3,763,035
Engineering and Administration (20%)				$ 2,508,690
Land Acquisition	SF	377,010	$ 2.27	$ 857,069
Total Estimated Improvement Cost (Rounded)				**$ 19,673,000**

Boulder WWCSMP
December 2008

System Improvement Recommendations
Detailed Cost Estimate

Improvement ID: *S Boulder Creek 2*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)	LS		10%	$ 184,998
Mobilization (6%)	LS		6%	$ 110,999
Traffic Control (5%)	LS		5%	$ 92,499
Utility Relocation (5%)	LS		5%	$ 92,499
Subtotal				$ 480,994
Pipe Improvements				
Dewatering (6% of Pipe Improvements Cost)	LS		6%	$ 93,632
Bypass Pumping (12% of Pipe Improvements Cost)	LS		12%	$ 187,264
Removal and Disposal				
8" to 36" pipe	LF	5,879	$ 19.37	$ 113,850
Manholes	EA	24	$ 2,192.32	$ 52,616
Connect to Existing	EA	16	$ 1,242.31	$ 19,877
Pipe - Diameter.depth - (inches.feet)				
10.04	LF	300	$ 39.84	$ 11,952
10.10	LF	320	$ 57.42	$ 18,373
12.10	LF	24	$ 67.40	$ 1,618
15.10	LF	771	$ 84.30	$ 64,998
15.12	LF	905	$ 91.92	$ 83,187
15.14	LF	1,214	$ 99.54	$ 120,837
18.10	LF	417	$ 77.98	$ 32,516
21.10	LF	949	$ 93.78	$ 89,001
21.12	LF	979	$ 102.57	$ 100,418
Service taps at various depths				
Depth 6' - 9'	EA	2	$ 968.58	$ 1,937
Stream/Road Crossing	in-dia/100ft	83	$ 4,345.73	$ 362,434
Surface Restoration				
Type 1 (Asphalt Patch)	LF	4,152	$ 54.20	$ 225,034
Type 3 (Soil amendments, Grading, Seeding)	LF	1,727	$ 8.04	$ 13,883
Manholes				
48" Dia., pipe dia. <21", <15' depth	EA	20	$ 10,000.00	$ 200,000
60" Dia., pipe dia. 21" - 42", <15' depth	EA	4	$ 12,000.00	$ 48,000
Subtotal				$ 1,841,427
Utility Relocation				
Water Line Relocation (5% of pipe length)	LF	294	$ 29.08	$ 8,549
Sanitary Sewer Relocation	LF	-	$ 29.08	$ -
Subtotal				$ 8,549
Subtotal Construction Costs				**$ 2,330,970**
Design Contingency (30%)				$ 699,291
Engineering and Administration (20%)				$ 466,194
Land Acquisition	SF	-	$ 11.37	$ -
Total Estimated Improvement Cost (Rounded)				**$ 3,497,000**

Boulder WWCSMP
December 2008

System Improvement Recommendations
Detailed Cost Estimate

Improvement ID: *Boulder Creek 2*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)	LS		10%	$ 666,911
Mobilization (6%)	LS		6%	$ 400,147
Traffic Control (5%)	LS		5%	$ 333,456
Utility Relocation (5%)	LS		5%	$ 333,456
Subtotal				$ 1,733,970
Pipe Improvements				
Dewatering (6% of Pipe Improvements Cost)	LS		6%	$ 338,308
Bypass Pumping (12% of Pipe Improvements Cost)	LS		12%	$ 676,617
Removal and Disposal				
8" to 36" pipe	LF	4,949	$ 19.37	$ 95,840
42" to 60" pipe	LF	5,861	$ 55.54	$ 325,513
Manholes	EA	44	$ 2,192.32	$ 96,462
Connect to Existing	EA	11	$ 1,242.31	$ 13,665
Pipe - Diameter.depth - (inches.feet)				
30.14	LF	262	$ 142.42	$ 37,313
36.08	LF	137	$ 145.92	$ 19,991
36.10	LF	331	$ 157.64	$ 52,179
36.12	LF	931	$ 169.36	$ 157,672
36.14	LF	1,879	$ 181.08	$ 340,240
36.16	LF	553	$ 192.79	$ 106,614
36.18	LF	855	$ 204.51	$ 174,856
42.12	LF	2,873	$ 201.41	$ 578,654
42.14	LF	2,735	$ 214.30	$ 586,111
42.16	LF	253	$ 227.19	$ 57,479
Service taps at various depths				
Depth 11.1' - 13'	EA	3	$ 1,301.39	$ 3,904
Depth 13.1' - 15'	EA	1	$ 1,467.94	$ 1,468
Stream/Road Crossing	in-dia/100ft	511	$ 4,345.73	$ 2,219,974
Surface Restoration				
Type 1 (Asphalt Patch)	LF	3,415	$ 54.20	$ 185,090
Type 3 (Soil amendments, Grading, Seeding)	LF	7,395	$ 8.04	$ 59,445
Manholes				
48" Dia., pipe dia. <21", <15' depth	EA	1	$ 10,000.00	$ 10,000
60" Dia., pipe dia. 21" - 42", <15' depth	EA	43	$ 12,000.00	$ 516,000
Subtotal				$ 6,653,396
Utility Relocation				
Water Line Relocation (5% of pipe length)	LF	540	$ 29.08	$ 15,719
Sanitary Sewer Relocation	LF	-	$ 29.08	$ -
Subtotal				$ 15,719
Subtotal Construction Costs				**$ 8,403,085**
Design Contingency (30%)				$ 2,520,925
Engineering and Administration (20%)				$ 1,680,617
Land Acquisition	SF	-	$ 11.37	$ -
Total Estimated Improvement Cost (Rounded)				**$ 12,605,000**

Boulder WWCSMP
December 2008

System Improvement Recommendations
Detailed Cost Estimate

Improvement ID: *Goose Creek 4*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)	LS		10%	$ 136,713
Mobilization (6%)	LS		6%	$ 82,028
Traffic Control (5%)	LS		5%	$ 68,356
Utility Relocation (5%)	LS		5%	$ 68,356
Subtotal				$ 355,454
Pipe Improvements				
Dewatering (6% of Pipe Improvements Cost)	LS		6%	$ 69,218
Bypass Pumping (12% of Pipe Improvements Cost)	LS		12%	$ 138,436
Removal and Disposal				
8" to 36" pipe	LF	4,016	$ 19.37	$ 77,772
Manholes	EA	13	$ 2,192.32	$ 28,500
Connect to Existing	EA	7	$ 1,242.31	$ 8,696
Pipe - Diameter.depth - (inches.feet)				
42.06	LF	987	$ 162.74	$ 160,628
42.08	LF	494	$ 175.63	$ 86,763
42.10	LF	955	$ 188.52	$ 180,038
42.12	LF	68	$ 201.41	$ 13,696
42.14	LF	487	$ 214.30	$ 104,364
42.16	LF	170	$ 227.19	$ 38,622
42.18	LF	537	$ 240.08	$ 128,922
42.20	LF	317	$ 252.97	$ 80,191
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,472	$ 54.20	$ 79,781
Type 3 (Soil amendments, Grading, Seeding)	LF	1,202	$ 8.04	$ 9,662
Manholes				
60" Dia., pipe dia. 21" - 42", <15' depth	EA	13	$ 12,000.00	$ 156,000
Subtotal				$ 1,361,291
Utility Relocation				
Water Line Relocation (5% of pipe length)	LF	201	$ 29.08	$ 5,839
Sanitary Sewer Relocation	LF	-	$ 29.08	$ -
Subtotal				$ 5,839
Subtotal Construction Costs				**$ 1,722,583**
Design Contingency (30%)				$ 516,775
Engineering and Administration (20%)				$ 344,517
Total Estimated Improvement Cost (Rounded)				**$ 2,584,000**

Boulder WWCSMP
December 2008

System Improvement Recommendations
Detailed Cost Estimate

Improvement ID: *Goose Creek 1*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)	LS		10%	$ 68,314
Mobilization (6%)	LS		6%	$ 40,988
Traffic Control (5%)	LS		5%	$ 34,157
Utility Relocation (5%)	LS		5%	$ 34,157
Subtotal				$ 177,615
Pipe Improvements				
Dewatering (6% of Pipe Improvements Cost)	LS		6%	$ 34,548
Bypass Pumping (12% of Pipe Improvements Cost)	LS		12%	$ 69,096
Removal and Disposal				
8" to 36" pipe	LF	2,539	$ 19.37	$ 49,169
Manholes	EA	12	$ 2,192.32	$ 26,308
Connect to Existing	EA	11	$ 1,242.31	$ 13,665
Pipe - Diameter.depth - (inches.feet)				
12.10	LF	1,989	$ 67.40	$ 134,064
12.12	LF	550	$ 74.43	$ 40,938
Service taps at various depths				
Depth 6' - 9'	EA	5	$ 968.58	$ 4,843
Depth 9.1' -11'	EA	19	$ 1,134.83	$ 21,562
Stream/Road Crossing	in-dia/100ft	6	$ 4,345.73	$ 27,639
Surface Restoration				
Type 1 (Asphalt Patch)	LF	2,539	$ 54.20	$ 137,611
Manholes				
48" Dia., pipe dia. <21", <15' depth	EA	12	$ 10,000.00	$ 120,000
Subtotal				$ 679,444
Utility Relocation				
Water Line Relocation (5% of pipe length)	LF	127	$ 29.08	$ 3,692
Sanitary Sewer Relocation	LF	-	$ 29.08	$ -
Subtotal				$ 3,692
Subtotal Construction Costs				**$ 860,751**
Design Contingency (30%)				$ 258,225
Engineering and Administration (20%)				$ 172,150
Land Acquisition	SF	-	$ 11.37	$ -
Total Estimated Improvement Cost (Rounded)				**$ 1,292,000**

Boulder WWCSMP
December 2008

System Improvement Recommendations
Detailed Cost Estimate

Improvement ID: *S Boulder Creek 1*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)	LS		10%	$ 919,005
Mobilization (6%)	LS		6%	$ 551,403
Traffic Control (5%)	LS		5%	$ 459,503
Utility Relocation (5%)	LS		5%	$ 459,503
Subtotal				$ 2,389,414
Pipe Improvements				
Dewatering (6% of Pipe Improvements Cost)	LS		6%	$ 465,691
Bypass Pumping (12% of Pipe Improvements Cost)	LS		12%	$ 931,381
Removal and Disposal				
8" to 36" pipe	LF	21,642	$ 19.37	$ 419,108
Manholes	EA	98	$ 2,192.32	$ 214,847
Connect to Existing	EA	47	$ 1,242.31	$ 58,389
Pipe - Diameter.depth - (inches.feet)				
10.06	LF	165	$ 45.70	$ 7,540
10.12	LF	109	$ 63.28	$ 6,897
12.08	LF	1,723	$ 60.37	$ 104,022
12.10	LF	1,569	$ 67.40	$ 105,755
12.12	LF	796	$ 74.43	$ 59,249
12.14	LF	1,141	$ 81.46	$ 92,950
15.10	LF	1,919	$ 84.30	$ 161,778
15.12	LF	532	$ 91.92	$ 48,901
15.14	LF	310	$ 99.54	$ 30,856
15.18	LF	255	$ 114.77	$ 29,266
18.06	LF	65	$ 61.57	$ 4,002
18.08	LF	886	$ 69.77	$ 61,820
18.10	LF	2,608	$ 77.98	$ 203,363
18.12	LF	1,759	$ 86.18	$ 151,589
18.14	LF	1,257	$ 94.38	$ 118,637
18.16	LF	501	$ 102.58	$ 51,394
21.14	LF	212	$ 111.36	$ 23,608
21.16	LF	165	$ 120.15	$ 19,824
24.10	LF	221	$ 97.93	$ 21,643
24.12	LF	154	$ 107.30	$ 16,525
30.08	LF	396	$ 110.78	$ 43,868
30.10	LF	511	$ 121.32	$ 61,997
30.12	LF	1,241	$ 131.87	$ 163,650
30.14	LF	1,771	$ 142.42	$ 252,218
30.16	LF	775	$ 152.96	$ 118,545
30.18	LF	600	$ 163.51	$ 98,104
Service taps at various depths				
Depth 6' - 9'	EA	37	$ 968.58	$ 35,837
Depth 9.1' -11'	EA	15	$ 1,134.83	$ 17,022
Depth 11.1' - 13'	EA	7	$ 1,301.39	$ 9,110
Depth 13.1' - 15'	EA	13	$ 1,467.94	$ 19,083
Depth 15.1' - 17'	EA	1	$ 1,634.19	$ 1,634
Stream/Road Crossing	in-dia/100ft	657	$ 4,345.73	$ 2,856,581
Surface Restoration				
Type 1 (Asphalt Patch)	LF	18,889	$ 54.20	$ 1,023,766
Type 3 (Soil amendments, Grading, Seeding)	LF	2,753	$ 8.04	$ 22,130
Manholes				
48" Dia., pipe dia. <21", <15' depth	EA	75	$ 10,000.00	$ 750,000
60" Dia., pipe dia. 21" - 42", <15' depth	EA	23	$ 12,000.00	$ 276,000
Subtotal				$ 9,158,582
Utility Relocation				
Water Line Relocation (5% of pipe length)	LF	1,082	$ 29.08	$ 31,471
Sanitary Sewer Relocation	LF	-	$ 29.08	$ -
Subtotal				$ 31,471
Subtotal Construction Costs				**$ 11,579,467**
Design Contingency (30%)				$ 3,473,840
Engineering and Administration (20%)				$ 2,315,893
Land Acquisition	SF	-	$ 11.37	$ -
Total Estimated Improvement Cost (Rounded)				**$ 17,370,000**

Boulder WWCSMP
December 2015

System Improvement Recommendations
Detailed Cost Estimate

Improvement ID: *Boulder Creek 1*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)	LS		10%	$ 227,402
Mobilization (6%)	LS		6%	$ 136,441
Traffic Control (5%)	LS		5%	$ 113,701
Utility Relocation (5%)	LS		5%	$ 113,701
Subtotal				$ 591,246
Pipe Improvements				
Dewatering (6% of Pipe Improvements Cost)	LS		6%	$ 115,250
Bypass Pumping (12% of Pipe Improvements Cost)	LS		12%	$ 230,500
Removal and Disposal				
8" to 36" pipe	LF	5,117	$ 19.37	$ 99,093
Manholes	EA	26	$ 2,192.32	$ 57,000
Connect to Existing	EA	9	$ 1,242.31	$ 11,181
Pipe - Diameter.depth - (inches.feet)				
12.08	LF	324	$ 60.37	$ 19,561
15.06	LF	239	$ 69.07	$ 16,508
15.08	LF	777	$ 76.69	$ 59,586
15.10	LF	1,491	$ 84.30	$ 125,696
15.12	LF	305	$ 91.92	$ 28,035
15.14	LF	647	$ 99.54	$ 64,400
15.16	LF	347	$ 107.15	$ 37,182
15.18	LF	718	$ 114.77	$ 82,404
15.20	LF	62	$ 122.39	$ 7,588
27.18	LF	208	$ 150.94	$ 31,395
Service taps at various depths				
Depth 17.1' - 19'	EA	2	$ 1,800.75	$ 3,601
Stream/Road Crossing	in-dia/100ft	154	$ 4,780.31	$ 736,263
Surface Restoration				
Type 1 (Asphalt Patch)	LF	5,117	$ 54.20	$ 277,336
Manholes				
48" Dia., pipe dia. <21", <15' depth	EA	24	$ 10,000.00	$ 240,000
60" Dia., pipe dia. 21" - 42", <15' depth	EA	2	$ 12,000.00	$ 24,000
Subtotal				$ 2,266,579
Utility Relocation				
Water Line Relocation (5% of pipe length)	LF	256	$ 29.08	$ 7,443
Sanitary Sewer Relocation	LF	-	$ 29.08	$ -
Subtotal				$ 7,443
Subtotal Construction Costs				**$ 2,865,267**
Design Contingency (30%)				$ 859,580
Engineering and Administration (20%)				$ 573,053
Land Acquisition	SF	-	$ 11.37	$ -
Total Estimated Improvement Cost (Rounded)				**$ 4,298,000**

Boulder WWCSMP
December 2008

System Improvement Recommendations
Detailed Cost Estimate

Improvement ID: *Goose Creek 3*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)	LS		10%	$ 66,138
Mobilization (6%)	LS		6%	$ 39,683
Traffic Control (5%)	LS		5%	$ 33,069
Utility Relocation (5%)	LS		5%	$ 33,069
Subtotal				$ 171,958
Pipe Improvements				
Dewatering (6% of Pipe Improvements Cost)	LS		6%	$ 33,485
Bypass Pumping (12% of Pipe Improvements Cost)	LS		12%	$ 66,971
Removal and Disposal				
8" to 36" pipe	LF	1,945	$ 19.37	$ 37,666
Manholes	EA	13	$ 2,192.32	$ 28,500
Connect to Existing	EA	8	$ 1,242.31	$ 9,939
Pipe - Diameter.depth - (inches.feet)				
24.06	LF	272	$ 79.18	$ 21,538
30.06	LF	359	$ 100.23	$ 35,984
30.08	LF	710	$ 110.78	$ 78,653
30.10	LF	346	$ 121.32	$ 41,978
30.14	LF	32	$ 142.42	$ 4,557
30.16	LF	122	$ 152.96	$ 18,661
30.22	LF	104	$ 184.60	$ 19,198
Service taps at various depths				
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,945	$ 54.20	$ 105,417
Manholes				
60" Dia., pipe dia. 21" - 42", <15' depth	EA	13	$ 12,000.00	$ 156,000
Subtotal				$ 658,547
Utility Relocation				
Water Line Relocation (5% of pipe length)	LF	97	$ 29.08	$ 2,828
Sanitary Sewer Relocation	LF	-	$ 29.08	$ -
Subtotal				$ 2,828
Subtotal Construction Costs				**$ 833,333**
Design Contingency (30%)				$ 250,000
Engineering and Administration (20%)				$ 166,667
Land Acquisition	SF	-	$ 11.37	$ -
Total Estimated Improvement Cost (Rounded)				**$ 1,250,000**

Boulder WWCSMP
December 2008

System Improvement Recommendations
Detailed Cost Estimate

Improvement ID: *Goose Creek 2*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)	LS		10%	$ 211,803
Mobilization (6%)	LS		6%	$ 127,082
Traffic Control (5%)	LS		5%	$ 105,902
Utility Relocation (5%)	LS		5%	$ 105,902
Subtotal				$ 550,688
Pipe Improvements				
Dewatering (6% of Pipe Improvements Cost)	LS		6%	$ 107,174
Bypass Pumping (12% of Pipe Improvements Cost)	LS		12%	$ 214,349
Removal and Disposal				
8" to 36" pipe	LF	7,063	$ 19.37	$ 136,779
Manholes	EA	34	$ 2,192.32	$ 74,539
Connect to Existing	EA	22	$ 1,242.31	$ 27,331
Pipe - Diameter.depth - (inches.feet)				
12.10	LF	852	$ 67.40	$ 57,427
12.12	LF	992	$ 74.43	$ 73,838
12.14	LF	22	$ 81.46	$ 1,792
18.10	LF	1,283	$ 77.98	$ 100,044
18.12	LF	2,291	$ 86.18	$ 197,436
18.14	LF	683	$ 94.38	$ 64,462
18.16	LF	939	$ 102.58	$ 96,326
Service taps at various depths				
Depth 9.1' -11'	EA	3	$ 1,134.83	$ 3,404
Stream/Road Crossing	in-dia/100ft	111	$ 4,345.73	$ 483,159
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,580	$ 54.20	$ 85,634
Type 3 (Soil amendments, Grading, Seeding)	LF	5,482	$ 8.04	$ 44,067
Manholes				
48" Dia., pipe dia. <21", <15' depth	EA	34	$ 10,000.00	$ 340,000
Subtotal				$ 2,107,761
Utility Relocation				
Water Line Relocation (5% of pipe length)	LF	353	$ 29.08	$ 10,270
Sanitary Sewer Relocation	LF	-	$ 29.08	$ -
Subtotal				$ 10,270
Subtotal Construction Costs				**$ 2,668,719**
Design Contingency (30%)				$ 800,616
Engineering and Administration (20%)				$ 533,744
Land Acquisition	SF	-	$ 11.37	$ -
Total Estimated Improvement Cost (Rounded)				**$ 4,004,000**

Boulder WWCSMP
December 2008

System Improvement Recommendations
Detailed Cost Estimate

Improvement ID: *Gunbarrel 1*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)	LS		10%	$ 232,126
Mobilization (6%)	LS		6%	$ 139,275
Traffic Control (5%)	LS		5%	$ 116,063
Utility Relocation (5%)	LS		5%	$ 116,063
Subtotal				$ 603,527
Pipe Improvements				
Dewatering (6% of Pipe Improvements Cost)	LS		6%	$ 117,483
Bypass Pumping (12% of Pipe Improvements Cost)	LS		12%	$ 234,966
Removal and Disposal				
8" to 36" pipe	LF	7,396	$ 19.37	$ 143,227
Manholes	EA	32	$ 2,192.32	$ 70,154
Connect to Existing	EA	14	$ 1,242.31	$ 17,392
Pipe - Diameter.depth - (inches.feet)				
8.08	LF	37	$ 44.33	$ 1,640
8.12	LF	1,111	$ 56.05	$ 62,271
10.12	LF	1,111	$ 63.28	$ 70,299
12.10	LF	962	$ 67.40	$ 64,841
12.12	LF	316	$ 74.43	$ 23,521
15.10	LF	258	$ 84.30	$ 21,750
15.12	LF	525	$ 91.92	$ 48,258
21.08	LF	931	$ 85.00	$ 79,131
21.10	LF	569	$ 93.78	$ 53,363
21.12	LF	377	$ 102.57	$ 38,670
24.08	LF	1,204	$ 88.56	$ 106,622
24.10	LF	1,105	$ 97.93	$ 108,213
Service taps at various depths				
Depth 6' - 9'	EA	9	$ 968.58	$ 8,717
Depth 9.1' -11'	EA	32	$ 1,134.83	$ 36,315
Depth 11.1' - 13'	EA	5	$ 1,301.39	$ 6,507
Stream/Road Crossing	in-dia/100ft	109	$ 4,345.73	$ 472,990
Surface Restoration				
Type 1 (Asphalt Patch)	LF	2,832	$ 54.20	$ 153,492
Type 3 (Soil amendments, Grading, Seeding)	LF	4,563	$ 8.04	$ 36,680
Manholes				
48" Dia., pipe dia. <21", <15' depth	EA	25	$ 10,000.00	$ 250,000
60" Dia., pipe dia. 21" - 42", <15' depth	EA	7	$ 12,000.00	$ 84,000
Subtotal				$ 2,310,503
Utility Relocation				
Water Line Relocation (5% of pipe length)	LF	370	$ 29.08	$ 10,754
Sanitary Sewer Relocation	LF	-	$ 29.08	$ -
Subtotal				$ 10,754
Subtotal Construction Costs				**$ 2,924,784**
Design Contingency (30%)				$ 877,435
Engineering and Administration (20%)				$ 584,957
Land Acquisition	SF	-	$ 11.37	$ -
Total Estimated Improvement Cost (Rounded)				**$ 4,388,000**

Boulder WWCSMP
December 2008

System Improvement Recommendations
Detailed Cost Estimate

Improvement ID: *Gunbarrel 2*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)	LS		10%	$ 289,238
Mobilization (6%)	LS		6%	$ 173,543
Traffic Control (5%)	LS		5%	$ 144,619
Utility Relocation (5%)	LS		5%	$ 144,619
Subtotal				$ 752,018
Pipe Improvements				
Dewatering (6% of Pipe Improvements Cost)	LS		6%	$ 146,568
Bypass Pumping (12% of Pipe Improvements Cost)	LS		12%	$ 293,137
Removal and Disposal				
8" to 36" pipe	LF	6,786	$ 19.37	$ 131,414
Manholes	EA	21	$ 2,192.32	$ 46,039
Connect to Existing	EA	6	$ 1,242.31	$ 7,454
Pipe - Diameter.depth - (inches.feet)				
18.12	LF	930	$ 86.18	$ 80,146
18.14	LF	264	$ 94.38	$ 24,917
30.14	LF	983	$ 142.42	$ 139,994
30.18	LF	1,212	$ 163.51	$ 198,170
30.20	LF	1,389	$ 174.05	$ 241,759
36.12	LF	913	$ 169.36	$ 154,623
36.14	LF	597	$ 181.08	$ 108,102
36.16	LF	497	$ 192.79	$ 95,818
Service taps at various depths				
Stream/Road Crossing	in-dia/100ft	211	$ 4,345.73	$ 917,819
Surface Restoration				
Type 3 (Soil amendments, Grading, Seeding)	LF	6,786	$ 8.04	$ 54,549
Manholes				
48" Dia., pipe dia. <21", <15' depth	EA	5	$ 10,000.00	$ 50,000
60" Dia., pipe dia. 21" - 42", <15' depth	EA	16	$ 12,000.00	$ 192,000
Subtotal				$ 2,882,510
Utility Relocation				
Water Line Relocation (5% of pipe length)	LF	339	$ 29.08	$ 9,867
Sanitary Sewer Relocation	LF	-	$ 29.08	$ -
Subtotal				$ 9,867
Subtotal Construction Costs				**$ 3,644,395**
Design Contingency (30%)				$ 1,093,319
Engineering and Administration (20%)				$ 728,879
Land Acquisition	SF	-	$ 11.37	$ -
Total Estimated Improvement Cost (Rounded)				**$ 5,467,000**

ATTACHMENT B
Proposed revisions to the BVCP Master Plan Summary

Wastewater Utility
The 2009 Wastewater Utility Master Plan (WWUMP) presents key issues, programs, policies and associated budgets for the wastewater collection system, wastewater treatment plant, and water quality programs. The WWUMP is supported by three primary planning documents: the Wastewater Collection System Master Plan (updated in ~~2009~~2016), the Wastewater Treatment Plant Master Plan (updated in 2007) and the Water Quality Strategic Plan (updated in 2009).

The three guiding principles for the WWUMP are:

- Protect public health and safety
- Protect Boulder's natural resources and the environment, and
- Maximize the use of the Wastewater Utility's funds.

The wastewater treatment plant has recently undergone significant modifications to increase the hydraulic capacity to 25 million gallons per day and meet future ammonia nitrogen limit requirements. The Wastewater Collection System Master Plan ~~included the development of a new GIS-based hydraulic sewer model~~ 2016 update incorporates new data on collection system performance during wet weather events and prioritizes capital needs.~~.~~

C I T Y OF B O U L D E R
PLANNING BOARD AGENDA ITEM

MEETING DATE: November 17, 2016

AGENDA TITLE: Public Hearing and Recommendation to City Council for Acceptance of the Boulder Stormwater Master Plan and Action on the Proposed Amendments to the Comprehensive Plan (BVCP) Flood and Stormwater Utility Summary.

REQUESTING DEPARTMENT: PUBLIC WORKS
Maureen Rait, Executive Director of Public Works
David Driskell, Director, Planning, Housing & Sustainability
Susan Richstone, Deputy Director, Planning, Housing & Sustainability
Jeff Arthur, Director for Public Works for Utilities
Douglas Sullivan, Engineering Project Manager
Pieter Beyer, Civil Engineer II
Lesli Ellis, Comprehensive Planning Manager
Jean Gatza, Senior Planner
Phil Kleisler, Planner II

EXECUTIVE SUMMARY:
The core mission of the Boulder Public Works (PW) Department is to maintain and improve the quality of life in Boulder by planning for future needs, promoting environmental quality, building and maintaining municipal infrastructure, managing public investments, and protecting health and safety. Originally adopted in 1984 and revised in 2007, the Stormwater Master Plan (SMP) is being updated to better reflect current conditions and new regulatory requirements. The purpose of this agenda item is to review the Stormwater Master Plan (**Attachment A**) and provide a recommendation to City Council regarding acceptance of the plan and approval of the revised master plan summary for the Boulder Valley Comprehensive Plan (BVCP) **(Attachment B)**.

Master plans provide a bridge between the BVCP, service delivery, future capital needs, and the Capital Improvements Program (CIP). The Planning Board's role in reviewing master plans is to look for consistency with BVCP goals and policies before the plans are accepted by City Council. Because of its role in reviewing the Capital Improvements Program (CIP), the Planning Board also reviews master plans to ensure that capital improvement needs and funding strategies have been identified to meet adopted service standards. The questions that are the focus of the Planning Board's review are:

1. Is the master plan consistent with the goals, policies, and growth projections of the BVCP?

2. Does the master plan outline the BVCP service standards and a plan to meet them in the future?
3. Does the plan describe and assess capital needs and a funding plan for them?

STAFF RECOMMENDATION:
Staff recommends that the Planning Board provide a recommendation to City Council for acceptance of the Stormwater Master Plan and that the Planning Board approves the revised BVCP Flood and Stormwater Master Plan Summary.

PUBLIC AND BOARD COMMENT AND PROCESS:
The master plan process has been led by a staff team with support from consulting firm HDR Engineering. Public input was largely received during the response to the 2013 flood event. At that time city staff initiated a comprehensive process to collect data on the extent of surface flooding, the severity of property damage, the source of flooding and the performance of the existing stormwater systems. Residents provided input through the Public Works call center during the flood, numerous open houses, on-site damage assessment surveys and CIP open houses.

The Water Resources Board held three public hearings during the planning period to accept public testimony and provide direction to the project team. The Water Resources Advisory Board unanimously recommended the plan to City Council for acceptance on April 18, 2016.

BACKGROUND AND PLAN OVERVIEW:
The first City of Boulder stormwater master plan was developed in 1984 by WRC Engineering. The 1984 plan focused solely on the collector system to ensure they could convey the necessary level of storm runoff generated during the two and five-year rainfall events. Collector systems generally include storm sewers 18 inches in diameter and larger, and open channel drainage systems that are not a part of the city's major drainageways. These systems primarily serve commercial development along arterial streets.

The next master plan, developed in 2007 by HDR, improved on the 1984 master plan through the utilization of a more accurate GIS-based mapping and more advanced hydraulic modeling techniques. However, like the 1984 plan, it also recommended improvements to the existing collector system. Focusing solely on the larger diameter collector systems in previous plans created a gap in knowledge about smaller local collector systems.

Extensive flooding in 2013 highlighted the need to address stormwater capacity in local collector systems that serve established residential areas. The 2016 Stormwater Plan includes analysis of areas of the city that will benefit from improvements to, and expansion of, the local collector systems as well as specific recommendations to guide the city to compliance with updated stormwater quality regulations.

ANALYSIS:

1. **Is the master plan consistent with the goals, policies, and growth projections of the BVCP?**

Staff finds that the Stormwater Master Plan is consistent with the goals, policies and growth projections of the BVCP. The built environment affects both the quality and quantity of water entering the city's stormwater system. As such, the BVCP Future Land Use Map was a key factor in assessing the city stormwater capacity needs in the years to come. Specific BVCP policies are referenced *Appendix A, Stormwater Management Policies* of the proposed 2016 Stormwater Master Plan.

The 2007 Stormwater Master Plan used the 2006 BVCP Land Use Designation Map to model a fully developed urban area. Since 2007 there have been only minor changes to the BVCP that have limited influence on the results of the 2016 stormwater analysis. For example, since 2006 there has only been a net increase in impervious coverage of 0.2% within the utility service area. This increase in impervious coverage was found to be insignificant enough that it would not create an impact to the model results and improvement recommendations if incorporated into the hydraulic model update process. The 2016 stormwater master plan update therefore carried forward the land use scenarios that were also used in the 2007 analysis.

Factors Driving the Need for Change
Some key trends point to changing conditions in the community and provide the context for the Stormwater Master Plan update. These current and emerging trends have implications for the future of drainage and stormwater quality:

- **The need to address localized flooding, such as what was experienced during the 2013 flood event**
  As explained above, previous stormwater master plans focused on larger diameter collector systems, with no focus on small local systems. This created several areas of the city underserved by stormwater infrastructure. The need to address these underserved areas was made evident during the 2013 flood event.

- **Compliance with revised stormwater regulations**
  The city's Municipal Separate Storm Sewer System (MS4) Permit authorizes the city to discharge stormwater from storm sewers and city facilities to waters of the State. The revised permit was reissued in 2016 with significantly expanded regulatory requirements. The 2016 Stormwater Master Plan will guide the city toward compliance with these expanded requirements.

2. Does the master plan outline BVCP service standards and a plan to meet them in the future?
The Public Works Department is currently meeting or exceeding BVCP urban service criteria for stormwater and floodplain management, as detailed in Chapter VI *Urban Service Criteria and Standards.*

3. Does the master plan describe and assess capital needs and a funding plan for them?
Staff finds that the 2016 Stormwater Master Plan meets these criteria. The plan includes itemized cost estimates for each CIP project, with cost estimate worksheets as an appendix. While the

regulatory compliance recommendations associated with the new MS4 permit do not represent significant cost implications to the Stormwater and Flood Management CIP, the 10 new Tier 1 high priority projects are estimated to cost approximately $20 M. This cost would likely be in addition to the estimated $20 M (in 2007 dollars) associated with the Tier 1 funding needs identified in the 2007 SMP for collector system improvements. As such, the implementation timeline for many projects identified in the plan extends beyond the city's standard six year CIP.

The funding needs for the collector system (identified in the 2007 plan) and local system (2016 plan) exceed current funding levels. Therefore, the city must implement a program balancing both types of projects to ensure that the storm sewer program is adequately addressing both underserved areas while maintaining sufficient capacity in the existing collector system.

BVCP MASTER PLAN SUMMARY

The BVCP Amendment Procedures provide direction that Master Plan and Program Summaries included in the plan can be updated at any time and are generally updated at the time of acceptance. Since the 2010 BVCP update, accepted plans are directly linked to the BVCP website and there is no longer the need for detailed summaries to be included in the plan. **Attachment B** includes new language describing the Stormwater Master Plan that would follow the overall mission and goals of the Stormwater and Flood Utility (*there is not currently a reference to this plan*).

NEXT STEPS:

Staff will consider Planning Board's feedback and revise the Stormwater Master Plan if necessary. The revised Stormwater Master Plan will be presented to City Council as a public hearing item for review and acceptance in early 2017.

Approved By:

David Driskell, Executive Director
Department of Community Planning and Sustainability

ATTACHMENTS:

A – Stormwater Master Plan
B – BVCP Master Plan Summary for the Stormwater Master Plan

ATTACHMENT A

City of Boulder

2016 Stormwater Master Plan

FINAL DRAFT

City of Boulder, Colorado

October 27, 2016

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Appendices

Appendix A: Stormwater Management Policies
Appendix B: Cost Estimates

Glossary of Acronyms

ac-ft	acre-feet
BMP	best management practice
BTV	Boulder Transit Village
BVCP	Boulder Valley Comprehensive Plan
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health and Environment
CDPS	Colorado Department of Public Safety
CFS	Comprehensive Flood and Stormwater Utility Master Plan
cfs	cubic feet per second
CFU	colony forming units
CIP	Capital Improvement Plan
City	the City of Boulder
CMMS	Computerized Maintenance Management System
CRM	Community Relations Management
Cu	Copper
CRS	Colorado Revised Statute
CUHP	Colorado urban hydrograph procedure
DCS	design and construction standards
DTM	digital terrain model
EMC	event mean concentration
EPA	Environmental Protection Agency
FAM	Facilities asset management
HGL	hydraulic grade line
IDDE	illicit discharge detection and elimination

Glossary of Acronyms

KICP	Keep It Clean Partnership
lbs/ac/yr	pounds per acre per year
LID	low impact development practices
MCM	minimum control measures
mg/L	milligrams per liter
µg/L	micrograms per liter
MS4	municipal separate storm sewer system
msl	mean sea level
NOAA	National Oceanic & Atmospheric Administration
NPDES	National pollutant discharge elimination system
NRCS	Natural Resources Conservation Service (formerly the Soil Conservation Service)
O&M	Operations and Maintenance
OSMP	Open Space and Mountain Parks
P	Phosphorous
PACE	Partners for A Clean Environment
Pb	Lead
PPD	program description document
Q_{Ratio}	ratio of peak flow capacity to full flow capacity
Q(wq)	water quality design storm peak flow (cfs)
ROW	right-of-way
SMP	Stormwater Master Plan
SOP	standard operating procedure
SSURGO	Soil Survey Geographic (database)
SMP	Stormwater Master Plan
SUSTAIN	System for Urban Stormwater Treatment and Integration Analysis
SWMM	Stormwater Management Model
TDP	total dissolved phosphorus
TKN	total Kjeldahl nitrogen
TMCC	Two Mile Canyon Creek
TMs	technical memorandums
TP	total phosphorus
TSS	total suspended solids
TMDL	Total Maximum Daily Load
UDFCD	Urban Storm Drainage Criteria Manual
USDA	United States Department of Agriculture

Glossary of Acronyms

USGS	U.S. Geological Survey
WLA	Waste load allocation
WQCV	Water quality capture volume
WQES	Water Quality and Environmental Services
WQIMP	water quality improvement projects
Zn	zinc

Executive Summary

This 2016 Boulder Stormwater Master Plan (SMP) replaces all previous stormwater master plans. The primary goal of the SMP is to provide the City of Boulder (city) with a guide to proactively address existing and future stormwater drainage and stormwater quality through a series of recommended improvements to the city's stormwater collection system. In 1984, the City developed a stormwater collection system master plan to guide upgrades and expansion to the system through a capital improvement program. While this plan had been a useful document, in 2007 it was recognized that new data and analysis tools were available, land use conditions had changed and new environmental regulations needed to be addressed. With this in mind, the 2007 Boulder SMP was developed to replace the 1984 plan with a document that was more in line with current problems and opportunities and the city's overarching environmental, economic and social goals.

The 2007 Stormwater Master Plan (SMP) was developed to provide the necessary planning tools and capital improvement projects to manage stormwater drainage and water quality throughout the city. Specifically, the 2007 SMP focused on assessment of the city's collector storm sewer system, consisting of storm sewers 18" in diameter and greater, and larger open channel drainage systems that are not a part of the city's major drainageways. The 2007 SMP did not analyze the local stormwater drainage systems (storm drain less than 18") or assess areas of non-existent drainage systems unless a historic drainage problem location was identified.

The 2016 SMP addresses this gap in the analysis of the local stormwater drainage systems by expanding on the 2007 SMP through additional analysis of where under-served or non-existent drainage systems create potential conveyance problems and develops improvements and associated estimates of capital costs needed to increase the level of service in these local drainage system areas. While the 2016 SMP did not re-analyze the entire collector storm sewer system or change those system recommendations, several local drainage systems overlapped the collector storm sewer system. In these instances, the collector system model and recommendations were updated as a part of the 2016 SMP.

Major activities undertaken in the development of the SMP include the following:

- Develop system analysis and problem identification criteria for both collector and local drainage systems
- Develop hydrologic, hydraulic and water quality models of the collector storm sewer system and extensions of that model to select areas of the local stormwater drainage system
- Assess post-flood problem areas within the stormwater drainage system based on Boulder 2013 Flood Survey data
- Evaluate the system and rank problem areas
- Perform alternatives analysis and develop a recommended plan
- Prepare a capital improvement plan
- Review new water quality regulations and their respective impact
- Develop an operation and maintenance assessment and provide recommendations
- Review current construction stormwater program and provide recommendations for standardizing the program across the city

- Provide recommendations for implementing the revised MS4 permit
- Provide recommendations for implementing other new water quality regulations

Study Area Characterization

The City of Boulder (city) has a population of approximately 100,000 and an area of nearly 25.5 square miles. Within the city, there are 12 subbasin and 15 major drainageways that generally flow from west to east as they converge on Boulder Creek, which is the primary major drainageway through the city. Runoff is conveyed to major drainageways by the city's collector storm sewer system and overland flow. Upstream of the collector storm sewer system are local drainage systems which generally consist of storm sewers less than 18" in diameter or areas with limited or no sub-surface drainage system.

At present, Boulder is nearly fully built-out with much of the future development expected to occur as site redevelopment. The city-wide existing condition impervious percentage was estimated to be 32% and is projected to be 34% under the 2006 Boulder Valley Comprehensive Plan as determined with the 2007 SMP analysis. However, considering the city's Design and Construction Standards (DCS) requirement for development to mitigate new impervious area through on-site best management practices (BMPs), the resulting net future condition imperviousness was determined to be 33%.

Planning and Analysis Criteria

A master planning analysis was performed to identify potential stormwater conveyance and water quality improvements within the city. The analysis was guided by a set of criteria used to identify problem areas and to evaluate potential improvements. These criteria included quantitative assessments of storm sewer surcharging, culvert overtopping, channel and irrigation ditch flooding, structure flooding (buildings, etc), reported drainage problems, and pollutant loadings.

Analysis Approach

The focus of the 2007 SMP was the collector storm sewer system, which included storm sewers 18" in diameter and larger and open channel systems that are not part of the city's major drainageways. Two levels of service associated with system capacity were provided based on land use, per the BVCP, and roadway category. For areas that are mainly residential in land use, the 2-year design storm was used to identify problems in the downstream conveyance system. For areas draining mainly commercial, industrial and collector and arterial roadways, the 5-year event was used.

Areas within the city that experience localized flooding (e.g., undersized pipes that are less than 18 inches in diameter; roadside ditches; and clogged catch basins) were addressed with the 2016 SMP as part of the local drainage system analysis. As with the collector storm sewer system analysis, the 2-yr and 5-yr storms were used to define the level of service based on 2006 BVCP land use and roadway category.

Modeling Approach

The modeling approach for the SMP integrated GIS as a pre- and post-processing tool with an EPA-based Storm Water Management Model (SWMM) as the hydrologic, hydraulic and water quality analysis tool. The analysis software used for the project was XPSWMM which is a proprietary

version of EPA-SWMM software that provided an efficient GIS interface that EPA-SWMM does not have at this date. Workflow began in GIS, where the input parameters for the SWMM model were developed. This data was transferred out of GIS to SWMM for the evaluation of the system hydraulics and water quality. Model results were ultimately brought back into GIS for post processing and storage for future reference by the City.

The 2007 SMP model was used as the basis for modeling performed with the 2016 analysis. Hydrologic data remained unchanged for the 2016 analysis with the exception of subbasins that were re-delineated with the local stormwater drainage system analysis. For these re-delineated subbasins, model parameters of area, basin width, slope, and imperviousness were recalculated; no other hydrologic parameters were modified. The 2016 analysis also updated the 2007 SMP model to reflect improvements to the storm sewer system constructed since the completion of the 2007 SMP analysis.

Future Land Use and Development Criteria

Land use is a key factor in assessing stormwater runoff because it affects both the quantity (volume and peak) and quality of water being routed through the stormwater system. The future conditions land use scenario, used in the 2007 SMP, was based on the 2006 Boulder Valley Comprehensive Plan and represents a fully developed urban area. Although there have been updates to the BVCP since 2006, updates to the future land use were verified to have little effect stormwater modeling parameters. In addition, the future land use scenario also incorporates the city's DCS, which requires detention and water quality treatment for all new impervious areas that preserve pre-development runoff characteristics.

Hydraulic Problem Areas and Ranking

The stormwater drainage system hydraulic analysis was accomplished in two phases: 1) a collector system analysis performed with the 2007 SMP and 2) a local system analysis performed with the 2016 SMP.

Collector System Analysis

Utilizing the XPSWMM model, runoff, hydraulic, and water quality calculations were completed for existing and future condition land use scenarios using the 2- and 5-yr storms events. These results were then evaluated with respect the previously noted system analysis criteria to identify specific system deficiencies within the city's collector storm sewer system.

Model results for existing conditions indicate that 572 nodes out of 1635 nodes within the model violate one or more of the problem threshold criteria. Deficient model nodes and links were grouped together into problem locations based on their hydraulic connectivity. This resulted in a total of 51 hydraulic problem locations for the collector storm sewer system. Irrigation ditch segments were also added to the problem identification list if the corresponding design storm resulted in overtopping while the ditch was conveying irrigation water.

Due to the relatively large number of collector storm sewer system problem locations identified through the modeling and GIS analysis, and due to limitations within the city's capital budget, a ranking was performed on the problem areas to prioritize the conveyance problems. This process resulted in identifying three problem priority levels; Tier 1, Tier 2 and Tier 3 indicating severe, major or minor problem areas, respectively. The process of ranking problem areas into tiers utilized a

point-based matrix using a weighted criteria approach. Six criteria were used to rank the problem areas and include:

- Extent of the problem
- Flooded volume
- Impact to neighboring structures
- Length of under capacity pipe
- Confidence in the underlying data
- Proximity of a hydraulic problem to water quality area of concern

The problem prioritization process resulted in five Tier 1 problem areas, 17 Tier 2 problem areas, and 31 Tier 3 problem areas. These collector storm sewer system problem locations are shown on Figure ES-1.

Local System Analysis

A GIS-based analysis evaluated city-reported problem areas from the city's Community Relations Management (CRM) database, 2013 flood survey data, and GIS storm sewer data to identify areas that have limited stormwater drainage systems and/or have observed local flooding issues. Fact sheets were developed to characterize the stormwater drainage system issues and potential opportunities. Site visits to the local system problem areas were made to confirm and better assess the system issues.

The analysis process identified forty two (42) local drainage system problem areas. To assist in the development of improvement recommendations, a prioritization process was used to assess the risk of future drainage related impacts in these 42 areas. Seven criteria were used to rank the problem areas and include:

- Known problem areas reported in the CRM database
- Known problem areas reported in the CRM database and observed flooding in the 2013 flood Reports, and/or modeled problem area in the collector storm sewer system
- Irrigation ditch storm flow reduction
- Underserved area
- Recorded problem area in 2013 Flood Reports
- Recorded problem area in 2013 Flood Reports and modeled problem area in the collector storm sewer system
- Severity and consequences of flooding

This analysis process resulted in identifying three problem levels, Tier I, Tier II, and Tier III. The prioritization process resulted in 10 Tier I problem areas, 11 Tier II problem areas and 14 Tier III problem areas. 7 problem areas were removed following a site visit which revealed that analysis assumptions for those areas did not match actual field conditions. The resulting 35 local stormwater drainage system problem locations are shown on Figure ES-2.

Water Quality Analysis and Problem Areas

The water quality analysis, performed with the 2007 SMP analysis, included two separate approaches to identify problem locations within the collector system: 1) a buildup-washoff analysis using the XPSWMM model to identify water quality areas of concern that produce high pollutant loads and 2) targeted outfall approach focusing on the collector system outfalls to Boulder Creek. The water quality area of concern approach used the XPSWMM model to identify areas within the city having comparatively higher pollutant concentrations and/or loads. This approach identified 12 locations within the city that were characterized as water quality areas of concern. The Boulder Creek outfall approach identified 17 collector system outfalls that do not currently receive pollution reduction through regional water quality facilities. The water quality areas of concern and Boulder Creek outfall sites are shown on Figure ES-3.

Capital Improvement Plan

The Capital Improvement Plan (CIP) is separated into two general categories: 1) collector storm sewer system improvements and 2) local drainage system improvements. Figures ES-4 through ES-8 present the collector, local and water quality system improvements. Estimates of capital construction costs included in this plan are considered planning level estimates to be used in developing stormwater capital budget requirements.

Collector Storm Sewer System CIP

The collector storm sewer system improvement recommendations were categorized as 1) Hydraulic , 2) Combined Hydraulic/Water Quality projects or 2) Water Quality Improvement projects.

The implementation plan for the Hydraulic and Combined Hydraulic/Water Quality CIP projects follows the Tier 1, 2 and 3 problem areas. Tier 1 CIP projects are considered high priority improvements as they resolve severe collector storm sewer system problems and in some instances also address stormwater quality problems. Tier 1 problem areas are anticipated to a) have a high social benefit by resolving street and property flooding issues, b) have a high economic benefit by reducing flooding risk and property damage, and c) provide an environmental benefit by addressing stormwater quality issues. Note that not all Tier 1 locations included a water quality problem site and that the overriding criterion for prioritization was resolving flooding issues. Table ES-1 identifies the Tier 1 CIP projects; Tier 2 and 3 projects are identified in the main report.

Table ES-1: Collector Storm Sewer System Tier 1 Hydraulic and Combined Hydraulic/Water Quality CIP Projects

Ranking	Improvement ID	Location	Improvement Type	Capital Cost
1	GC_02	Upper Goose Creek	Pipe Replacement New Storm Drain Channel Improvement	$8,269,000
3	MBC_14	Arapahoe and 28th Street	Pipe Replacement Storm Drain Re-Routing/Extension Proprietary BMP	$2,076,000
4	DC_01	Gunbarrel – Spine Road, Lookout and 63rd Systems	Pipe Replacement Storm Drain Re-Routing/Extension Constructed Wetland	$7,195,000

Table ES-1: Collector Storm Sewer System Tier 1 Hydraulic and Combined Hydraulic/Water Quality CIP Projects

Ranking	Improvement ID	Location	Improvement Type	Capital Cost
			TOTAL	**$17,540,000**

Local Drainage System CIP

The implementation plan for the local drainage system improvement projects was prioritized based on reported problem areas, observed flooding, stormwater removal from irrigation ditches, lack of existing stormwater infrastructure, and field observations. Table ES-3 identifies the Tier I local drainage system CIP projects; Tier II and III projects are identified in Tables 7.2-2 and 7.2-3 within Section 7 of the main report.

Table ES-2: Tier I Local Drainage System CIP Projects

Ranking	Project ID	Location	Improvement Type	Capital Cost
1	Wonderland Creek -1	Broadway Street from Rosewood Ave to Violet Ave	New Storm Sewer Replacement Storm Sewer	$318,000
2	Elmer's Twomile Creek-2	Farmer's Ditch – Iris Ave to Linden Ave and Broadway St to Cloverleaf Drive	New Storm Sewer Replacement Storm Sewer	$3,874,000
3	Goose Creek-1	Intersection of 8th St and Dellwood Ave	New Storm Sewer Replacement Storm Sewer	$1,585,000
4	Goose Creek-2	Alpine Ave to Dellwood Ave and 3rd St to 7th St	New Storm Sewer Replacement Storm Sewer	$2,417,000
5	Goose Creek-3	Dewey Ave from 4th St to 9th St	New Storm Sewer Replacement Storm Sewer	$984,000
6	Middle Boulder Creek-2	Vicinity of Pine Street from 16th St to 21st St	New Storm Sewer Replacement Storm Sewer	$3,175,000
7	Dry Creek No, 2-1	Intersection of Chippewa Dr and Caddo Pkwy east of Inca Pkwy	New Storm Sewer Replacement Storm Sewer	$1,837,000
8	Dry Creek No 2-3	Intersection of Chippewa Dr Baseline and 55th St from Foothills Hwy to Arapahoe Ave	New Storm Sewer Replacement Storm Sewer	$6,505,000
9	Bear Canyon Creek-3	Vicinity of Kohler Dr from south of Dartmouth Ave	Hydraulic Improvement	$2,265,000
10	Bear Canyon Creek-5	Vicinity of Wildwood and Ithaca Drive	Hydraulic Improvement	$267,000
			TOTAL	**$23,227,000**

Water Quality Improvement CIP

The implementation plan for the Water Quality Improvement (WQIMP) projects was prioritized based on problem severity as identified by pollutant load. The WQIMP category was developed since many of the water quality project sites were not adjacent to hydraulic problem and improvement locations. In addition, many of these WQIMP projects could be defined as a small capital projects since the estimated construction costs are less than $100,000.

Table ES-3: Water Quality Improvement CIP Projects

Improvement ID	Location	Capital Cost
WQIMP 2	Boulder Creek 1,400' East of 75th Street	$133,000
WQIMP 3	Boulder Creek & 28th Street	$104,000
WQIMP 5	Boulder Creek & 75th Street	$97,000
WQIMP 6 & WQIMP 9	Boulder Creek & East Broadway Street & Arapahoe Avenue	$201,000
WQIMP 8	Boulder Creek 200' West of Folsom Street	$108,000
WQIMP 12	Boulder Creek & Folsom Street	$100,000
WQIMP 14	Boulder Creek & 9th Street	$93,000
WQIMP 15	Broadway & Skunk Creek	$93,000
WQIMP 16	Boulder Creek & 13th Street	$104,000
WQIMP 18	Boulder Creek & 11th Street	$65,000
	TOTAL	**$1,098,000**

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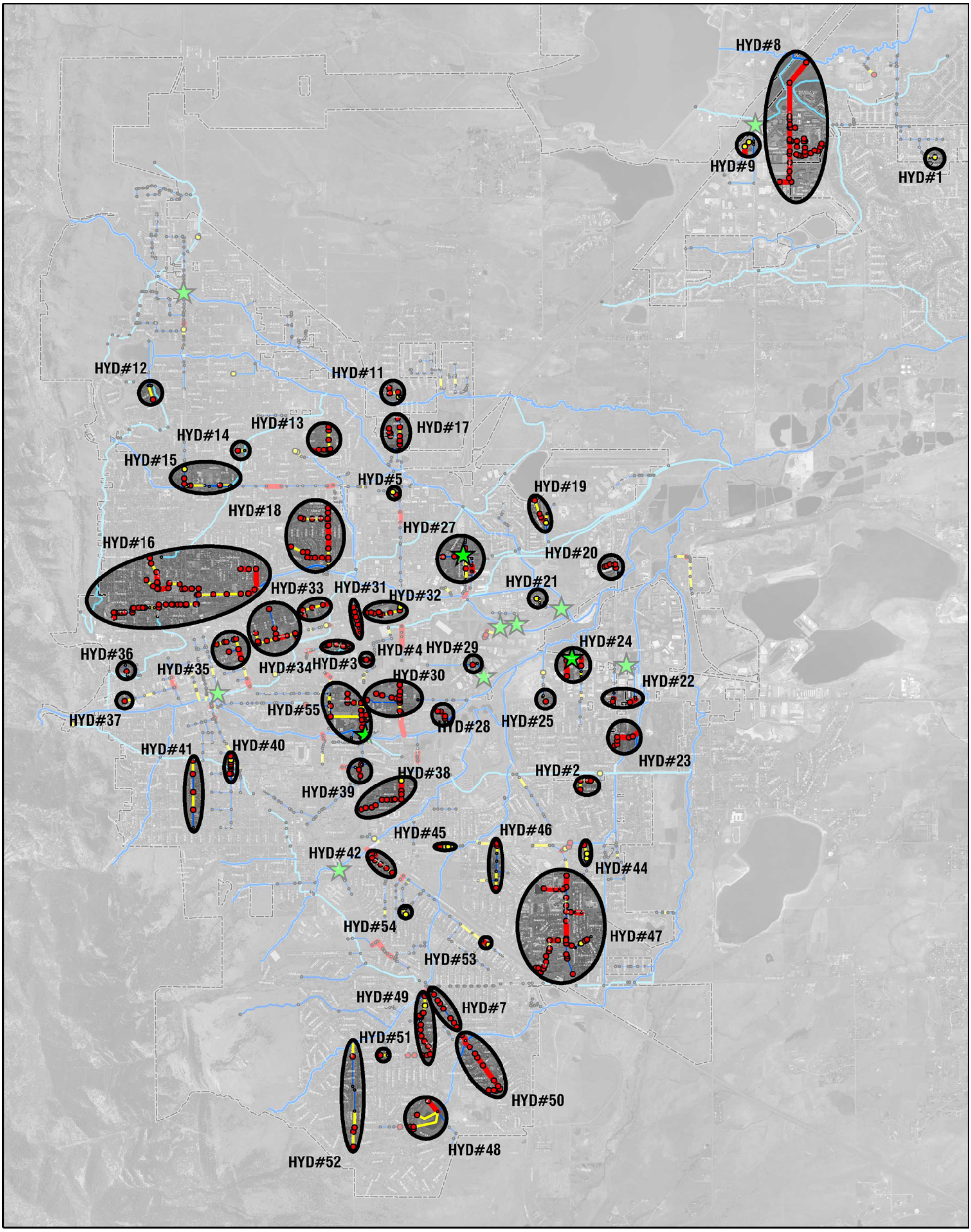

Legend

- Hydraulic Problem Areas
- Flooded
- Surcharged
- OK

Conveyance Capacity
- Sufficient Capacity
- Under Capacity
- Severely Under Capacity

Modeled network
- Canal/ Ditch
- Major drainageway
- Major Roads

- City Limits
- Lakes
- Water Quality Areas of Concern

0 4,000
1 inch equals 3,500 feet

N

Collector Storm Sewer System Hydraulic Problem Summary Map

Figure ES-1

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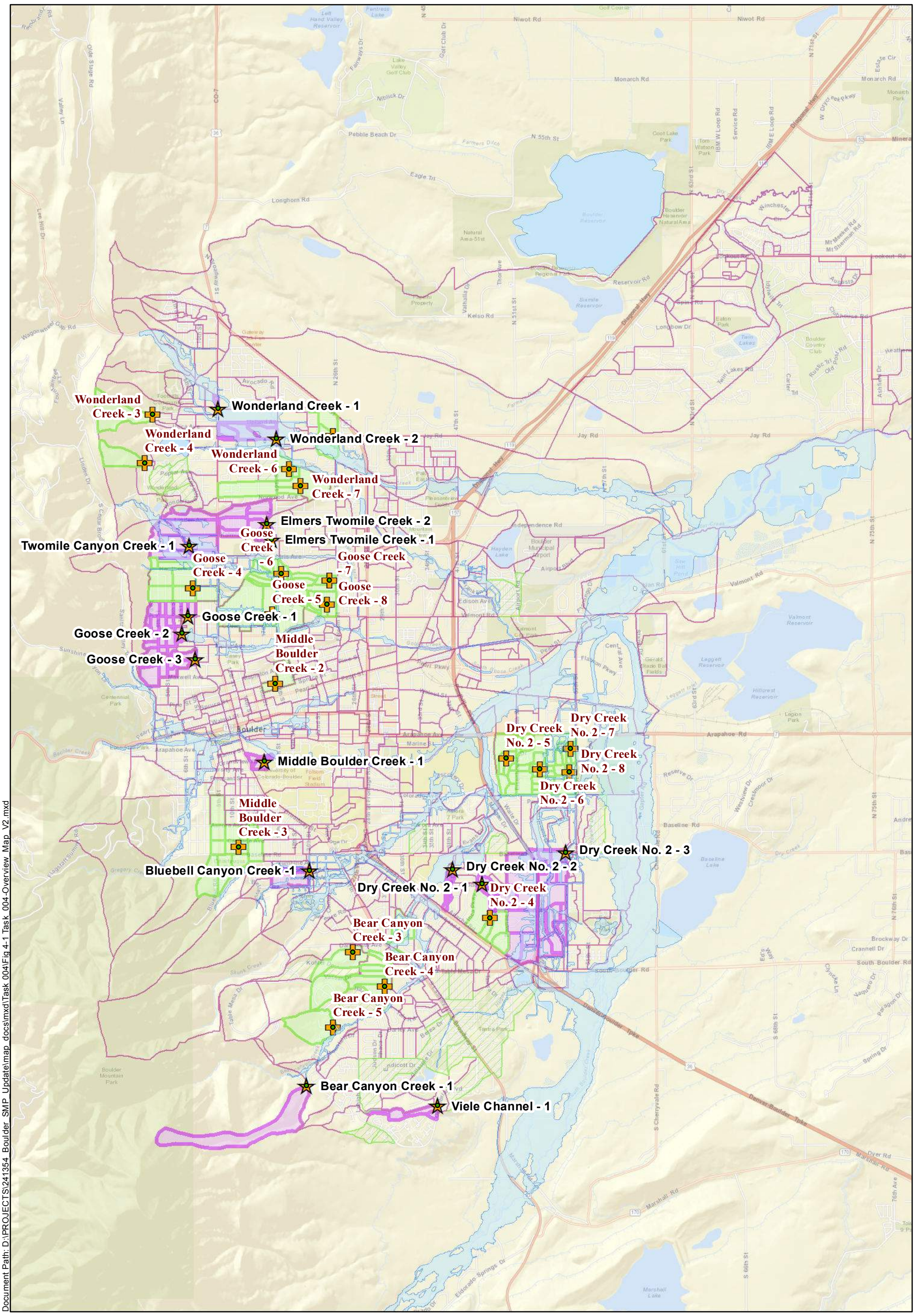

Type A - Local Drainage Problem Area
Type B - Local Drainage Problem Area
2013 Flood Extents
Subcatchment
Type A Priority Subbasin
Type B Priority Subbasin
Type B Override

0 4,000 8,000 Feet

Local Storm Sewer System Problem Locations

Figure ES-2

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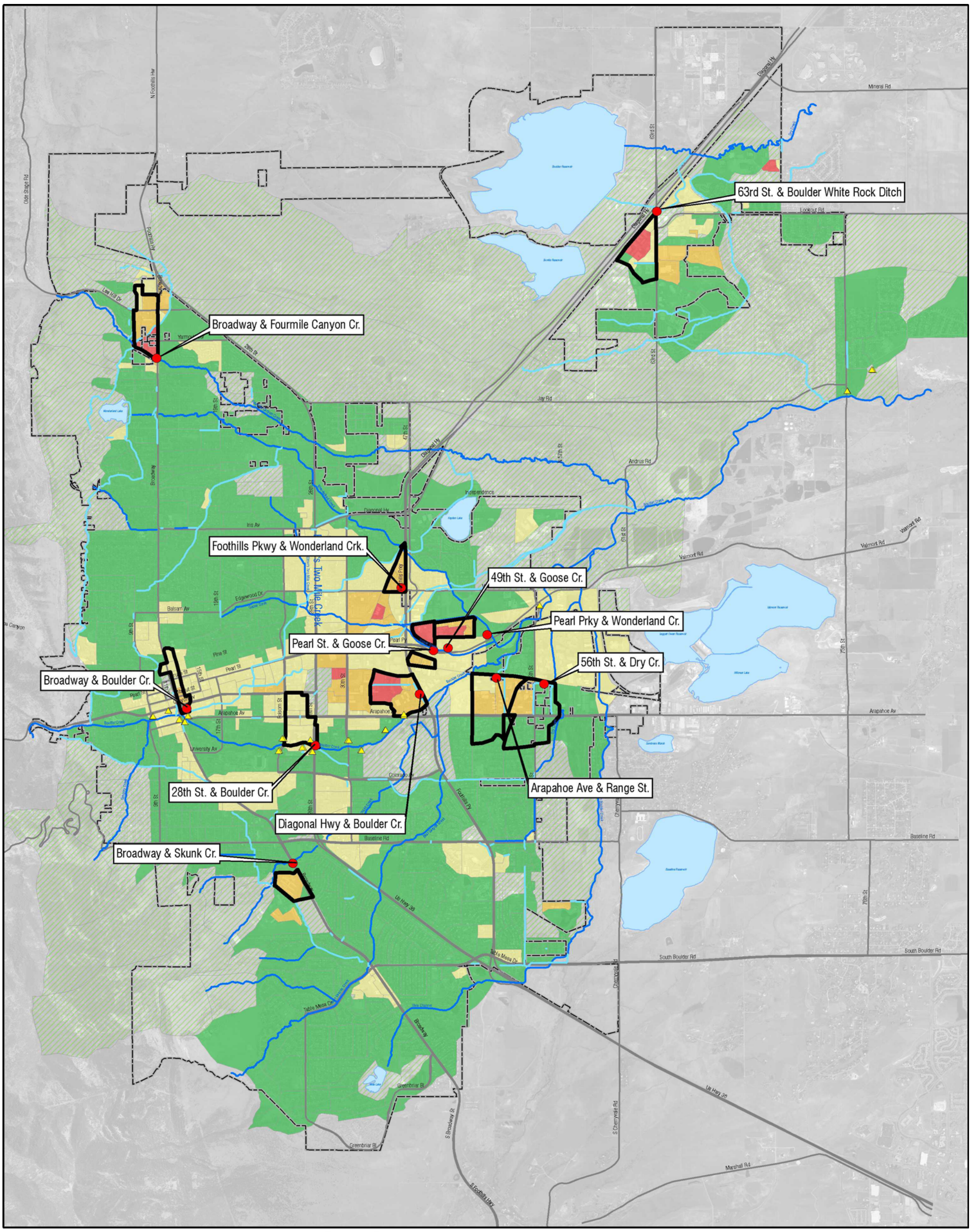

Legend

- Key Pollutant Load Outfalls
- Outfall Catchments
- Modeled network
- Canal/ Ditch
- Major drainageway
- Major Roads
- City Limits
- Lakes
- Boulder Creek Outfalls

Load (Lbs TSS/Ac/Yr)
- 0 - 250
- 251 - 500
- 501 - 750
- 751 - 1000
- 1001 +

0 4,000
1 inch equals 4,000 feet

N

Collector Storm Sewer System
Water Quality Areas of Concern Map

Figure ES-3

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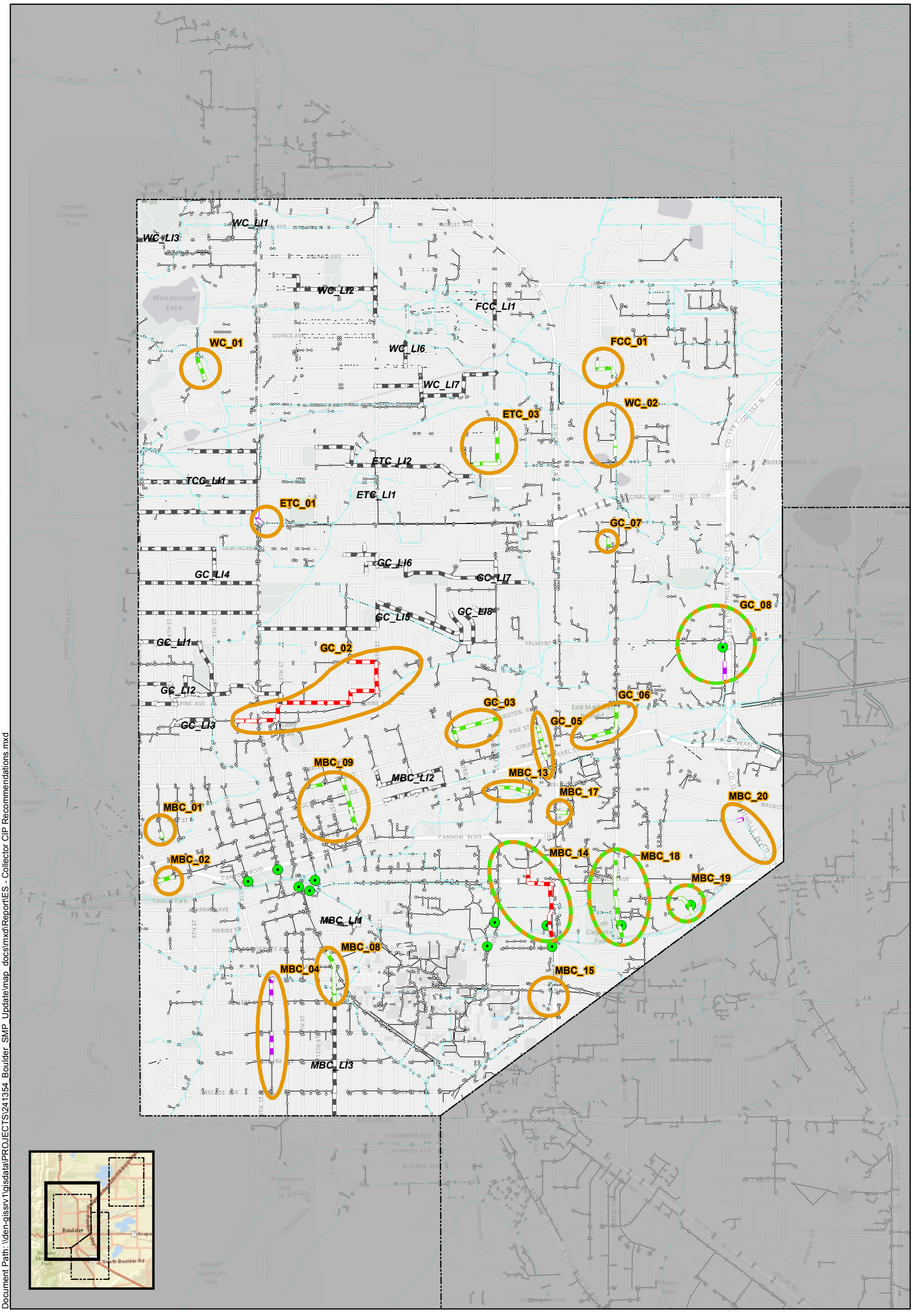

Collector System Improvement Area
Local Storm Sewer Improvements

Collector Storm Sewer System Improvements

Tier I Pipes
Tier II Pipes
Tier III Pipes
Water Quality Manholes
Water Quality Surface BMP

Creek/Ditch
Existing Storm Sewer
Existing Open Channel

N

0 1,200 2,400 Feet

Collector Storm Sewer System Improvements, 1 of 3

Figure ES-4

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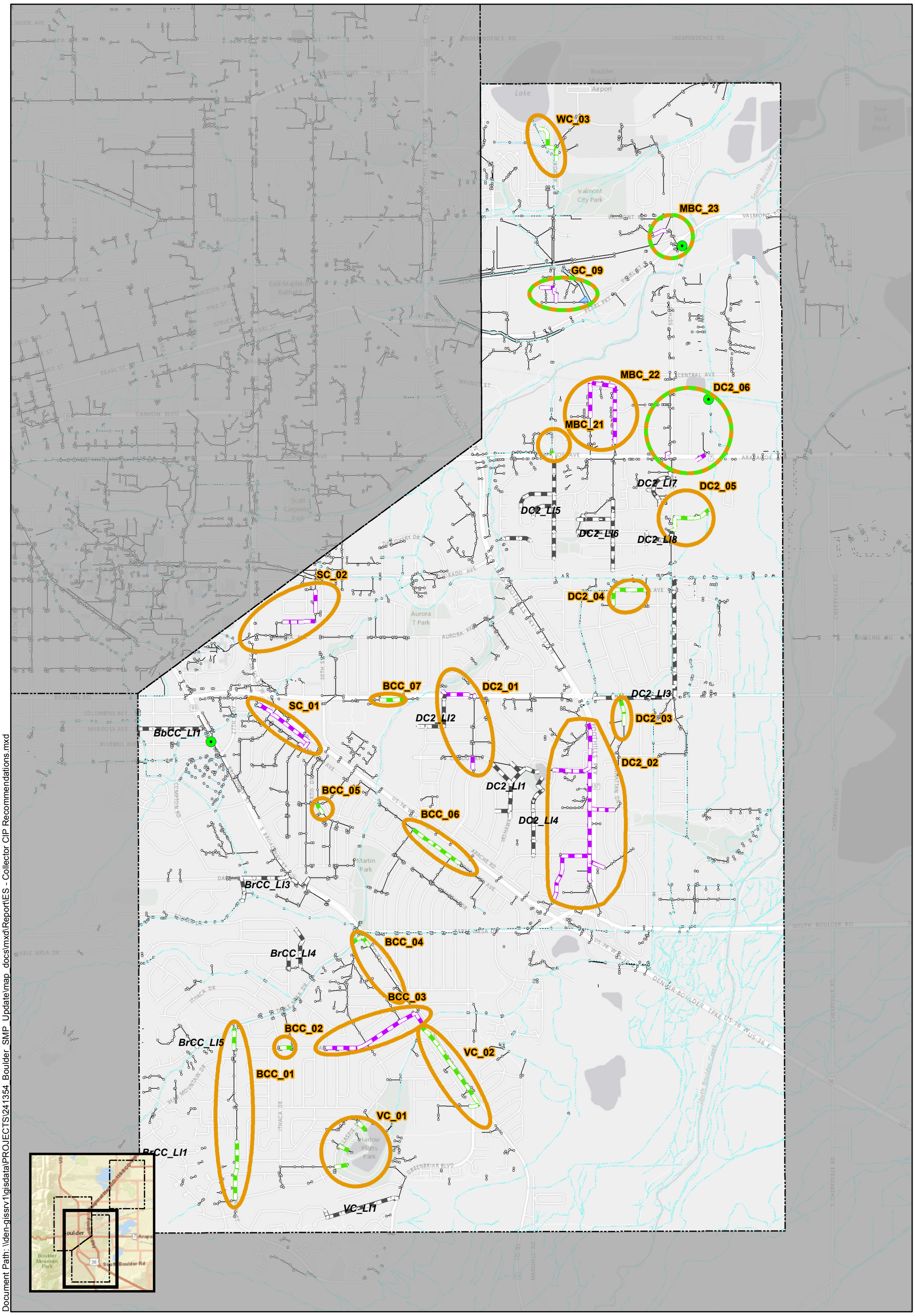

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Collector System Improvement Area
Local Storm Sewer Improvements

Collector Storm Sewer System Improvements

Tier I Pipes
Tier II Pipes
Tier III Pipes
Water Quality Manholes
Water Quality Surface BMP

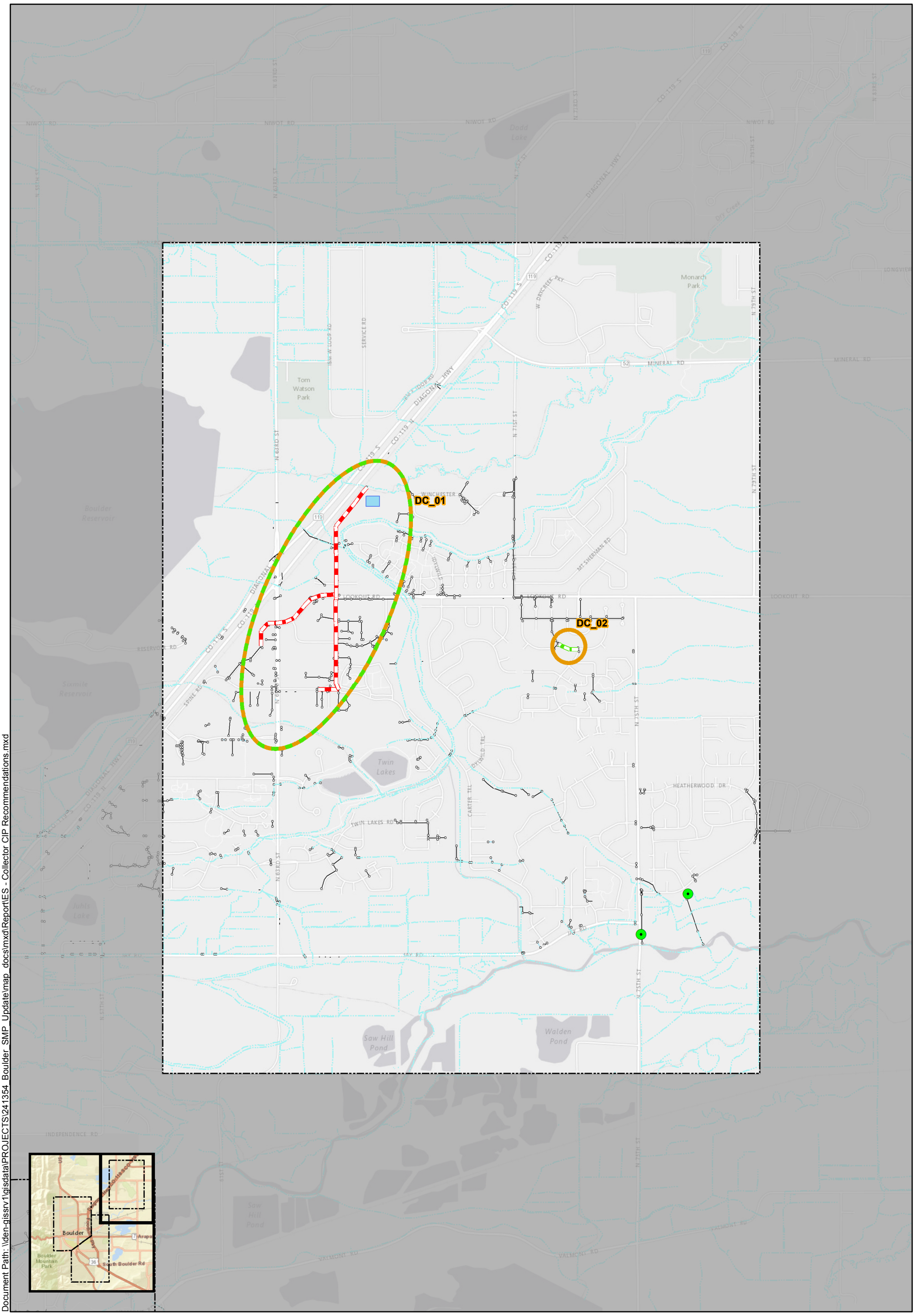
Creek/Ditch
Existing Storm Sewer
Existing Open Channel

N

0 1,200 2,400 Feet

Collector Storm Sewer System Improvements, 2 of 3

Figure ES-5



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N

0 1,200 2,400 Feet

Collector System Improvement Area

Local Storm Sewer Improvements

Collector Storm Sewer System Improvements

Tier I Pipes

Tier II Pipes

Tier III Pipes

Water Quality Manholes

Water Quality Surface BMP

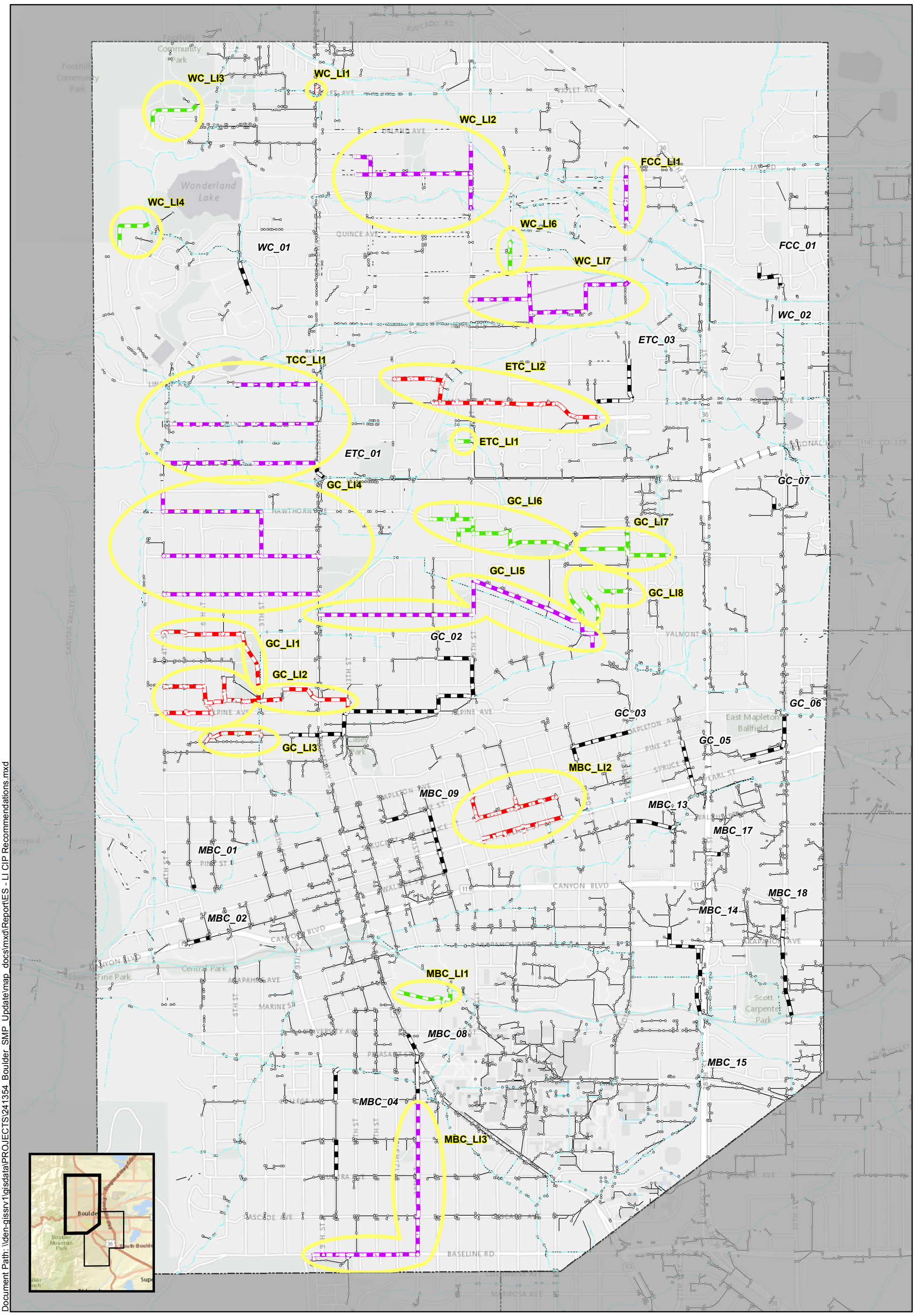
Creek/Ditch

Existing Storm Sewer

Existing Open Channel

Collector Storm Sewer System Improvements, 3 of 3

Figure ES-6



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N

Local System Improvement Area

Collector Storm Sewer System Improvements

Local System Improvements

Tier I Pipes

Tier II Pipes

Tier III Pipes

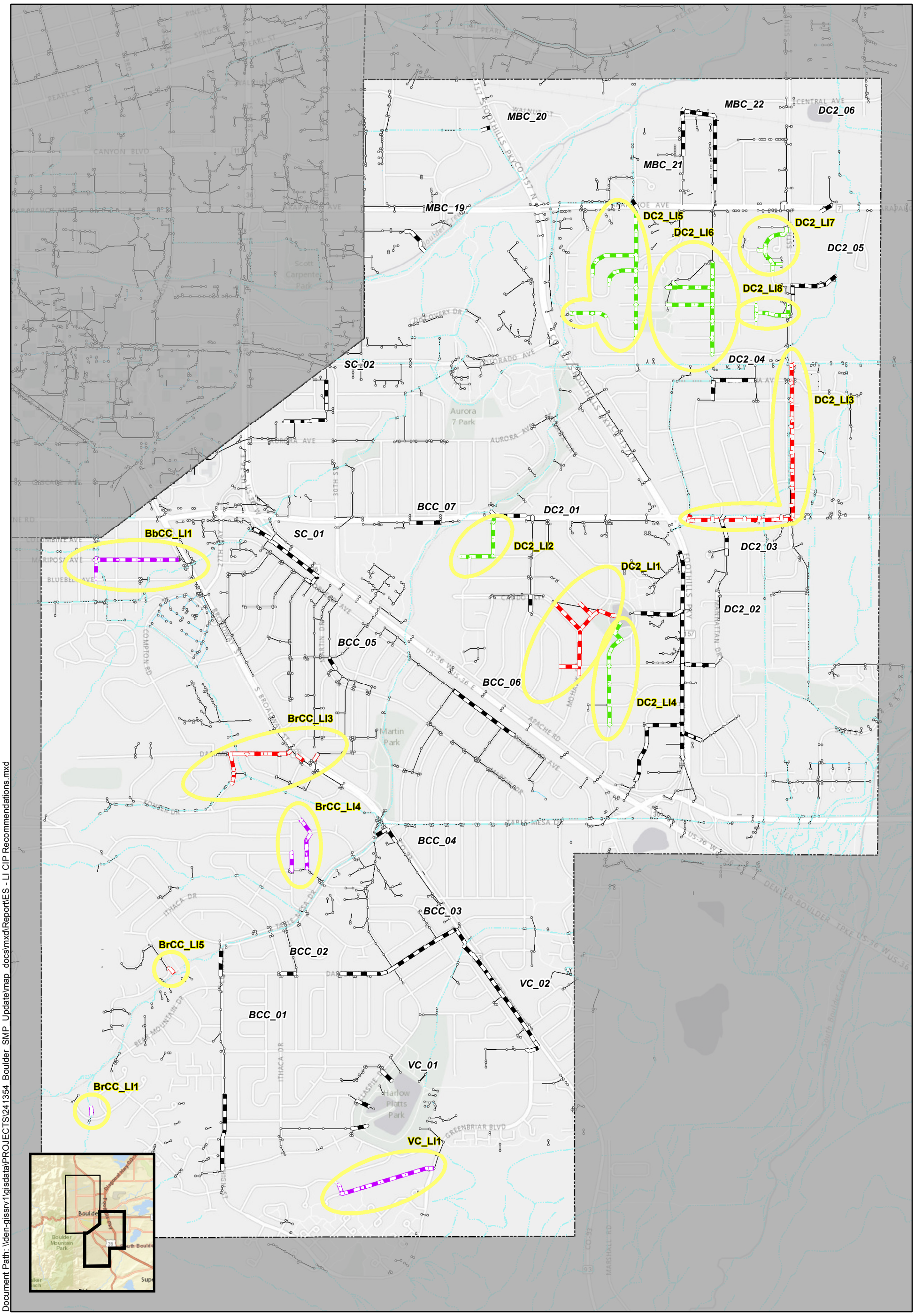
Creek/Ditch

Existing Storm Sewer

Existing Open Channel

0 900 1,800 Feet

Local System Improvements - North
Figure ES-7



Document Path: \\den-gissrv1\gisdata\PROJECTS\241354_Boulder_SMP_Update\map_docs\mxd\Report\ES - LI CIP Recommendations.mxd

0 900 1,800 Feet

N

Local System Improvement Area
Collector Storm Sewer System Improvements

Local System Improvements

Tier I Pipes
Tier II Pipes
Tier III Pipes

Creek/Ditch
Existing Storm Sewer
Existing Open Channel

Local System Improvements - South
Figure ES-8

1 Introduction

This 2016 Boulder Stormwater Master Plan (SMP) replaces all previous stormwater master plans. Recent history of the stormwater master planning process started in 1984 when the city developed a master plan to guide upgrades and expansion to the storm sewer system. While this plan had been a useful document, in 2007 it was recognized that new data and analysis tools were available, land use conditions had changed and new environmental regulations needed to be addressed. With this in mind, the 2007 Boulder SMP was developed to replace the 1984 plan with a document that was more in line with current problems and opportunities and the city's overarching environmental, economic and social goals.

The 2007 SMP provided the City with the necessary planning tools and capital improvement projects to address flood management and water quality. Specifically, the 2007 SMP focused on assessment of the city's existing collector storm drainage conveyance system, consisting of storm sewer 18" and greater and larger open channel drainage systems that are not a part of the city's major drainageways. The 2007 SMP did not analyze the local storm drainage conveyance systems (storm drain less than 18") or assess areas of non-existent drainage systems unless a historic drainage problem location was identified.

This 2016 SMP updated the 2007 SMP analyses to address portions of the local drainage system that are considered "underserved" in regards to stormwater infrastructure and/or lacking in the protection provided by a sufficient stormwater collection and conveyance system. As described in Boulder's Design and Construction Standards (DCS), the level of service specified for residential areas is the 2-year design storm. All other areas of local and collector storm sewer system are provided a 5-year storm level of service.

1.1 Goals and Objectives

The goal of the SMP is to proactively manage stormwater runoff to protect water quality and to minimize impacts of localized and downstream flooding by identifying infrastructure improvements for the collection, conveyance and treatment of stormwater within the city limits. The development of the SMP expanded and built upon the city's goals to address environmental, economic and social issues through the following planning objectives:

- Develop a master plan for the collector storm sewer system and local drainage systems that alleviates current capacity and flooding problems.
- Develop a master plan such that the stormwater drainage system can accommodate additional runoff generated from future development or redevelopment.
- Identify site specific improvements that address stormwater quality to improve receiving water quality for environmental and recreational benefit.
- Incorporate social implications in the prioritization of recommended projects by focusing on problem locations that impact key community facilities, major transportation corridors and protection of private property.
- Recommend improvements that are sustainable from an operations and maintenance perspective.

1.2 Stormwater Planning Process

The 2007 SMP analyzed and developed recommendations for the collector storm sewer system which was defined as the storm sewer system generally 18-inches in diameter and greater. The process used in preparing this 2016 SMP involved updating the 2007 SMP to reflect current conditions and address upstream local drainage systems that are smaller than 18 inches in diameter and that were not evaluated with the 2007 SMP analyses.

The SMP process was based on a series of steps as described below. Additionally, through a progression of workshops at the onset and completion of key steps, input from city staff was gathered and incorporated into the SMP to ensure the overall goals and objectives were met.

- Collect and review existing information, including previous studies, designs, survey information (including new survey), drainage reports and other data to support development of the plan.
- Establish a set of goals, policies and analysis criteria that will guide the analysis and development of a recommended plan.
- Develop a hydrologic, hydraulic and water quality model of the collector storm sewer system.
- Identify and assess reported problem areas within the local stormwater drainage system.
- Evaluate the existing stormwater infrastructure with respect to the system analysis criteria and rank each problem in terms of severity.
- Develop alternatives for each problem area.
- Prepare a recommended plan, documenting the preferred alternatives, detailed cost estimates, and significant implementation.

The format of the SMP report is based on the project workflow starting with project goals and ending with a recommended plan. The city's Project Planning and Approval Process Handbook for Capital Improvement Program Projects (July 2003) presents a general framework for master plans. The SMP report modified the suggested framework to accommodate the project scope, purpose and needs.

2 Analysis and Problem Identification Criteria

The SMP identifies improvements to the city's collector and local drainage systems. The evaluation was guided by a set of system analysis criteria used to identify conveyance and water quality problem areas and to evaluate potential improvements. These criteria included quantitative assessments of storm drain surcharging, culvert overtopping, channel/ditch flooding, structure flooding (buildings, etc) and pollutant loadings.

This section presents a description of the study area, the criteria used in the analysis of the stormwater drainage system and the criteria used for identifying problems within the system.

2.1 Study Area

The City of Boulder, with a population of approximately 100,000 and an area of nearly 25.5 square miles, is located along the front range of the Rocky Mountains, northwest of Denver, Colorado. Within the city, there are 12 subbasin and 15 major drainageways that generally flow from west to east as they converge on Boulder Creek, which is the main tributary flowing through the city. Runoff is conveyed to these major drainageways by the city's collector storm sewer system and overland flow. Upstream of the collector storm sewer system are local drainage systems which consist of storm sewers less than 18" in diameter or areas with limited or no sub-surface drainage system.

2.1.1 Topography

Topographically, Boulder sits roughly 5,430 feet above sea level. Elevations in the city range from over 6,400 feet mean sea level (msl) above Wonderland Lake on the west side of the city to approximately 5,100 feet (msl) near Boulder Reservoir in the northeast corner of town. Surface slopes within the city are generally flat with few areas exceeding 5% except for the area abutting the foothills, where slopes nearing 1:1 are not uncommon (Figure 2-2).

2.1.2 Land Use

The city is nearly fully "built-out" with the majority of the land use in the basin as residential. The highest density commercial areas are located along Boulder Creek in the central downtown core area and along 28th Avenue, Foothills Highway, and Gunbarrel. The University of Colorado is also located within Boulder and occupies roughly 1 square mile of land in the southwestern portion of the city. At present, because the city is almost fully developed, anticipated future land use is not expected to substantially change with construction activities mainly involving site redevelopment.

2.1.3 Soils

The City of Boulder is located at the foothills of the Rocky Mountains. Its underlying geologic unit is classified as young Quaternary deposits of stream gravels and sand, slope wash, terrace gravels and landslides and was deposited approximately 65 million years ago. The surface soils are mainly composed of poorly cemented and unconsolidated sands and gravels. Hydrologically speaking, the soils are largely classified as Type C according to the Natural Resources Conservation System (NRCS, formerly the Soil Conservation Service), however all other hydrologic soils type classifications can be found in the city.

2.1.4 Climate

The climate of the Boulder Valley area is typical of the Front Range. During the summer months, the average temperature is approximately 66 F; during the winter months, the average temperature is about 35 F but freezing temperatures are not uncommon. The average annual precipitation in Boulder is approximately 20 inches with nearly 60% occurring as rain between March and July. Significant summer rainfall events are typically thunderstorms and are characterized as high in intensity and short in duration. On average, 54 thunderstorms occur annually between April and September (NOAA, 2005).

2.2 System Analysis Criteria

Stormwater planning was accomplished using a set of planning and design criteria. The following information summarizes these criteria, including design storms, modeling assumptions and other system analysis criteria that were used for the Boulder SMP.

2.2.1 Design Storms

Design storm analysis criteria influence runoff volume, pipe capacity requirements, and water quality treatment criteria. As noted in the UDFCD Volume 1 criteria manual, intense rainfall events in the Denver/Boulder area often are less than one or two hours in duration and can produce brief periods of high rainfall intensities. Thus, the UDFCD 2-hour design storm was used for the Boulder SMP.

Table 2.2-1 summarizes the 1-hour precipitation depths for the Boulder area for the 2- and 5-year recurrence interval events and the water quality storm based on NOAA Atlas II, current at the time of the 2007 SMP. The UDFCD Volume 1 procedure was used to generate 2-hour rainfall distributions for 2-year and 5-year storms based on these 1-hour precipitation values.

Table 2.2-1 Rainfall Depth-Duration-Frequency Values, NOAA Atlas II

Return Frequency (yr)	1-Hour Precipitation (in)
WQ	0.43
2	1.05
5	1.48

In 2004, the Boulder Creek Climatology study evaluated rainfall depth, duration, frequency and spatial distribution across the city. The findings from this study were compared to the temporal distribution of rainfall in the UDFCD 2-hour design storm, which is a front weighted distribution with peak precipitation occurring 25 minutes after the onset of the event. The measured rainfall data from the South Boulder Creek design storm evaluation validated the use of the UDFCD designs storm temporal distribution. Similarly, the spatial distribution of rainfall from the South Boulder Creek study was observed to be uniformly spread across the central core of the city. This observation validates the use of a design storm applied uniformly to the modeled subbasin across the entire study area.

For the water quality design storm, the UDFCD criteria manual recommends a total depth of 0.43 inches, which represents the average runoff producing storm in the Boulder area (Figure SQ-3, Volume 3 of UDFCD). This precipitation was distributed into 5-minute increments using the 2-year rainfall distribution noted above. The resulting hyetograph for this storm is shown on Figure 2-3.

2.2.2 Continuous Simulation Modeling

In addition to the event-based design storm criteria, a year-long continuous rainfall event was also developed. This event was used to estimate annual pollutant loadings at key locations throughout the city as a part of the stormwater quality analysis performed with the 2007 SMP. Rain gage data, from a gage located in the north area of the city, was available for 57 years of record (1949 – 2005). Data for 2003 was selected for the continuous rainfall event as it best represents a typical year in terms of total depth during the wet months of April through September (10.4 inches) and the total number of storms with more than an inch of precipitation during a 6-hour period (two events). Because the stormwater quality analysis was not re-evaluated with the 2016 SMP, this rainfall analysis and model scenario were not updated.

2.2.3 Stormwater Conveyance Elements

The SMP analysis addresses both the collector and local stormwater drainage systems. The collector stormwater drainage system was analyzed using two level of services based on land use and roadway category. For areas that are mainly residential in land use, the 2-year recurrence interval design storm was used to identify problems in the conveyance system. For areas draining mainly commercial, industrial and collector and arterial roadways, the 5-year event was used. Figure 2-4 illustrates the recurrence interval used throughout the city's collector storm sewer system.

For the local stormwater drainage system, the existing storm sewer network was not analyzed explicitly with SMP hydraulic or specific design storms. Rather, the local system analysis focused on reported problem areas as documented in the city's CRM database with a supporting GIS-based desktop analysis.

Irrigation ditches throughout the city play a major role in the conveyance of stormwater runoff. Many ditches receive stormwater from storm drains that outfall directly to the ditch system and from overland flow. Since irrigation ditches receive storm runoff from collector storm sewer outfalls, a 5-year design storm criteria was used to provide continuity with the collector system criteria.

2.2.4 Land Use and Imperviousness

Land use affects both the quantity (volume and peak rate) and quality of water running off and routed through the city's stormwater drainage system. The effect land use has on water quantity is generally linked to the amount of impervious area for a particular land use category. The more impervious the area, the faster the water will be routed to the storm water collection system due to the lower surface roughness of the ground. It will also increase the total volume of runoff since infiltration cannot occur through impervious surfaces. Consequently, an area with a higher percentage of impervious surfaces will produce higher peak flows and large volumes over a shorter period of time than will similar area with a lower percentage of impervious surfaces. Areas of higher impervious coverage are also a byproduct of development and the associated land use based pollutants that affect water quality. In order to identify problem areas within the stormwater drainage system, two land use scenarios with their associated impervious coverage values, were used in the SMP.

Existing Conditions

As developed with the 2007 SMP, the existing conditions scenario represents 2006 land use (Figure 2-5) within the city limits and reflects existing condition problems within the system. To supplement the land use data within the city's GIS database, an actual impervious surfaces layer based on 2005 aerial photography was also incorporated into this scenario.

Future Conditions

The future conditions land use scenario was developed with the 2007 SMP and was based on the 2006 Boulder Valley Comprehensive Plan to represent a fully developed urban area (Figure 2-6). Although there have been updates to the BVCP since 2006, updates to the future land use were verified to have little effect stormwater modeling parameters. In addition, the future land use scenario also incorporates the city's DCS, which requires detention and water quality treatment for all new impervious areas that preserve pre-development runoff characteristics.

2.3 Problem Identification Criteria – Collector Storm Sewer System

The SMP was guided by a set of criteria used to identify and categorize storm drain collector system conveyance and water quality problem areas and to evaluate potential improvements. This section describes each of the hydraulic and water quality problem identification criteria.

2.3.1 Hydraulic Problem Identification Criteria

Hydraulic deficiencies are generally related to insufficient system storage, excessive runoff generated from highly impervious land covers or flooded backwater conditions from the major drainageways; however, they can also result from an undersized or poorly designed conveyance system. To identify system deficiencies, results from the hydraulic model compared to hydraulic problem identification criteria within ArcGIS. Other problem areas were also added to the system deficiency list if they were known flooding locations within the collector system, as provided by the City. Depending on the type of the conveyance element being investigated, the following criteria were used.

Storm Sewer Surcharging

Surcharge conditions for the piped system are acceptable only for demonstrating the adequacy of the system to convey the peak runoff for the corresponding design storms, provided that the hydraulic grade line (HGL) is one foot lower than the manhole rim elevation. If the HGL is within, or higher, than one foot below the manhole rim elevation, that particular section of pipe was identified as undersized.

Culvert Overtopping

There are several locations within the city where open channel flow is conveyed through a culvert under a public roadway. Culverts at locations where the estimated HGL will inundate the road sub-grade were classified as undersized. The roadway sub-grade elevation was determined by subtracting one foot from the roadway crown elevation as determined from the DTM coverage

supplied by the city. Culverts were evaluated to the 2-year event for residential drainage systems and the 5-year event for commercial and industrial systems.

Irrigation Ditches and Open Channel Flooding

Open channel conveyance elements, including primary irrigation ditches, were added to the problem identification list if the corresponding design storm causes the channel to overtop its banks and flood the surrounding area. It should be noted that it was outside the scope of this project to complete a detailed capacity analysis of the primary irrigation ditches.

Structure Flood Risk

Buildings or other structures that are within 100 feet of a flooded manhole and whose ground elevation is at or below the adjacent water surface elevation of that flooded manhole or open channel were added to the problem identification list. Areas within the city that exhibit significant potential structural flooding risk are considered high priority areas in terms of conveyance system improvements.

2.3.2 Water Quality

In addition to evaluating localized flooding potential, a buildup-washoff model analysis was used to evaluate stormwater pollutant loading at outfalls throughout the city. The primary goal of the water quality model and analysis was to identify drainage basins and the associated outfalls within the city where relatively high pollutant loads are expected. These locations of high pollutant loads were identified as Water Quality Areas of Concern. In addition to the model results, other factors considered during the evaluation included:

- Recent development and construction of water quality BMPs
- Areas where development is likely in the near future
- Areas where property ownership will likely preclude BMP construction
- Proximity to Boulder Creek.

Using the model results and these other factors, specific outfalls were identified for further analysis including recommendations for water quality BMPs. These BMPs can be integrated into the capital program, and projects can be targeted throughout the city to maximize the system-wide water quality benefit.

2.4 Problem Identification Criteria – Local Drainage System

The purpose of this analysis was to identify subbasins within Boulder that have limited stormwater drainage systems and/or have observed local drainage system flooding issues where the benefits of future stormwater infrastructure would be greatest. The datasets used for this analysis consisted of:

- City-reported problem areas (CRM database)
- 2013 flood survey data
- Existing city GIS stormwater drainage system infrastructure data

The problem area subbasins were categorized as either Type A or Type B based on the following:

- Type A subbasins consisted of those containing a drainage problem reported directly to the City by residents.
- The Type B subbasins consisted of those having problems that were inferred from multiple observed instances of shallow, localized flooding and an observed lack of stormwater infrastructure but have not been explicitly reported to the City.

The following sections provide a description of both the data and how it was utilized to identify the Type A and Type B priority subbasins.

2.4.1 Type A Priority Subbasins

A summary of the problem areas was reported to City staff by residents was provided and was used to identify the Type A priority subbasins. This dataset consisted of problem areas as reported through the city's Customer Relationship Management (CRM) database. Specifically, the dataset was obtained in electronic form with information describing the location, approximate number of properties affected, and issues experienced for each of the reported problem areas. A georeferenced dataset was generated within the GIS based on the CRM address to provide a dataset with spatial reference.

All subbasins containing the City Reported Problem Areas and their tributary subbasins were identified as Type A priority subbasins for further analysis. Table 2.4.1 displays the information contained within the CRM dataset and Type A problem areas.

Table 2.4.1 – City Reported Problem Area Data

Problem ID	Location	Description of Issue
Wonderland Creek -1	Broadway - Rosewood to Violet	Lack of storm sewer on east side of Broadway from Fourmile Creek to Violet. Runoff continues across Violet and floods properties on south side of street.
Wonderland Creek - 2	19th & Sumac	Runoff from Sumac flows across 19th and inundates residences on east side of 19th which are below road grade. There is existing storm sewer on the N side of the intersection, however, runoff is predominantly on south side.
Elmers Twomile Creek - 1	3490 Catalpa Way	Catalpa way south of Clover Circle flows towards cul-de-sac where there is no storm system causing cul-de-sac and adjacent homes to flood.
Elmers Twomile Creek - 2	Iris Ave to Linden Ave and Broadway to Cloverleaf Dr.	Entire neighborhood drains to Farmer's irrigation ditch which becomes overwhelmed by the runoff during heavy rains and overflows into downstream properties.
Twomile Canyon Creek - 1	Kalmia and Juniper Ave west of Broadway	Streets have no curb and gutter and surface runoff collects in irrigation ditch laterals which parallel the roads. During heavy rains runoff overwhelms the laterals causing storm water to flood the homes in the downstream sections of the lateral near Broadway.
Goose Creek - 1	8th St and Dellwood Ave	Intersection is a collection point for neighborhood surface drainage. Even smaller storms overwhelm the existing storms ewers at this intersection and cause flooding of the roadway to the point that the crown of the road is several inches below water.

Goose Creek - 2	Alpine to Dellwood and 3rd to 7th St.	Steep slopes and inadequate existing storm sewer network causes high surface runoff flows. Homes at intersections are threatened from runoff jumping curbs and entering the homes. Many alley s have low points in the middle of the block meaning they collect runoff and send it through yards and homes. Steep slopes means heavy storms can cause hazardous conditions for pedestrians and due to the high velocity flows. Runoff from 3rd St collects at low point in 3rd St south of Cedar and then flows through yards and homes to the east.
Goose Creek - 3	Dewey from 4th St to 9th St	4th St from Maxwell to Dewey has insufficient inlets and surface runoff is moving too quickly to make it into the existing inlets. A lot of runoff from the hospital complex is also directed this way making the problem worse. Additionally there is a bottleneck (orifice plate) in storm sewer at 6th St and North St which backs-up the storm sewers causing street flooding.
Middle Boulder Creek - 1	Grandview Ave from 13th to 15th St	Street Drainage and storm sewer discharge to the hillside south of the Boulder High School football field. During heavy rains this runoff flows across the football field to Boulder Creek and damages the school property.
Bluebell Canyon Creek - 1	20th & Mariposa	Anderson ditch culvert under Mariposa is too tall which caused a crown perpendicular to the slope on the east side of the intersection. This crown acts as a dam and floods the intersection and adjoining properties.
Dry Creek No. 2 - 1	Chippewa Dr. and Caddo Pkwy east of Inca Pkwy	Grading of Chippewa Dr. and Caddo Pkwy is from south side of street to the north. During heavy rains all drainage flows on north side and overwhelms the inlets on the north side causing water to flood yards and garages.
Dry Creek No. 2 - 2	Erie Dr. & Pinon Dr.	Runoff from Erie Dr. flows N towards Pinon Dr. where Pinon acts as a dam and causes flooding of the intersection.
Dry Creek No. 2 - 3	Baseline Rd from Foothills Pkwy to 55th St and 55th St from Baseline Rd to Arapahoe Ave	The storm sewer system for western Frasier Meadows and Keewaydin Medaows (bounded by Baseline to South Boulder RD & Inca to 55th St) discharges to two large detention basins at the intersection of Baseline Rd and Foothills Pkwy. From the detention basins the storm water discharges to the west to an open drainage swale on the north side of Baseline. This swale flows to the west and discharges to Dry Creek Ditch #2. Dry Creek Ditch #2 conveys the storm water to the north along 55th St, through the flatirons golf course open space to South Boulder Creek. Several sections of the drainage swale and Dry Creek Ditch #2 are capacity limited and cause storm water to back up through the detention basins and into the upstream collection system.
Bear Canyon Creek - 1	1575 Stony Hill Drive	A 48" storm culvert was constructed in 1973 under Stony Hill Drive as part of the Devil's Thumb subdivision. The culvert was not built as specified on the plans and the outlet alignment is aimed at directly at some residences instead of down the creek bed. During heavy storms flow from the outlet can over-shoot the creek and flow directly into the nearest house. Additionally, the creek was not excavated as called out on the plans. Six homes may flood during heavy rainfall.
Viele Channel - 1	Longwood Ave and Lafayette Dr from Lehigh St to Greenbriar Blvd	Approximately 1.5 miles of roadway and residential drainage flows down Lafayette Dr. and Longwood Ave towards Greenbrier Blvd. There are no storm sewers to capture this runoff and there is insufficient street capacity for the volume of flow. Runoff frequently floods sidewalks and creates hazardous conditions due to the steepness of the road and the velocity that the runoff achieves. The problem is exacerbated by the pitch and crown of the roads which causes almost all runoff to flow on the north side of Longwood Ave.

2.4.2 Type B Priority Subbasins and 2013 Flood Survey Data

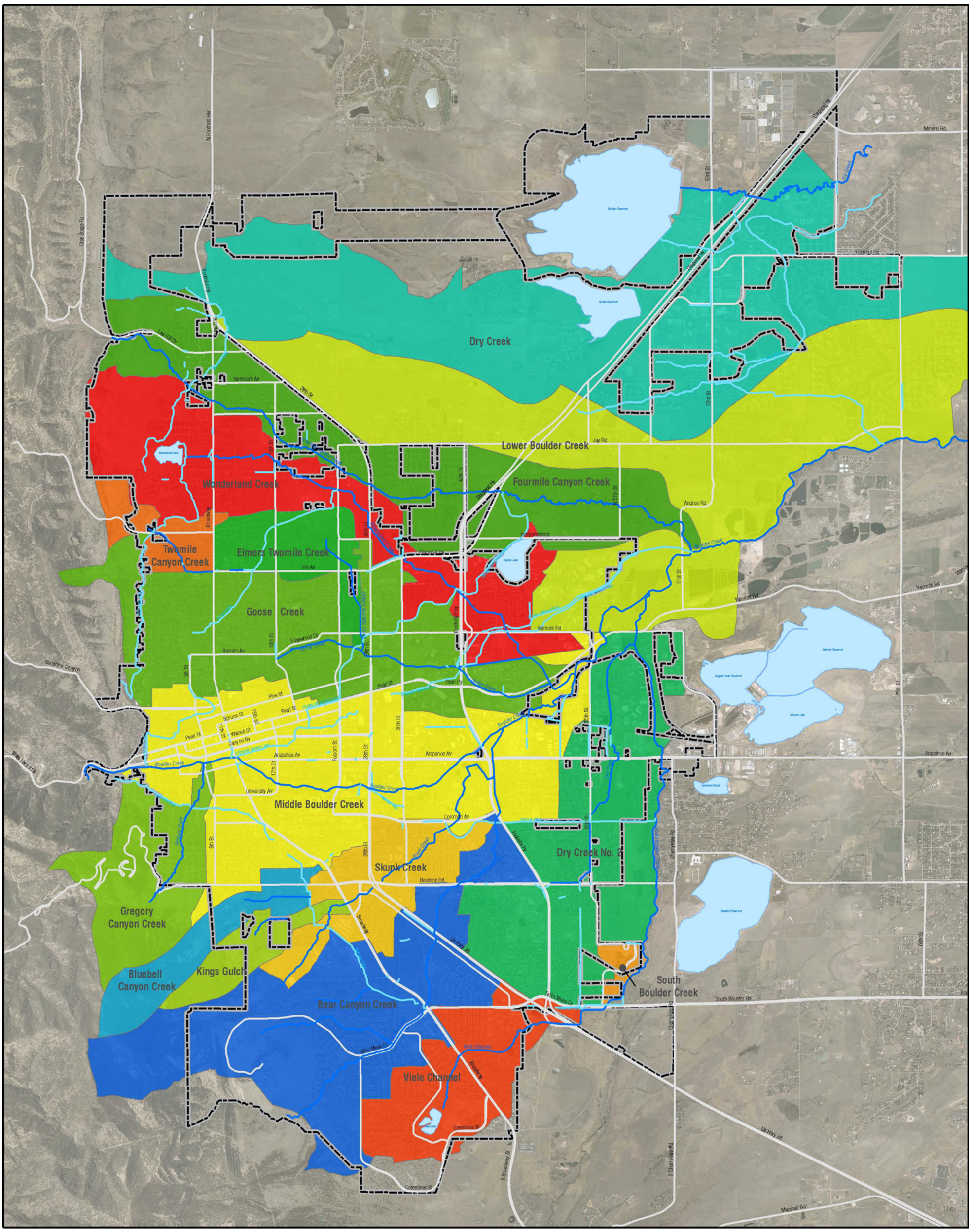
This portion of the analysis utilized a city GIS dataset describing location of reported flooding occurrences during the 2013 flood. To focus the review on the local and collector drainage system, the dataset was screened to represent data for only the shallow and localized flooding. The dataset screening used the 2013 flood extent polygon layer to filter out data points attributed to Major Drainageway flooding as was prevalent during the 2013 event. The resulting dataset was intended to represent rainfall induced flooding within the local stormwater drainage system.

Upon review of the flooding descriptions with the resulting local flooding dataset, the following general observations were made:

- A majority of the initial data set was a direct result of local and collector system drainage issues and not impacted by the major drainageway flooding issues.
- Some data points, outside the surveyed major drainageway flood extents were still related to impacts created by the major drainageways.
- Some data points were a result of major drainageway spill locations where floodwaters were conveyed within the street system, local storm sewer, and collector storm sewer networks.
- Flooding impacts from many of the data points can be attributed to irrigation ditch systems overflowing into the local and collector drainage systems.
- Some data points were a result of steep hillsides from open space or similar open lands draining into private properties.

Even though the local flooding dataset has some inconsistencies (damage type comments or flood depth comments not correlating to other dataset information), the majority of the points provide a good representation of impacts resulting from local and collector system conveyance issues. This was validated in several instances where the local flooding data points were within a CRM reported problem subbasin or adjacent to a modeled collector storm sewer system problem area. Given the correlation between local flooding dataset, CRM reported problem areas, and collector system model results, the following criteria were used to identify Type B subbasins based on flood survey data:

- Subbasins containing more than three locations of local flooding points (outside the 2013 flood extents polygon).
- Subbasins with a density of 0.3 observations/acre and greater.



Legend

- Bear Canyon Creek
- Bluebell Canyon Creek
- Dry Creek
- Dry Creek No. 2
- Elmers Twomile Creek
- Fourmile Canyon Creek
- Goose Creek
- Gregory Canyon Creek
- Kings Gulch
- Lower Boulder Creek
- Middle Boulder Creek
- Skunk Creek
- South Boulder Creek
- Twomile Canyon Creek
- Viele Channel
- Wonderland Creek

0 4,000
1 inch equals 4,000 feet

N

Study Area Subbasins

Figure 2-1

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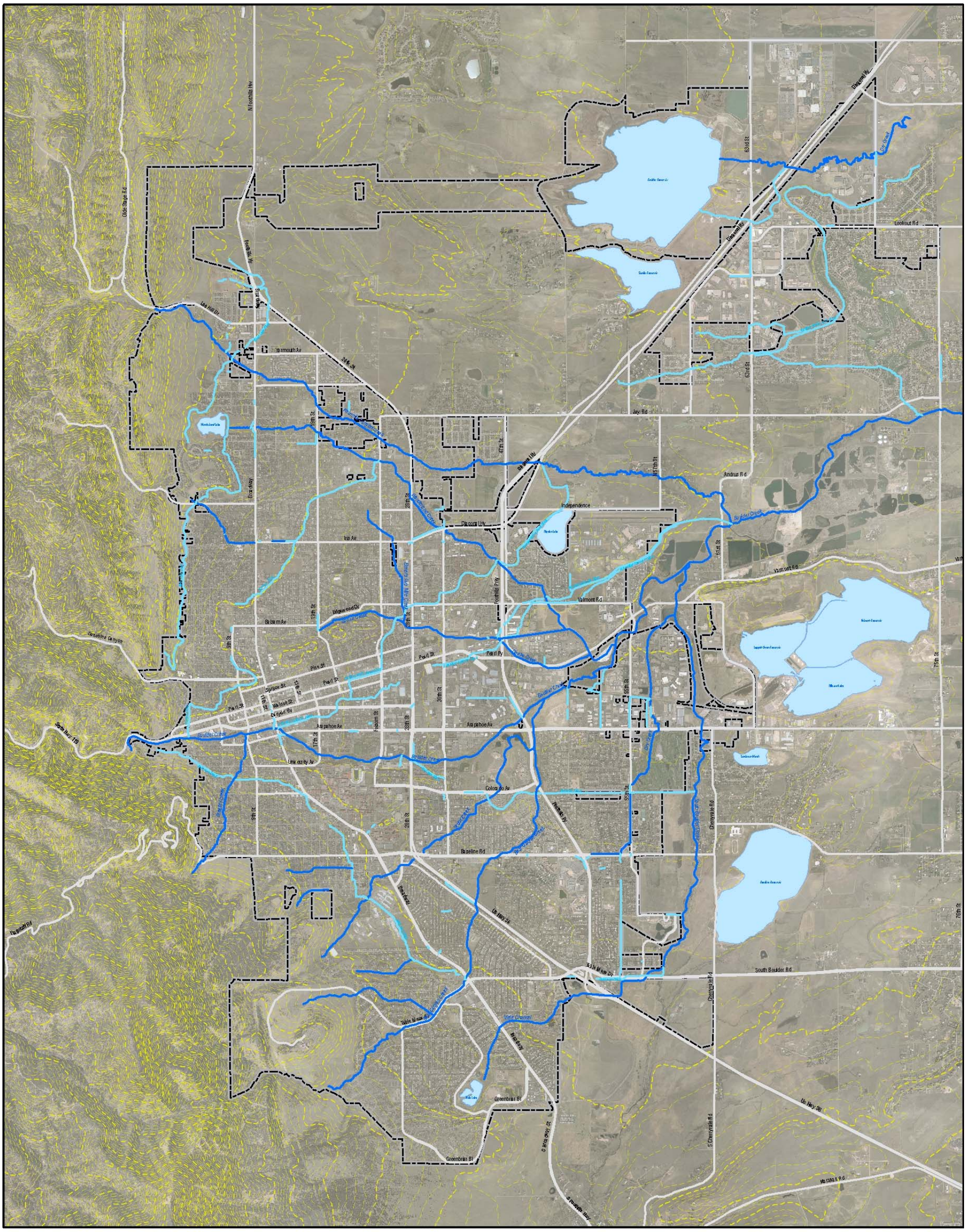

Existing Contours and Major Drainageways

Figure 2-2

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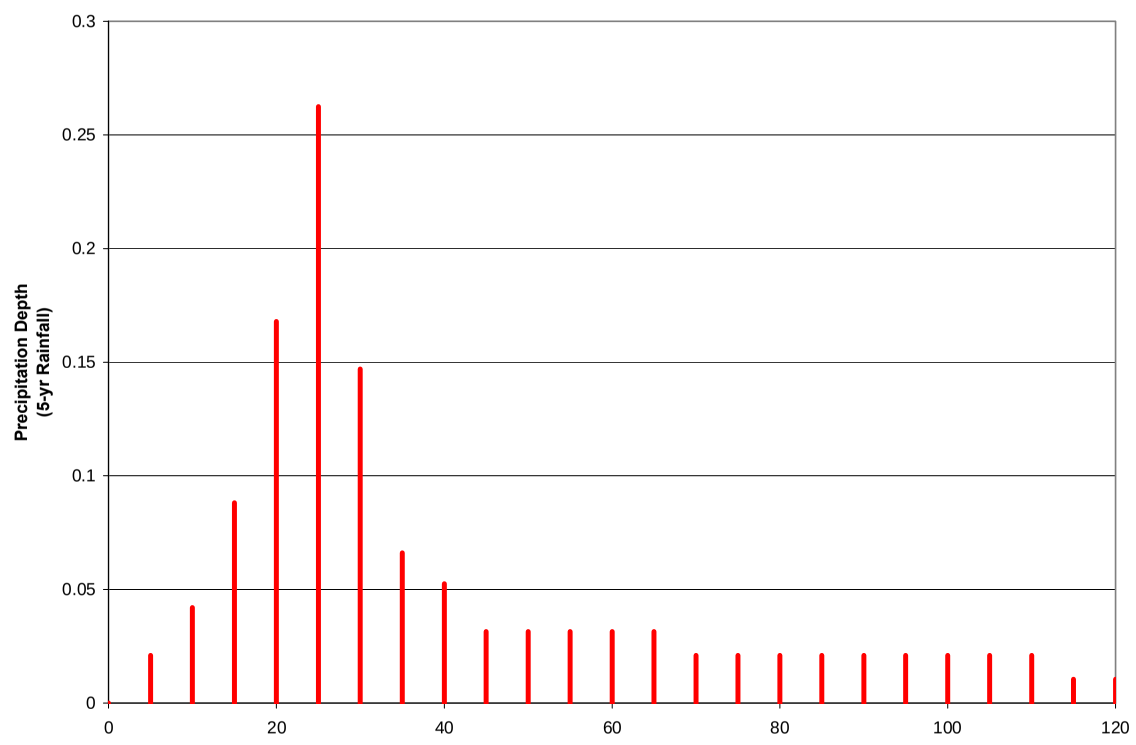


Figure 2-3. 2-yr Event

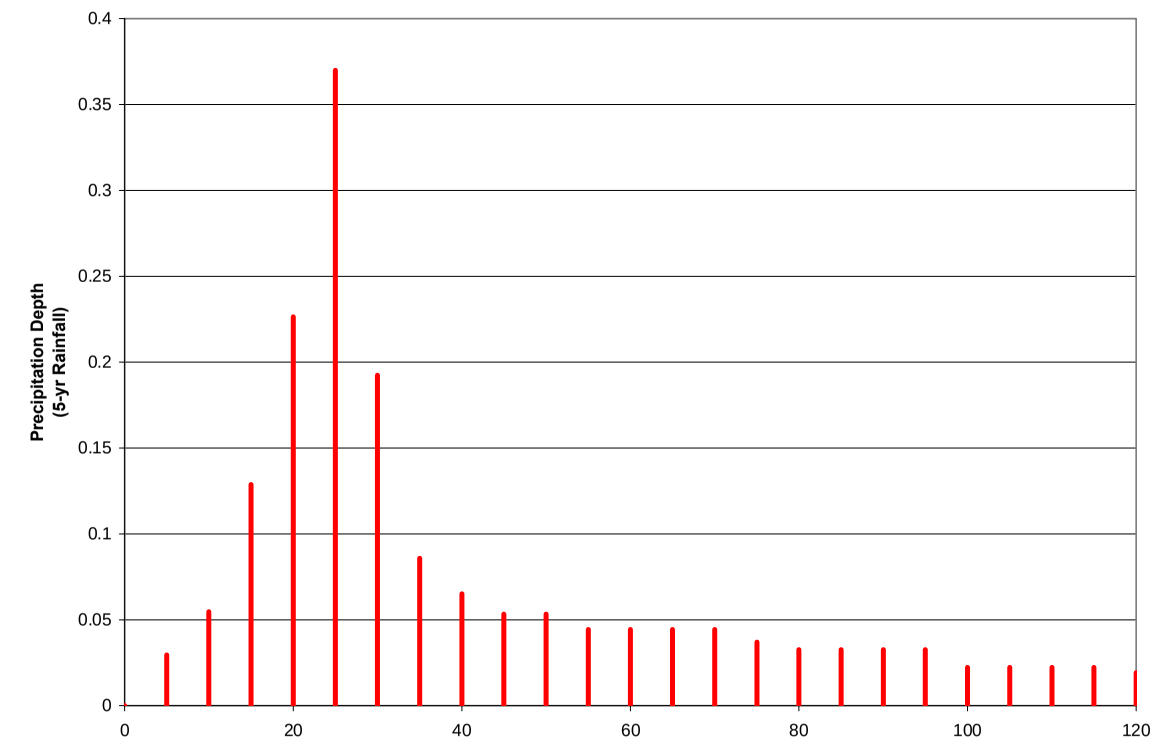


Figure 2-4. 5-yr Event

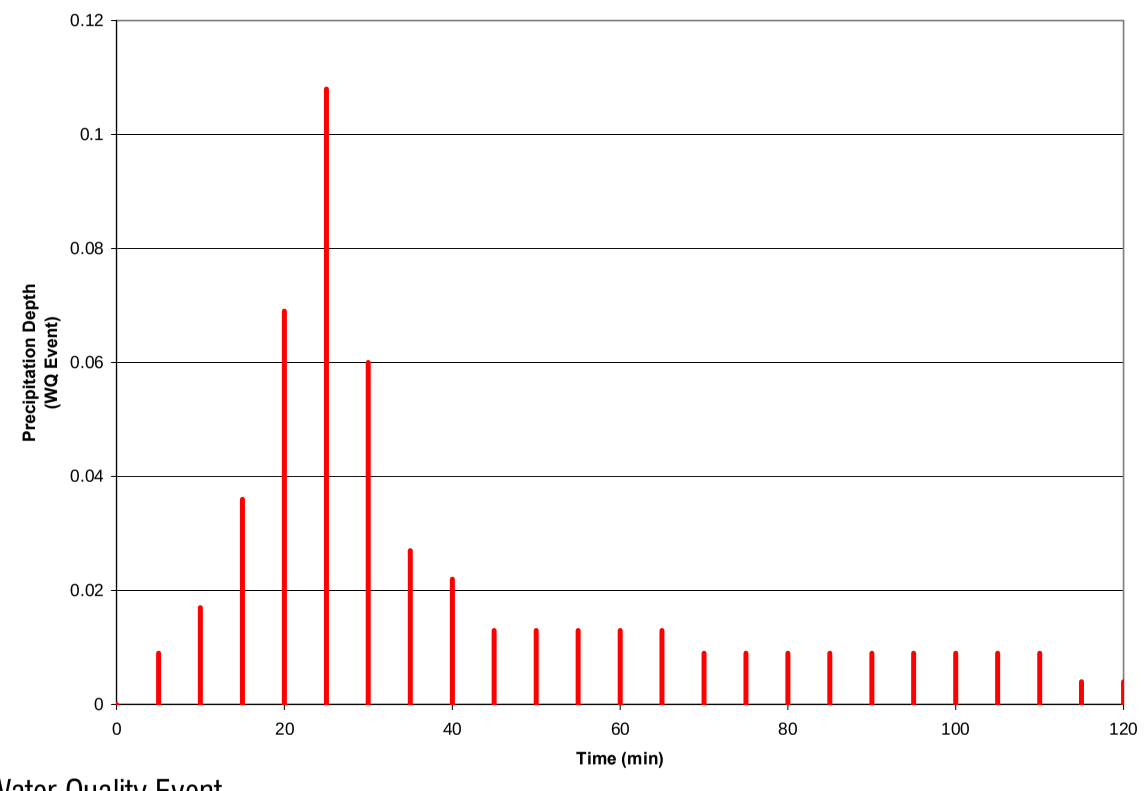


Figure 2-5. Water Quality Event

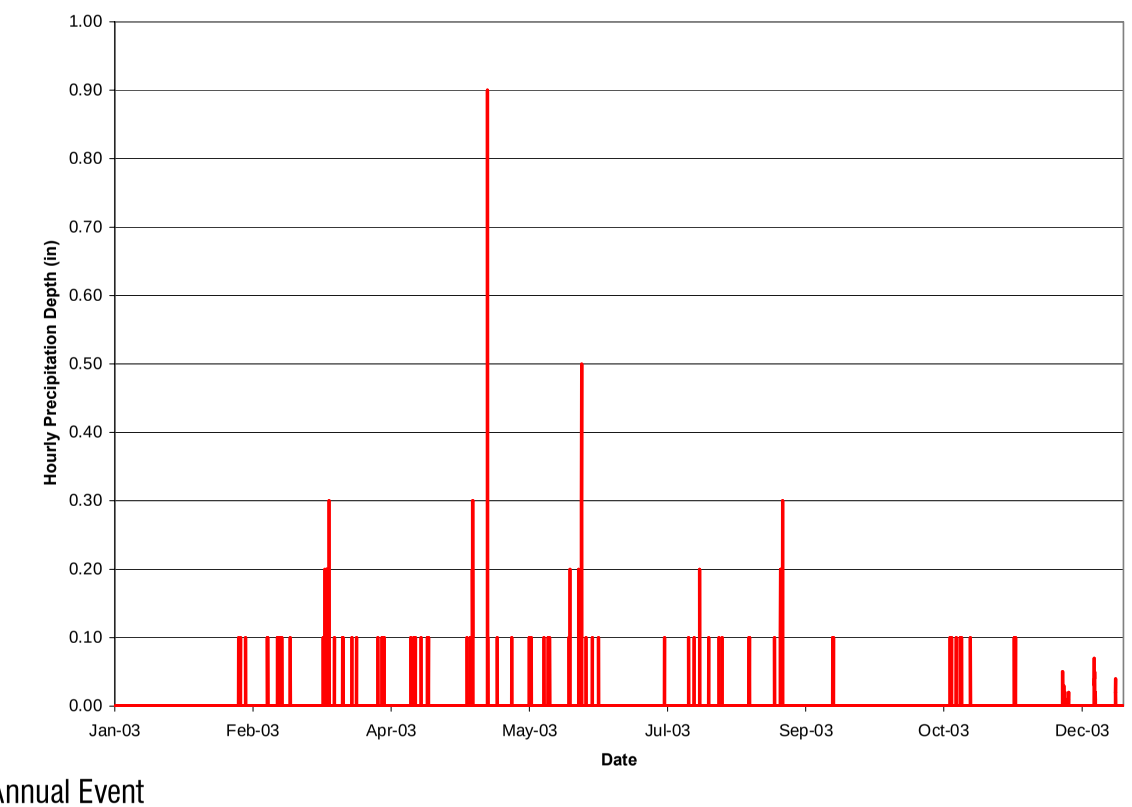
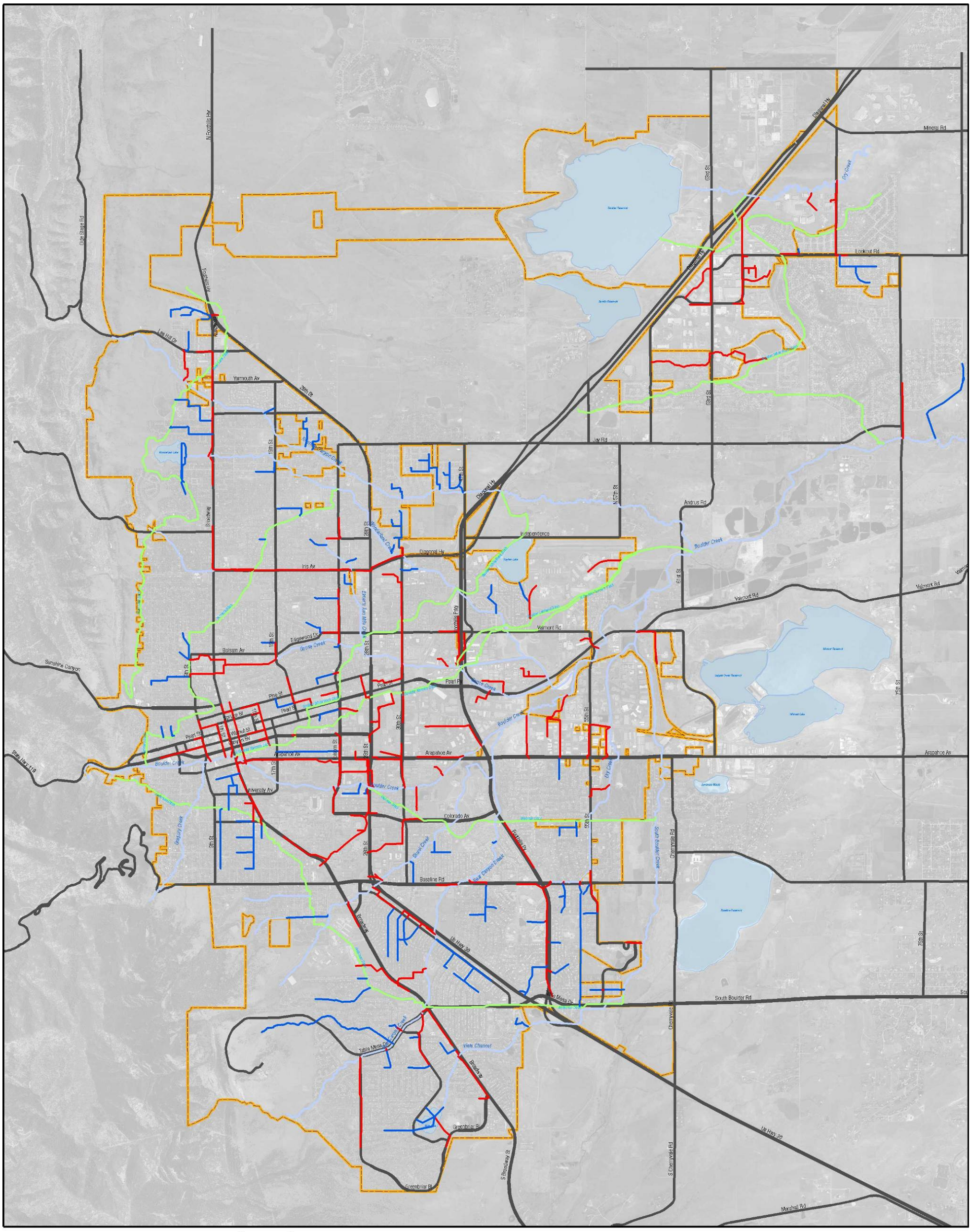


Figure 2-6. Annual Event

Design Storm Hyetographs (2- and 5-yr, Water Quality and Annual Events)

Figure 2-3



Collector Storm Sewer System Design Storm Criteria

Figure 2-4

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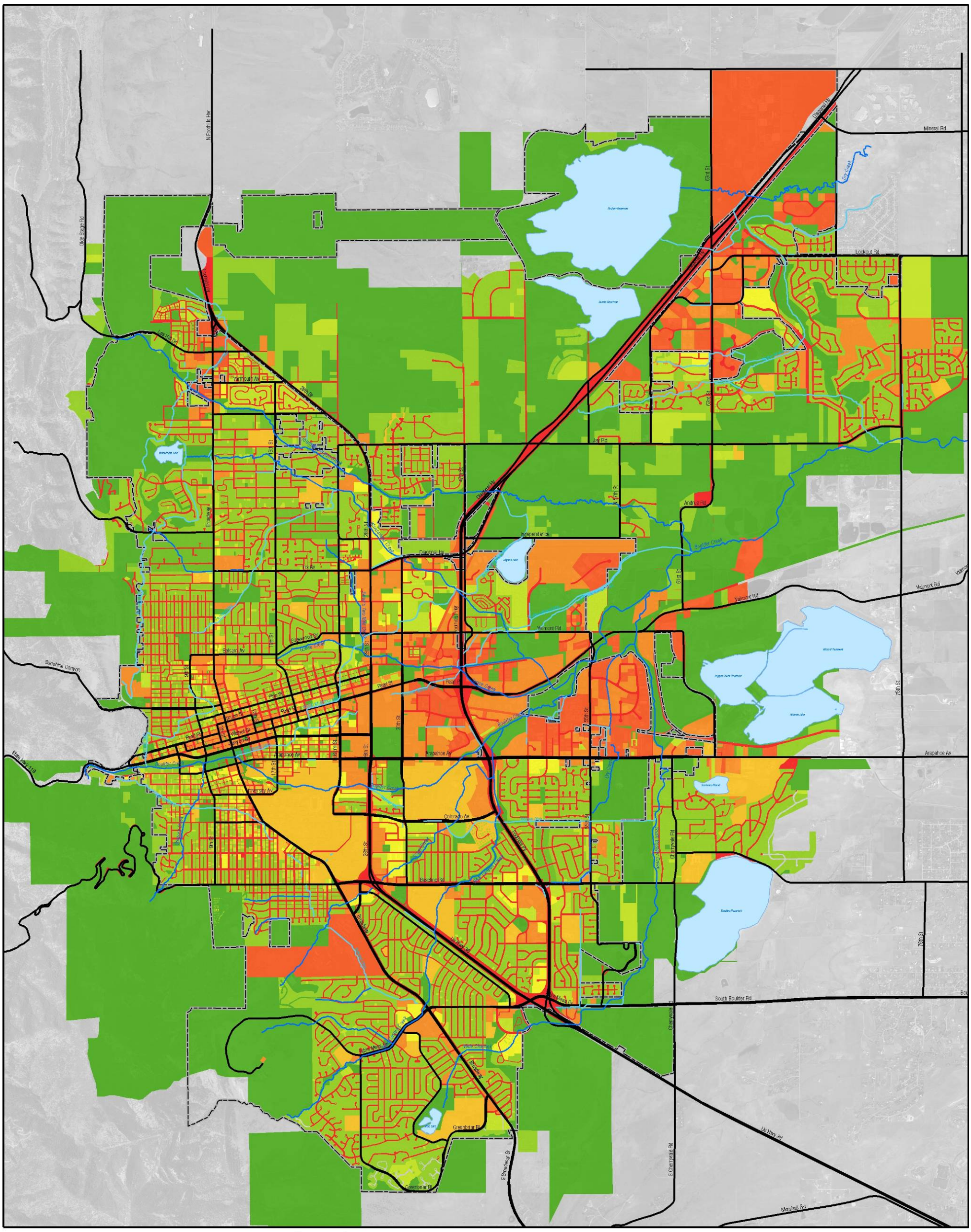

Legend

- Open Space (OPEN)
- Rural Residential (RR)
- Low Density Residential (LDR)
- Mediam Density Residential (MDR)
- High Density Residential (HDR)
- Educational (EDU)
- Commercial (COM)
- Industrial (IND)
- Right-of-Way (TRANS)
- Major Roads
- Lakes
- City Limits
- Ditches
- Major Drainageways

0 4,000

1 inch equals 4,000 feet

N

Existing Land Use Map

Figure 2-5

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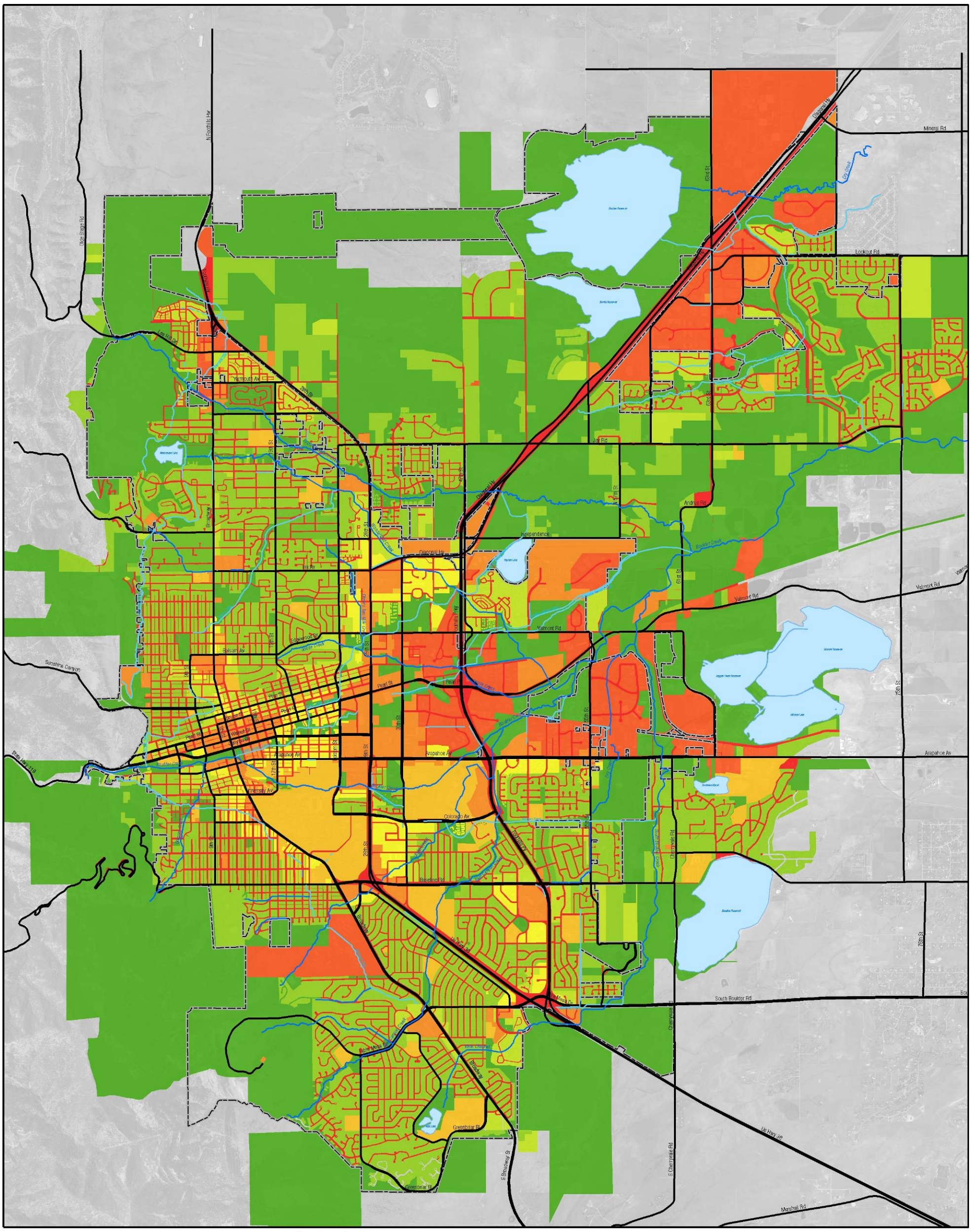

Legend

- Open Space (OPEN)
- Rural Residential (RR)
- Low Density Residential (LDR)
- Mediam Density Residential (MDR)
- High Density Residential (HDR)
- Educational (EDU)
- Commercial (COM)
- Industrial (IND)
- Right-of-Way (TRANS)
- Major Roads
- Lakes
- CityLimits
- Ditches
- Major Drainageways

0 4,000

1 inch equals 4,000 feet

N

Future Land Use Map (Boulder Comprehensive Plan)

Figure 2-6

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3 Model Development

The 2007 SMP modeling approach integrated ArcGIS as a pre- and post-processing tool with an EPA-based stormwater management model (SWMM) as the hydrologic, hydraulic and water quality analysis tool. A software review comparing EPA-SWMM to XPSWMM was included in the 2007 SMP. Resulting from this review, it was determined that XPSWMM provided a more efficient means for pre- and post-processing data for ArcGIS integration, better water quality analysis tools, and compatibilities for 2-dimensional analysis. XPSWMM was therefore selected as the modeling platform for the SMP.

Since the 2007 SMP, the city has continued to use XPSWMM, integrated with ArcGIS, to conduct hydrologic and hydraulic analyses for the stormwater drainage system. Boulder has invested significant time and resources into the development and maintenance of the hydrologic, hydraulic, and water quality components of the current model in combination with the supporting ArcGIS data. As a result, XPSWMM (Version 2014) was selected as the model platform for the 2016 SMP Update.

This section presents the development and verification of the stormwater hydraulic model from the 2007 SMP and updates to the model associated with the 2016 SMP analysis.

3.1 Data and Basis of Model Construction

Workflow for model development began in GIS, where the input parameters for XPSWMM were pre-processed. Data were transferred out of ArcGIS to XPSWMM, for the evaluation of the system hydraulics and potential improvements. Model results were ultimately brought back into ArcGIS for post processing and storage for future reference by the city. The following section describes the approach in more detail.

The primary sources of data used in this master plan originated from 1) the city's GIS database, 2) supplemental field survey data collected in 2006 by Merrick & Company, 3) the city's 2' contour data and associated digital terrain model (DTM), 4) previous storm sewer and flood studies completed for the city, and 5) discussions with city staff.

Of the city's original manhole database, there were 541 manholes missing invert or ground elevation data. Supplemental field survey collected 383 of those 541 data gaps. Of the remaining 158 data gaps, interpolation from the surrounding manholes was required to populate invert elevations, and rim elevation were extracted from the city's DTM. These data were not considered critical to the overall master planning analysis and primarily used to enhance the model results.

All other elevation data used in the analysis was derived from the city's 2' contour data and DTM. This included manhole rim elevations; ditch, channel and drainageway cross-sections; and pond/lake area-volume relationships. Due to the lack of actual field survey information for these areas, city staff visually compared several irrigation ditch cross-sections as a means to confirm the contour data's accuracy for the purposes of this study. Therefore, it should be noted the data used for the open channel analysis is relatively coarse as compared to the storm sewer and manhole data.

3.2 Hydrologic and Hydraulic Model

This section presents the data requirements and approach for construction of the existing conditions model, the model validation approach, and future condition model construction as developed with the 2007 SMP.

3.2.1 Existing Condition Model Construction

The hydrologic (rainfall-runoff) and hydraulic (routing) portions of the analysis and are summarized in the following sections.

Hydrologic Parameters

Modeling the rainfall-runoff process in XPSWMM involves a series of steps to determine appropriate model parameters in GIS prior to model execution.

Subcatchment Boundaries

One of the key tasks in building a hydrologic model is to allocate flows from individual subcatchments to their respective conveyance element. In addition, the spatial arrangement between these subcatchments in the model must represent ground conditions. Gridded elevation data, (provided by the city as a DTM), was processed using GIS software to initially examine the topography of each catchment. For areas with significant relief, the GIS delineation was used directly. Irrigation ditches and roadways were used to delineate subcatchment boundaries. For areas where topography alone could not accurately delineate the subcatchment boundary, aerial photos and the existing drainage network map were also reviewed and the subcatchment boundaries were adjusted manually. Ultimately, approximately 590 subcatchments were used to delineate the existing condition stormwater drainage system (Figure 3-1). It should be noted that some of these subcatchments were redefined as a part of the recommended system improvements based on storm sewer extensions or other similar recommendations.

Basin Width

Basin width represents the physical width of overland flow and is a variable in determining the time lag between peak precipitation and peak runoff. The basin width parameter was calculated by dividing the length of the longest flow path by the subcatchment area. Flow path length was determined as the distance from the upper-most point in the subcatchment, along the overland flow and stormwater conveyance path, and ending at the most downstream point in the subcatchment.

Slope

Subcatchment slope also influences the runoff travel time and resulting hydrograph shape. Subcatchment slopes were determined by intersecting the longest flow path length with the city's DTM data and then dividing the total elevation difference by the flow path length.

Impervious Percentage (Existing Conditions)

The existing conditions impervious data were developed to represent 2006 land use conditions. The existing impervious percentages for each subcatchment were determined by overlaying the subcatchments with the city's impervious area database (Figure 3-3) and determining a weighted average for each subcatchment. The existing impervious percentage across the city was calculated to be 32.3% and is graphically shown by subcatchment on Figure 3-4.

In addition to developing individual impervious percentages for each subcatchment, it was also necessary to estimate impervious percentages by land use to be used as a baseline for the future conditions analysis. This was accomplished by combining 1) the city and county parcel maps, 2) a set of lookup Tables that link building and land classification with nine generalized land use categories and 3) the impervious area database provided by the city.

The results of this analysis are listed below in Table 3.2-2 and compared to the original 1984 Stormwater Master Plan as well as the published impervious percentages recommended in the 2005 UDFCD Urban Storm Drainage Criteria Manual, Volume 1. In general, the impervious area database results are uniformly lower as compared to the other references.

Table 3.2-1: Comparison of Impervious Percentages

Land Use	Description	Impervious Percentages			Land Use Distribution w/in City
		1984 Master Plan	2005 UDFCD Manual	2005 Aerial Data	
RR	Rural Residential	34.0%	*	30.2%	1.3%
LDR	Low Density Residential	39.0%	*	31.5%	24.2%
MDR	Medium Density Residential	43.0%	67.5%	47.4%	4.8%
HDR	High Density Residential	58.0%	80.0%	57.6%	1.8%
COM	Commercial	88.0%	90.0%	64.5%	9.6%
IND	Industrial	70.0%	85.0%	44.9%	8.7%
EDU	Educational/College	25.0%	50.0%	38.5%	5.3%
OPEN	Open Space	5.0%	2.0%	7.3%	29.7%
TRANS	Transportation Right-of-Way	n/a	100.0%	70.3%	14.6%

* Variable depending on acreage and home type

Soil Infiltration

Infiltration is the process by which surface water percolates into the subsurface soil and groundwater column. Infiltration is an important hydrologic process because it governs groundwater recharge, soil moisture storage, and surface water runoff volume. As modeled in the XPSWMM runoff block, soil infiltration is one of several processes that represent a withdrawal of a portion of total storm precipitation that could otherwise generate surface runoff.

Information on soil types and characteristics within the city were compiled and grouped from the NRCS SSURGO dataset (Figure 3-2). Using GIS, the predominant hydrologic soil type in each subcatchment was identified. For each soil group, a set of Horton infiltration parameters including Max Infiltration Rate, Asymptotic Infiltration Rate and Decay Rate of Infiltration were assigned (Table 3.3.1) based on UDFCD guidance. The Horton infiltration method was used because parameters can be estimated from existing soil surveys without extensive field testing.

Table 3.2-2: Horton Infiltration Parameters

NRCS Hydrologic Soil Group	Infiltration (in/hr)		Decay Coefficient
	Initial	Final	
A	5.0	1.0	0.0007
B	4.5	0.6	0.0018
C	3.0	0.5	0.0018
D	3.0	0.5	0.0018

Other Hydrologic Parameters

In addition to the soil infiltration rates, impervious percentages, and subcatchment geometric parameters, XPSWMM also requires surface parameters that control the amount of immediate runoff and the rate of runoff from overland areas. There are three parameters required: depression storage, zero detention and Manning's "n".

DEPRESSION STORAGE

Depression storage defines the amount of rain that must fall before runoff can occur in a subcatchment. These values were assigned for pervious areas (0.35 inches) and impervious areas (0.1 inches) respectively, based on UDFCD guidance.

ZERO DETENTION

The zero detention parameter controls the amount (area) of a subcatchment that has immediate runoff, or the area that has no depression storage. Based on guidance in the XPSWMM users manual, this parameter was uniformly set to 10%.

MANNING'S ROUGHNESS

Manning's roughness, or "n", is used to calculate the time it takes for precipitation to be transformed to runoff. Higher values of Manning's "n" represent rougher surfaces like grass where runoff times will be delayed. Low values represent impervious areas such as roads or parking lots and produce higher peak flows with little or no runoff delay. These values were assigned for pervious areas (0.2) and impervious areas (0.03) respectively, based on guidance in the XPSWWM user's manual.

Hydraulic Parameters

The collector stormwater drainage system includes natural and manmade conveyance and storage elements (Figure 3-5). XPSWMM models these features together as a completed hydraulic system as defined by storm sewer and manhole geometric data, open channel geometry, storm sewer and channel roughness, and detention ponds. In addition to model data that represents the physical system characteristics, boundary conditions are also required to define initial flow conditions within the modeled system.

Storm Sewer and Manhole Data

The storm sewer pipe and manhole data used for model construction were developed from two sources. At the planimetric level, the city's GIS storm sewer and manhole data layers were used to develop a system schematic map. With this in hand, the existing manhole database, supplemented

by additional field surveys made at each key manhole within the system, was used to determine manhole invert and rim elevations as well as pipe invert elevations. Generally, the 2007 collector storm sewer model excluded pipes less than 18" in diameter.

Open Channel Geometry

Open channel data, including major roadside ditches, irrigation ditches and major drainageways were extracted from the city's DTM. The DTM data was used to determine channel cross-sections as well as overall reach slopes. Roughness estimates for each open channel element were derived from the city's high resolution aerial photography. The stormwater model includes the major drainageways for model connectivity and definition of outfall hydraulics only; major drainageway capacities were not analyzed in this study.

Storm Sewer and Channel Roughness

Roughness characteristics for each model segment were assigned based on material and its' associated Manning's roughness coefficient, "n" according to Table 3.3-3.

Table 3.2-3: Manning's Roughness Values

ID	Description	Manning's "n"	Description
NAT	Natural Channel	Variable (0.025 – 0.08)	Chapter 7 (UDFCD Storm Drainage Criteria Manual)
BOX	Box Culvert	0.015	Assume Concrete: From Section 7.08 in Boulder D&C Standards
CIP	Cast In Place	0.015	Assume Concrete: From Section 7.08 in Boulder D&C Standards
CMP	Corrugated Metal Pipe	0.026	Handbook of Hydraulics, 7th Edition (Table 6.4)
CONC	Concrete Pipe	0.015	From Section 7.08 in Boulder D&C Standards
DIP	Ductile Iron Pipe	0.014	Handbook of Hydraulics, 7th Edition (Table 6.4)
NJP	Unknown	0.015	Assume Concrete
PPVC	Polyvinyl Chloride Pipe	0.013	From Section 7.08 in Boulder D&C Standards
PVC	Polyvinyl Chloride Pipe	0.013	From Section 7.08 in Boulder D&C Standards
RCP	Reinforced Concrete Pipe	0.015	From Section 7.08 in Boulder D&C Standards
VCP	Vitrified Clay Pipe	0.015	Handbook of Hydraulics, 7th Edition (Table 6.4)
UNK	Unknown Material	0.015	Assume Concrete

Detention Ponds

According to the city's GIS database used in the preparation of the 2007 SMP model, 713 detention ponds exist within the city limits (Figure 3-6). To account for this additional storage during the system modeling two methods were used; 1) for subcatchments with a relatively small storage volume as compared to the subcatchments area, the depression storage parameter was adjusted to account for the additional volume and 2) for individually larger facilities, or subcatchments that have a significant cumulative storage as compared to their area, a synthetic pond approach was used.

To determine the appropriate pond simulation method, the total storage volume within each subcatchment was calculated by intersecting the detention pond and subcatchment layers and summing the total storage volumes. This volume was compared to the total subcatchment area. If the ratio of the storage volume to the subcatchment area was less than 1815 cu-ft/acre (0.5 in/acre), then method 1 was used to simulate the collective effect of the detention ponds; otherwise, scenario

2 was used to simulate individual ponds. For method 1, the total storage volume was converted to an average depth across the subcatchment and added to the depression storage parameter. For method 2, the total storage volume was explicitly included as a detention pond and modeled with appropriate outlet conditions and stage-storage relationships derived from average conditions within the city.

In addition to incorporating the detention storage volume into the XPSWMM analysis, the performance of each facility was included. Based on a detention pond inventory completed by the city prior to the 2007 SMP, it was determined that 22% of all the existing facilities are either failing to the point of needing major rehabilitation (9%) or completely failed (13%) and requiring total replacement (Figure 3-7). To account for this trend under existing conditions, the volume of any storage facility within these two categories was removed from the total subcatchment storage. Under future conditions, any new storage volume being added to a subcatchment will be uniformly reduced by 22%.

Boundary Conditions

Boundary conditions are an important part of the system analysis criteria because they establish flows and water levels at the upstream and downstream limits of the city-wide hydraulic model.

UPSTREAM BOUNDARY CONDITIONS

Upstream boundary conditions include inflows for Boulder Creek and South Boulder Creek where they enter the city. These flows were set to the maximum mean monthly discharge as per USGS gauge records. These flows rates were deemed appropriate because it was assumed that 2- and 5-year rainfall events within the city would not occur simultaneously with large flow events in Boulder and South Boulder Creeks.

INTERIOR BOUNDARY CONDITIONS (IRRIGATION DITCHES)

Interior boundary conditions are represented in the Boulder SWMM model as constant diversion flows into the primary irrigation ditches within the city. The actual flow rates are based on five years of measured diversions (recorded as ac-ft over the irrigation season and converted to an average flow in cfs) in the ditches and represent a typical condition during the irrigation season. These interior boundary conditions were provided by the city for use in the system analysis.

DOWNSTREAM BOUNDARY CONDITIONS

The upstream and interior boundary conditions also effect the piped collector system at outfall locations to major the noted drainageways and irrigation ditches. By routing flows from the major drainageways and ditches in the hydraulic model, boundary conditions at each storm drain outfall are included in the model simulation and do not require an individual boundary condition.

At the downstream limit of the model (Boulder Creek at the eastern city limits), normal depth boundary conditions were applied. This condition establishes a variable depth based on the channel slope, geometry and roughness and the contributing discharge.

3.2.2 Model Validation Parameters and Results

Development of hydrologic and hydraulic models typically relies on a calibration process to verify that model results represent actual conditions within the study area. Calibration consists of adjusting

a set of model parameters so that measured data (e.g., pipe flow, streamflow, rainfall) match the predicted runoff or flows from the corresponding model calculation. For the modeled stormwater sewer system, flow measurement data does not exist, and calibration could not be performed.

In lieu of calibration, a validation process was used to verify model accuracy in simulating hydrologic conditions within the basin. Validation of the Boulder XPSWMM model consisted of comparing the calculated peak flow and runoff volume results from the model at six selected locations within the city (Figure 3-8) to results from other analytical models. The analytical models used for validation were:

- The Colorado Urban Hydrograph Procedure (CUHP method)
- The USGS regional regression equations
- The City of Boulder 1984 Storm Water Master Plan SWMM model results

CUHP Method

The CUHP is a method of hydrologic analysis based upon the unit hydrograph principle. It has been developed and calibrated using rainfall-runoff data collected in Colorado (mostly in the Denver/Boulder metropolitan area) and is a standard procedure outlined in UDFCD criteria.

The CUHP computer program requires the input of a design storm and a set of hydrologic parameters that describe the subcatchment characteristics. The subcatchment characteristics include: area, flow path length, centroid flow path link, impervious percentage, basin slope, pervious and impervious depression storage and infiltration rates (Horton initial and final infiltration rate and the Horton decay rate). Table 3.3-4 summarizes these parameters for each of the six validation subcatchments.

Table 3.2-4: CUHP Validation Subcatchment Parameters

Basin ID	Area (sq-mi)	Flow Length (mi)	Centroid Length (mi)	Impervious Percent (%)	Slope (ft/ft)	Depression Storage[1] (in)	Horton Infiltration[2]
VAL_1	0.081	0.483	0.177	41.8	0.0627	0.35 / 0.1	5.0 / 1.0 / 0.0007
VAL_2	0.140	0.729	0.365	47.3	0.0478	0.35 / 0.1	4.75 / 0.8 / 0.0007
VAL_3	0.241	1.052	0.454	1.4	0.1559	0.35 / 0.1	4.75 / 0.8 / 0.0007
VAL_4	0.120	0.702	0.333	34.9	0.0084	0.35 / 0.1	3.0 / 0.5 / 0.0018
VAL_5	0.111	0.627	0.341	41.5	0.0169	0.35 / 0.1	3.0 / 0.5 / 0.0018
VAL_6	0.089	0.726	0.287	49.2	0.0112	0.35 / 0.1	3.0 / 0.5 / 0.0018

1. (A / B) A is pervious depression storage, B is impervious depression storage
2. (A / B / C) A is initial infiltration rate (in/hr), B is final infiltration rate (in/hr), C is decay rate

Table 3.3-5 compares the XPSWMM model results with the CUHP method for the 5-year event. The XPSWMM peak flow results are similar to the CUHP values for all catchments with the largest difference being approximately 14%. In terms of runoff volume, the average difference between the two calculation procedures for all six catchments is less than 2%. Such small differences between the two methods suggest the parameters used within the XPSWMM model are appropriate as validated by CUHP hydrology.

Table 3.2-5: Validation Results: 5-yr Peak Flow Summary

Basin ID	Runoff Volume (ac-ft)		Peak Flow (cfs)	
	XPSWMM Model	CUHP	XPSWMM Model	CUHP
VAL_1	2.87	2.39	57.2	62.8
VAL_2	5.97	5.23	105.6	115.0
VAL_3	0.49	0.75	11.7	13.6
VAL_4	4.91	4.54	74.8	73.5
VAL_5	4.41	4.98	90.4	96.0
VAL_6	3.98	4.42	69.9	79.9

Regional Regression Method

The USGS Regional Regression equations present another method for verifying peak discharges in the stormwater drainage system. The Colorado Plains region-specific regression equations were selected to provide a statistical approximation of peak runoff from the selected subcatchment within the city. It should be noted that because the regional regression equations are intended for subcatchments significantly larger that those within the Boulder city limits, the following results should be considered for comparison purposes only.

Table 3.3-6 compares the XPSWMM model results with the regional regression method for the 5-year event. In general, the two methods compare reasonably well to one another. With the exception of basin VAL_3, which has nearly no impervious cover and very permeable soils, peak flow results from the remaining five basins are within 20% for the two methods. This is well within the standard error range of the regional regression equations (± 34%) and supports the validation of the XPSWMM model.

Table 3.2-6: Validation Results: 5-yr, 1-hr, Peak Flow Summary

Basin ID	Peak Flow (cfs)	
	XPSWMM Model	Regional Regression
VAL_1	57.2	71.8
VAL_2	105.6	89.4
VAL_3	11.7	111.0
VAL_4	74.8	84.0
VAL_5	90.4	81.5
VAL_6	69.9	74.6

1984 City of Boulder SWMP

The 1984 City of Boulder Storm Water Collection System Master Plan modeled runoff for Boulder using EPA SWMM software. As a part of the 1984 study, the EPA-SWMM model results were verified using the CUHP program to produce SWMM flood peaks to within 15% of the CUHP results.

The results from the XPSWMM model and the 1984 SWMP are similar, but because the contributing areas vary between the two studies, a direct comparison of peak flows is not possible. Rather, a unit discharge comparison was also performed using data referenced in the appendix of the 1984 SWMP. Figure 3-9 displays the unit discharge vs. percent impervious for the 5-year, 1-hour event with the data points from the XPSWMM model plotted to show their conformance to the established discharge/impervious area relationship. The XPSWMM values are similar to the 1984 EPA-SWMM result, illustrating the similarity between the two data sets.

3.2.3 Future Condition Model Construction

The future conditions model represents a fully developed urban area according to the 2006 BVCP. This scenario represents the worst case from a stormwater perspective because it encompasses the maximum planned level of development and the corresponding highest level of imperviousness.

Impervious Percentage (Future Conditions)

In a similar method to that outlined for existing conditions, a unique impervious percentage was assigned for each catchment. Instead of directly calculating an impervious percentage from the impervious area database, the individual percentages were determined by joining the project parcels dataset with the average impervious percentage for each general land use and intersecting that with the subcatchment coverage to establish a future net impervious percentage for each subcatchment (Figure 3-10). City-wide, the future impervious percentage was estimated to be approximately 33%. Table 3.3-7 provides a summary of the calculated future condition imperviousness percentages by land use.

Table 3.2-7: Future Condition Imperviousness by Land Use

Land Use	Description	% Impervious	Land Use Distribution w/in City
		30.2%	1.3%
LDR	Low Density Residential	31.5%	24.2%
MDR	Medium Density Residential	47.4%	4.8%
HDR	High Density Residential	57.6%	1.8%
COM	Commercial	64.5%	9.6%
IND	Industrial	44.9%	8.7%
EDU	Educational/College	38.5%	5.3%
OPEN	Open Space	7.3%	29.7%
TRANS	Transportation Right-of-Way	70.3%	14.6%

* Variable depending on acreage and home type

3.3 Water Quality Model

The primary goal of the water quality model development and analysis was to identify areas within the city having comparatively high pollutant concentrations and/or loads. With this information, locations of BMPs or capital projects were targeted throughout the city to maximize the system-wide water quality benefit.

The water quality analysis was incorporated into the XPSWMM model by estimating the washoff and transport of pollutants in stormwater runoff, pollutant removal by existing BMPs, and calculations of annual pollutant loadings into the city's receiving waters. The following section describes the modeled constituents, event mean concentrations, and incorporation of existing quality facilities within XPSWMM.

3.3.1 Modeled Constituents

The stormwater quality analysis modeled five water quality constituents: total suspended solids (TSS), total phosphorus (P), and three metals – lead (Pb), copper (Cu), and zinc (Zn).

Total Suspended Solids

Total Suspended Solids (TSS) represents the amount of suspended organic and inorganic matter in the runoff. It includes all sediments and other constituents that are attached to the sediments or suspended in the water column itself. TSS is also a frequently reported parameter as a surrogate for other stormwater pollutants, including metals, nutrients, and various organic compounds.

Total Phosphorus

Phosphorus (P) is a relatively common element that is found uniformly throughout land uses as it is widely used in fertilizers and pesticides and as a cleanser. Phosphorus is also found to occur naturally in soils and groundwater.

Metals

Metals such as Lead (Pb), Copper (Cu) and Zinc (Zn) are relatively common in urban storm runoff. Lead is often found in paints used on older homes. Zinc is found on roadways due to its use as a galvanizing agent on automobiles and metal structures and is also used in tires and oil. Copper is a commonly used metal in electrical wires, paints, and in several automobile applications (such as brakes and wires).

3.3.2 Event Mean Concentrations

Event mean concentration (EMC) values are the typical concentrations in stormwater runoff for a particular land use and provides an industry standard method to model land-use-based water quality constituents in XPSWMM. EMC values were determined for industrial, commercial, residential, undeveloped and transportation land use categories through a review of the UDFCD Drainage Design Criteria Manual and other applicable reference documents (Table 3.4-1).

To incorporate these parameters into XPSWMM, the percentage of each land use category was determined using GIS for each individual subcatchment, and the model determined the corresponding net pollutant concentration for each subcatchment.

Table 3.3-1: Event Mean Concentrations (EMC) Values

Constituent	Land Use				
	Industrial	Commercial	Residential	Undeveloped	Transportation
Total Suspended Solids, TSS (mg/L)	399	225	240	400	150
Total Phosphorus, P (mg/L)	0.43	0.42	0.65	0.40	0.376
Copper, Cu (μg/L)	84	43	29	40	28
Lead, Pb (μg/L)	130	59	53	100	8
Zinc, Zn (μg/L)	520	240	180	100	197

1. Data source for all land uses except transportation: UDFCD Drainage Design Criteria, Volume 3.
2. Data source for transportation: Analysis of Oregon Water Quality Monitoring Data (ACWA, 1997).
3. mg/L = milligrams per liter. μg/L = micrograms per liter.

3.3.3 Existing Water Quality Facilities

Within the city, there are generally two different categories of water quality facilities. The most predominate facility type is the detention pond; there are numerous detention ponds located throughout the city. The other common facility type is the proprietary BMP, which is often referred to as a "water quality manhole."

Detention and Water Quality Ponds

According to the city's stormwater facility database used with the 2007 SMP analysis, 713 detention ponds exist within Boulder. Although not all off these ponds were originally designed with water quality treatment in mind, some level of pollution reduction can be expected at nearly all functioning facilities. This is due to storage volume and drawdown time, and the tendency for pollutants to settle out of suspension in this environment.

For all but the largest detention ponds, the depression storage concept was used. Depression storage reduces the net runoff and pollutant loads from each catchment by uniformly subtracting the total storage volume and associated pollutant loads within that catchment from the runoff hydrograph. For the larger facilities, each was modeled explicitly, with as-built stage-storage-volume curves, actual outlet structure configurations, and pollutant removal percentages as shown below in Table 3.4-2. Although the approach used draws upon the significant data within the stormwater facility database, the lack of detailed information regarding the design of individual detention ponds is a limiting factor.

Proprietary BMPs

Within the city, four sites exist where proprietary BMPs have been installed as a water quality treatment device. Each PRF was modeled explicitly in XPSWMM to account for pollutant removal efficiency as well as treatment and bypass flow capacities. The type, size and location of each PRF are described below in Table 3.4-3 with their associated pollutant removals listed in Table 3.4-2.

Table 3.3-2: BMP Pollutant Removal Efficiencies

BMP Type	Design Flow Rate (cfs)	Removal Efficiency (%)		
		Total Suspended Solids (*TSS*)	Total Phosphorus (*P*)	Metals (Lead, *Pb*; Zinc *Zn*; Copper, *Cu*)
Detention Ponds[1]	n/a	50%	30%	30%
Vortechs 3000	4.5	80%	50%	25%
Stormceptor 6000	1.8	80%	50%	50%
Stormceptor 11000	3.5	77%	50%	50%
Stormceptor 13000	3.5	71%	50%	50%

1. Removal efficiencies are for synthetic ponds. All other detention ponds remove pollutants through depression storage, which completely removes runoff volume in the simulation.

Table 3.3-3: Proprietary BMP Locations

Location	Description
14th Street at Fourmile Canyon Creek	Two Vortechnics Vortechs 3000 units.
29th Street Mall	Two Stormceptor units. One located at the north end of the 29th Street Mall (STC 13000) and one located at the south side of the 29th Street Mall (STC 11000).
Broadway at Boulder Cr	A single Stormceptor 6000 unit located at Broadway and Boulder Creek.

3.4 2016 SMP Model Updates

The model developed for the 2007 SMP was used as the basis for the 2016 SMP analysis. The model updates associated with the local system analysis for the 2016 SMP include the following:

- Upgrade the XPSWMM model to software Version 2014
- Update the existing condition model with post 2007 SMP projects
- Revise subcatchments and update based on local system analysis problem areas and update hydrology parameters based on 2007 SMP existing condition land use and revised subcatchment geometry.
- Update future condition hydrologic model based on 2007 SMP future condition land use scenario.
- Update the future condition hydraulic model of the 2007 SMP recommended improvements to include proposed local system improvements

This SMP uses the model files developed for the 2007 SMP as the base for updating both the existing conditions and the future conditions/recommended plan models. Since a thorough model validation process was conducted as part of the 2007 SMP, no further model validation was conducted.

3.4.1 Post 2007 SMP Project Updates

The 2016 SMP existing conditions and recommended plan models were updated to reflect storm sewer improvements constructed since the completion of the 2007 SMP. This included updates to both the hydrologic and hydraulic aspects of the model resulting from the following storm sewer improvements:

- Arapahoe Avenue, 15th Street to Folsom Street

  As-built drawings were used to update the storm sewer elements on the model since the city's GIS did not contain this data at the time of the analysis. The as-built drawings were georeferenced into ArcGIS and conveyance features were digitized in to ArcGIS. Relevant hydraulic information was then attributed to the specific features within the ArcGIS database and directly imported into the model. Subcatchment boundaries from the 2007 SMP correlated well with system manholes and were therefore not re-delineated.

- North Broadway Street, Iris Avenue to Balsam Avenue

The 2014 storm sewer infrastructure ArcGIS database was used to update the portion of storm sewer system within Broadway Street from Iris Avenue to Balsam Avenue. Manhole rim elevation and pipe invert elevation data was contained within the GIS data. Subcatchment boundaries from the 2007 SMP correlated well with system manholes and were therefore not re-delineated.

- Iris and North Broadway Intersection Improvements

  The 2014 storm sewer infrastructure ArcGIS database was used to update the portion of storm sewer system in the Iris/Broadway intersection that conveys runoff from the Two-mile Canyon Creek open channel west of Broadway. These improvements discharge to the open channel along the north side of Iris and are conveyed to the east.

- Anderson Ditch Inlet at Kohler Drive

  The stormwater drainage inlet improvements with this project did not result in changes to the hydraulic model. During the design of the inlet improvements, the subcatchment delineation was re-evaluated and modifications made. These revisions were incorporated into the 2016 SMP model.

3.4.2 Model Updates for Local System Analysis

Updates to the hydrologic and hydraulic portions of the 2007 SMP Recommended Plan model were required to conduct a representative hydraulic assessment of selected local system problem areas and size associated system improvements.

The updated subbasin boundaries result from storm sewer extensions or other system modifications needed to analyze city-identified local system conveyance problem areas. Of the 590 subcatchments from the 2007 SMP, the updates resulted in approximately 50 subcatchments being modified. For the re-delineated subcatchments, values for basin area and slope were re-calculated. Note the modified subcatchments were verified to have very similar characteristics to the larger area from which they were re-delineated/derived. Therefore, model inputs for modified subcatchments associated with infiltration, impervious percentage, zero detention, and Manning's roughness for overland flow were not recalculated as part of this effort and were attributed to the 2007 SMP subcatchments from which they originated.

3.5 2006 and 2011 Boulder Valley Comprehensive Plan Land Use Comparison

The impervious percentage used in 2007 SMP model was based on future condition land use as defined by the 2006 BVCP. With the 2016 SMP, a comparison of projected land use differences between the 2006 and 2011 BVCP was performed. These differences in land use are discussed in terms of their impact on the resulting impervious percentage. Land use imperviousness affects both the quantity (volume and peak) and quality of water being routed though the stormwater collection system. The more impervious the area, the less water that will be infiltrated on the landscape, the more water that will generally runoff into the stormwater collection system, and the faster the water will be routed to the storm water collection system (due to the lower surface roughness of the ground). Consequently, an area with a higher percentage of impervious surfaces will produce higher

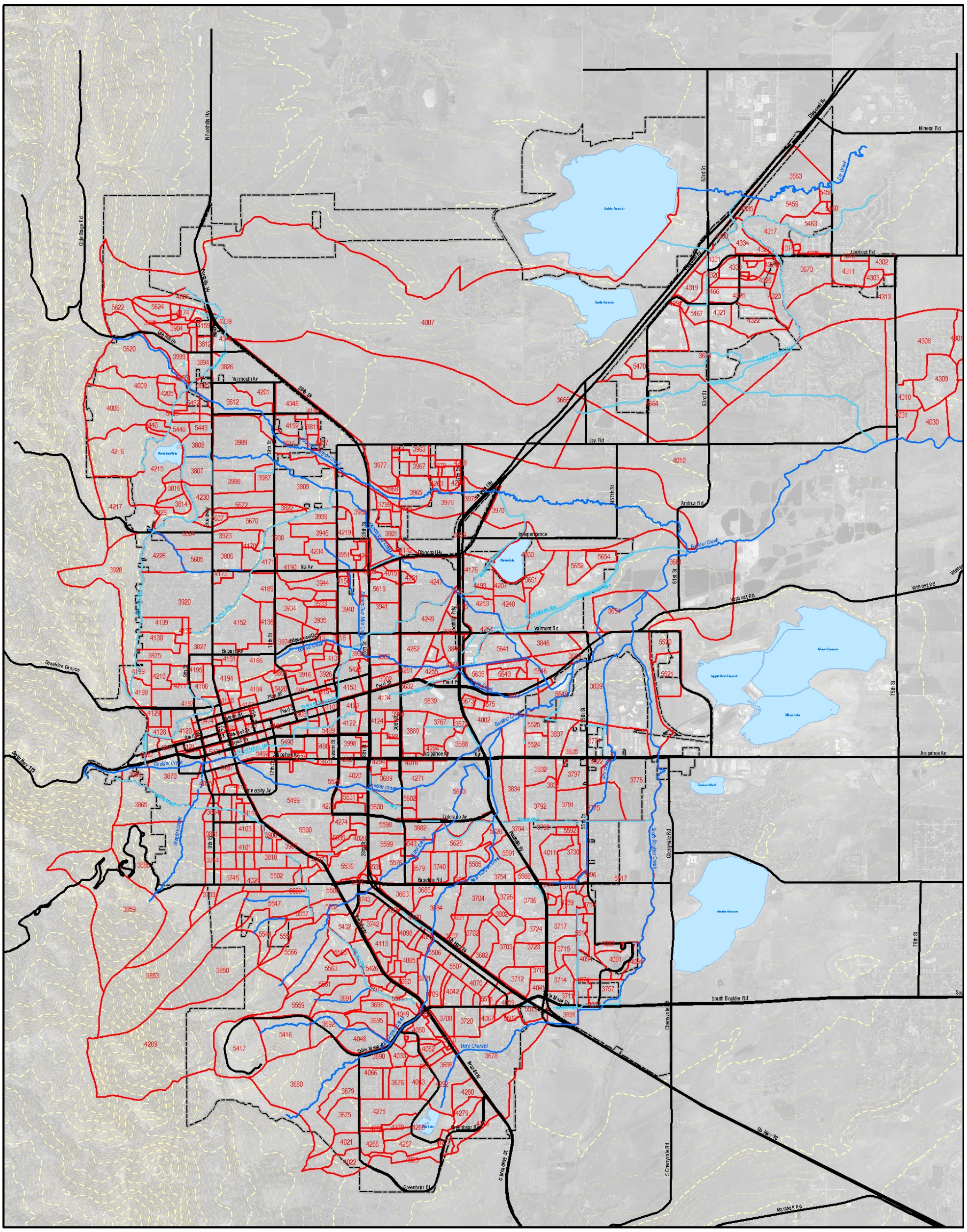
peak flows and greater volumes of runoff over a shorter period of time than a similar area with a lower percentage of impervious surfaces.

The 2011 BVCP contains similar land use definitions as the 2006 BVCP. These land use definitions, the associated parcel land use classifications, and average impervious percentages were used to compare the 2006 to the 2011 BVCPs. Based on this analysis, the following observations were made:

- Of the 39,020 parcels in the modeling area, there are 370 parcels that are impacted by the BVCP change from 2006 to 2011 (roughly 1 percent of the parcels), with 210 parcels having a land use difference that indicate a decrease in impervious percentage and 160 parcels having a land use difference that indicate an increase in impervious percentage.
- Of the 22,880 acre modeled area, the total parceled area that saw decreases in impervious percentages between the 2006 and 2011 BVCPs is equal to approximately 48 acres (roughly 0.2 percent) while the total parceled areas that saw increases is equal to approximately 126 acres (roughly 0.6 percent).
- Calculating the associated impervious area of these parcels (impervious percentage multiplied by parcel area) results in a total decrease of impervious acreage of 5.3 acres and a total increase in impervious acreage of 32.8 acres from the 2006 to the 2011 BVCP projected land use. This results in a net increase of 27.5 acres of projected impervious acreage of the total 22,880 acre modeled area.

Figure 3-11 illustrates the spatial extent of the parcels with a differing projected land use change between the 2006 and 2011 BVCPs.

This comparative analysis concluded that the observed differences in impervious area are considered relatively minor in the overall extent of the model and would have negligible impacts on the overall model results. The projected land use differences from the 2006 to 2011 BVCP are also in locations that will not affect model results for project areas. As a result, it is therefore recommended that model updates are not required reflect these land use differences.

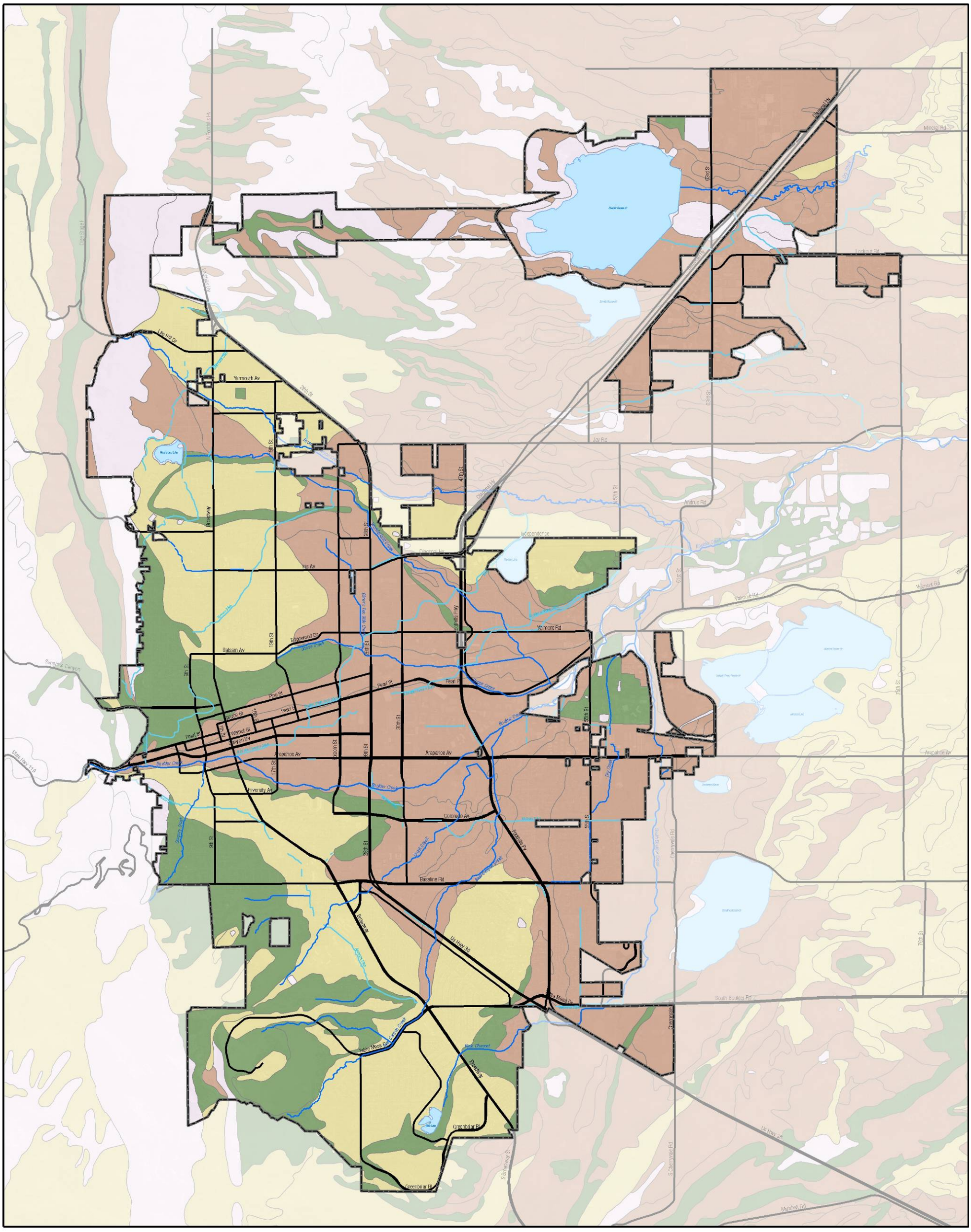


Summary of Model Subcatchments

Figure 3-1

Stormwater Master Plan | City of Boulder

HDR
ONE COMPANY | *Many Solutions* SM

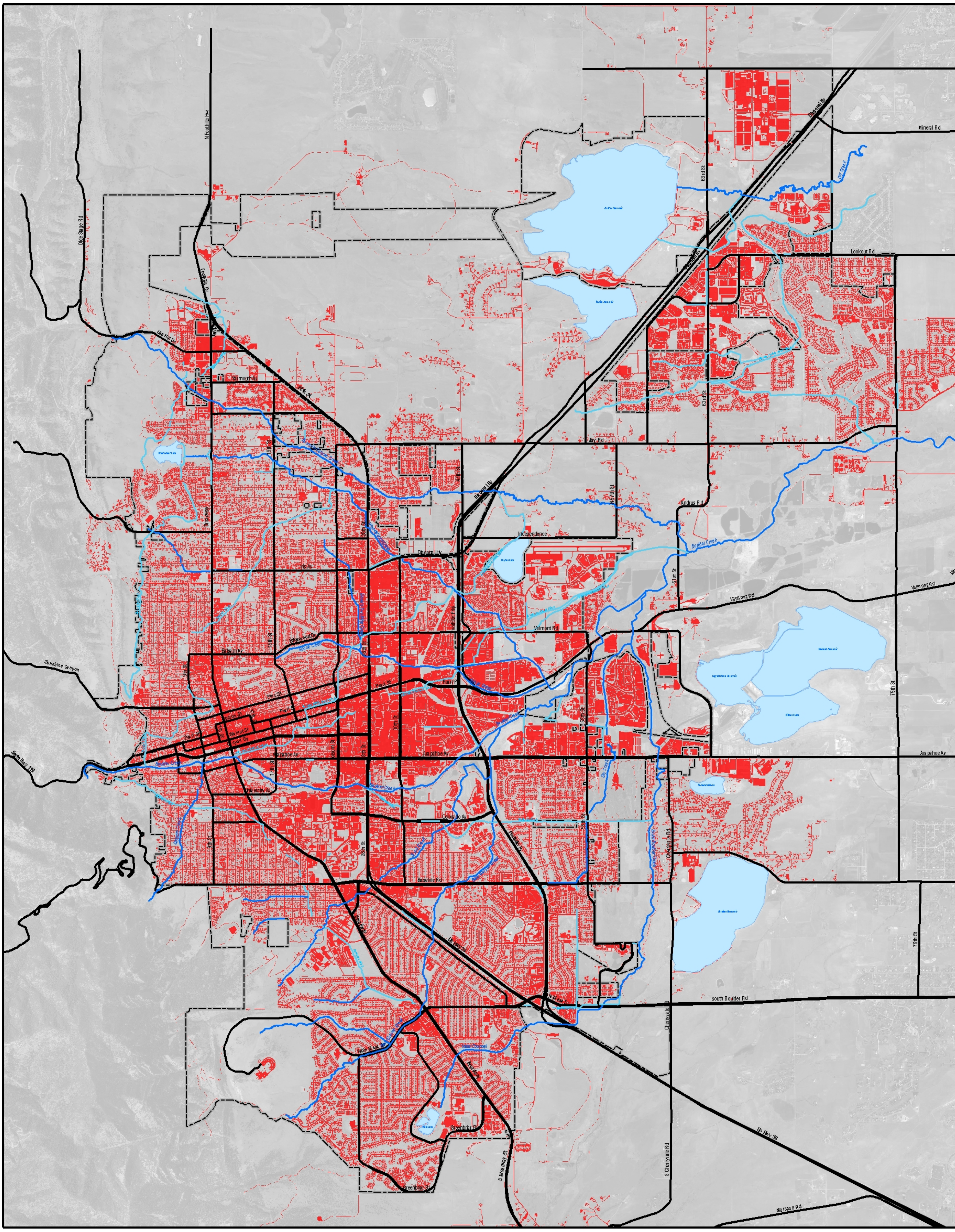


Hydrologic Soil Map

Figure 3-2

Stormwater Master Plan | City of Boulder

HDR
ONE COMPANY | *Many Solutions* SM



Legend

- Major Roads
- Ditches
- Major Drainageways
- Lakes
- City Limits
- Impervious Areas

0 4,000
1 inch equals 4,000 feet

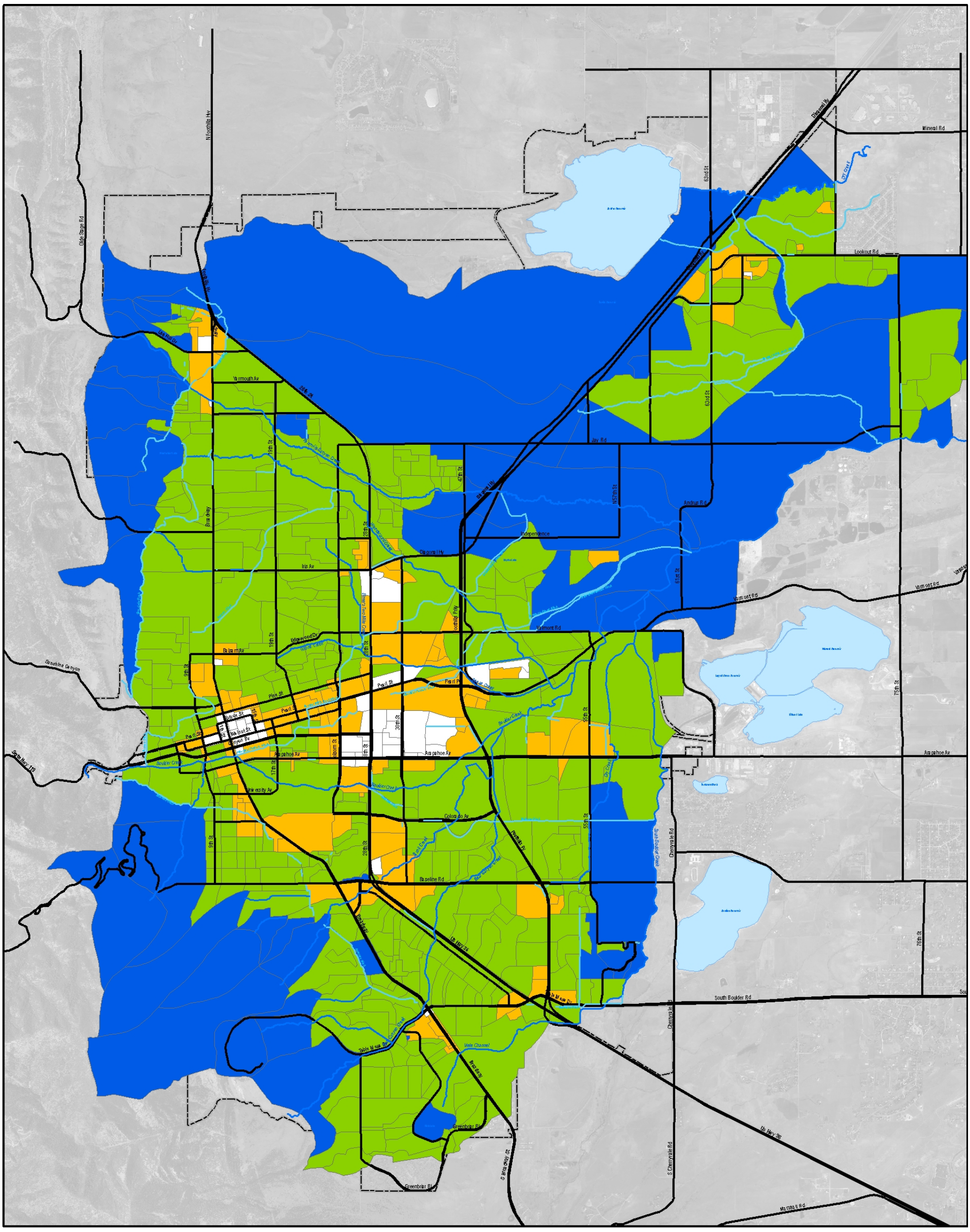
N

Existing Impervious Areas

Figure 3-3

Stormwater Master Plan | City of Boulder

HDR ONE COMPANY | *Many Solutions* ℠



Legend

- Major Roads
- Ditches
- Major Drainageways
- Lakes
- CityLimits

Impervious Percentage

- 0 - 20%
- 20 - 40%
- 40 - 60%
- 60 - 80%
- 80 - 100%

0 4,000

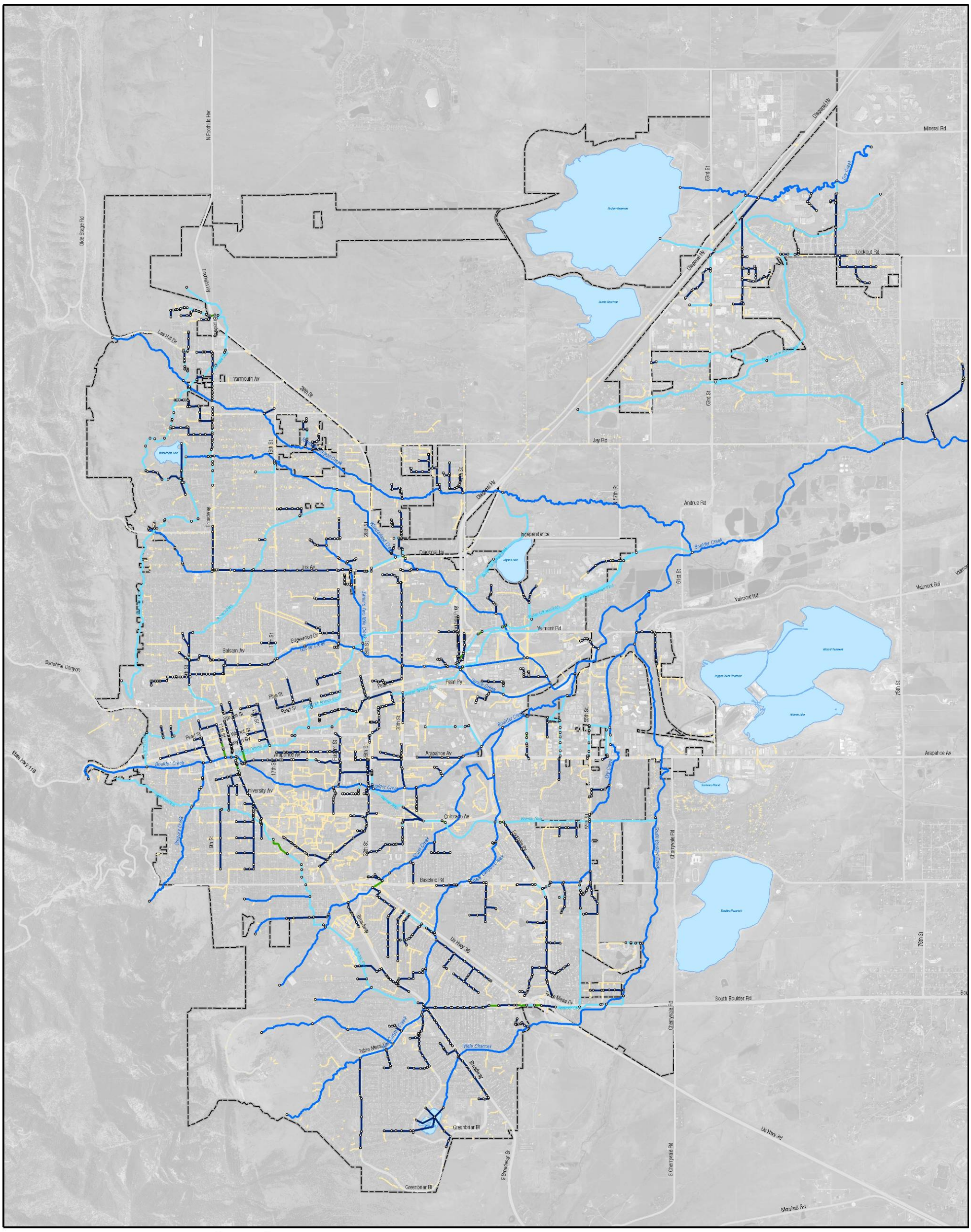
1 inch equals 4,000 feet

N

Existing Impervious Percentage by Subcatchment

Figure 3-4

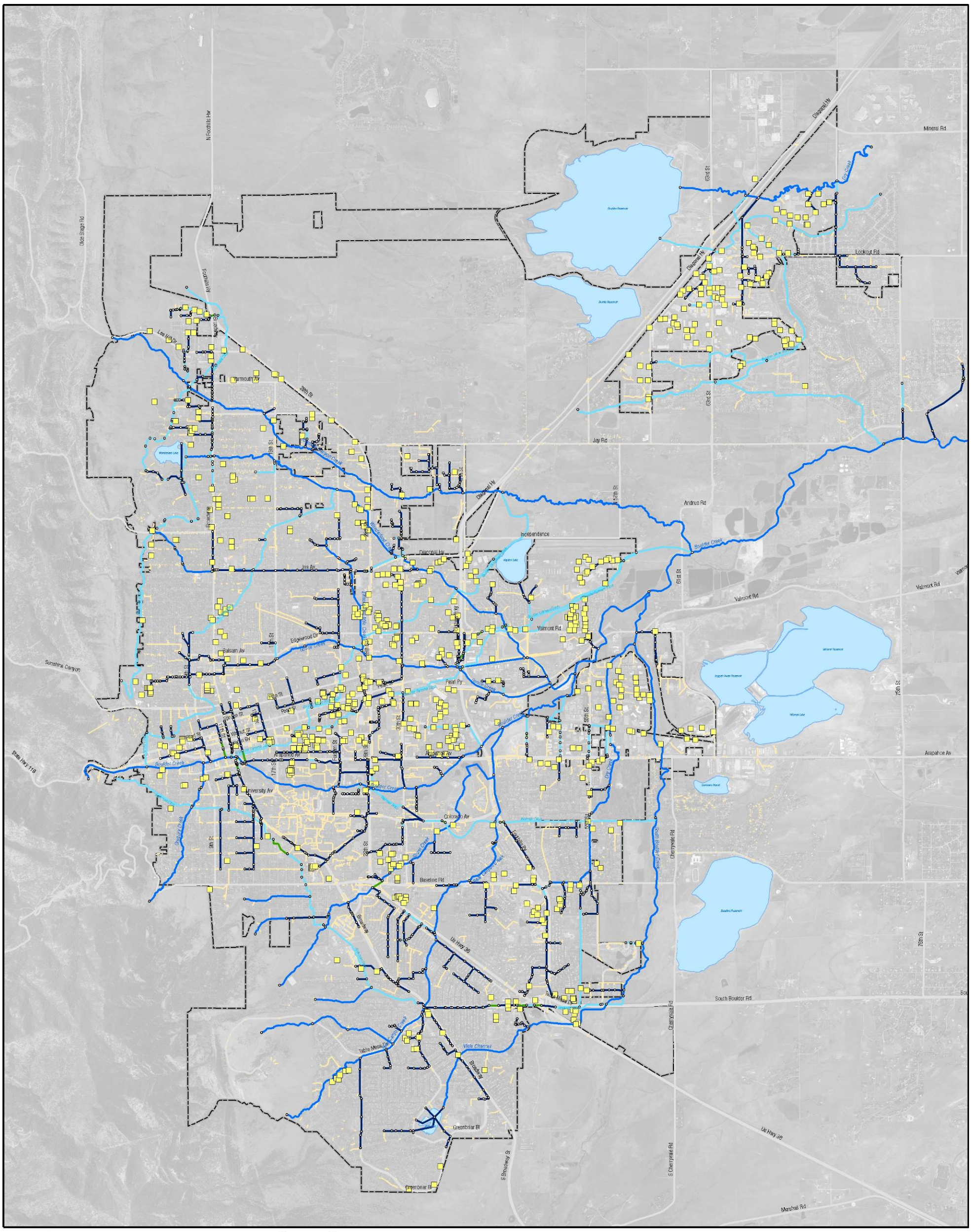
HDR ONE COMPANY | *Many Solutions*℠



Hydraulic Model Network Map

Figure 3-5

HDR
ONE COMPANY | *Many Solutions* SM



Map of Detention Ponds within Boulder

Figure 3-6

HDR
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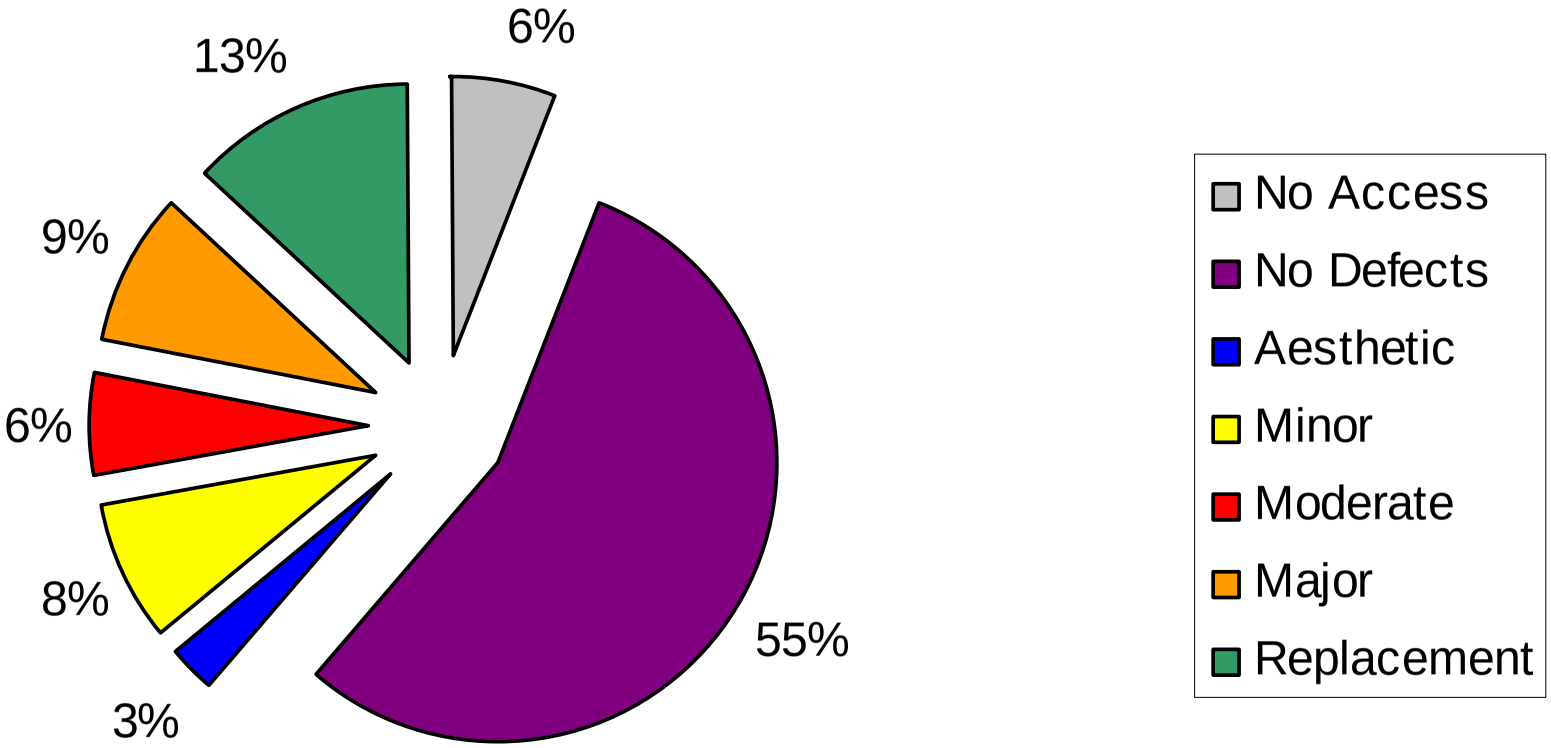

Estimate of Pond Conditions in Boulder

Figure 3-7

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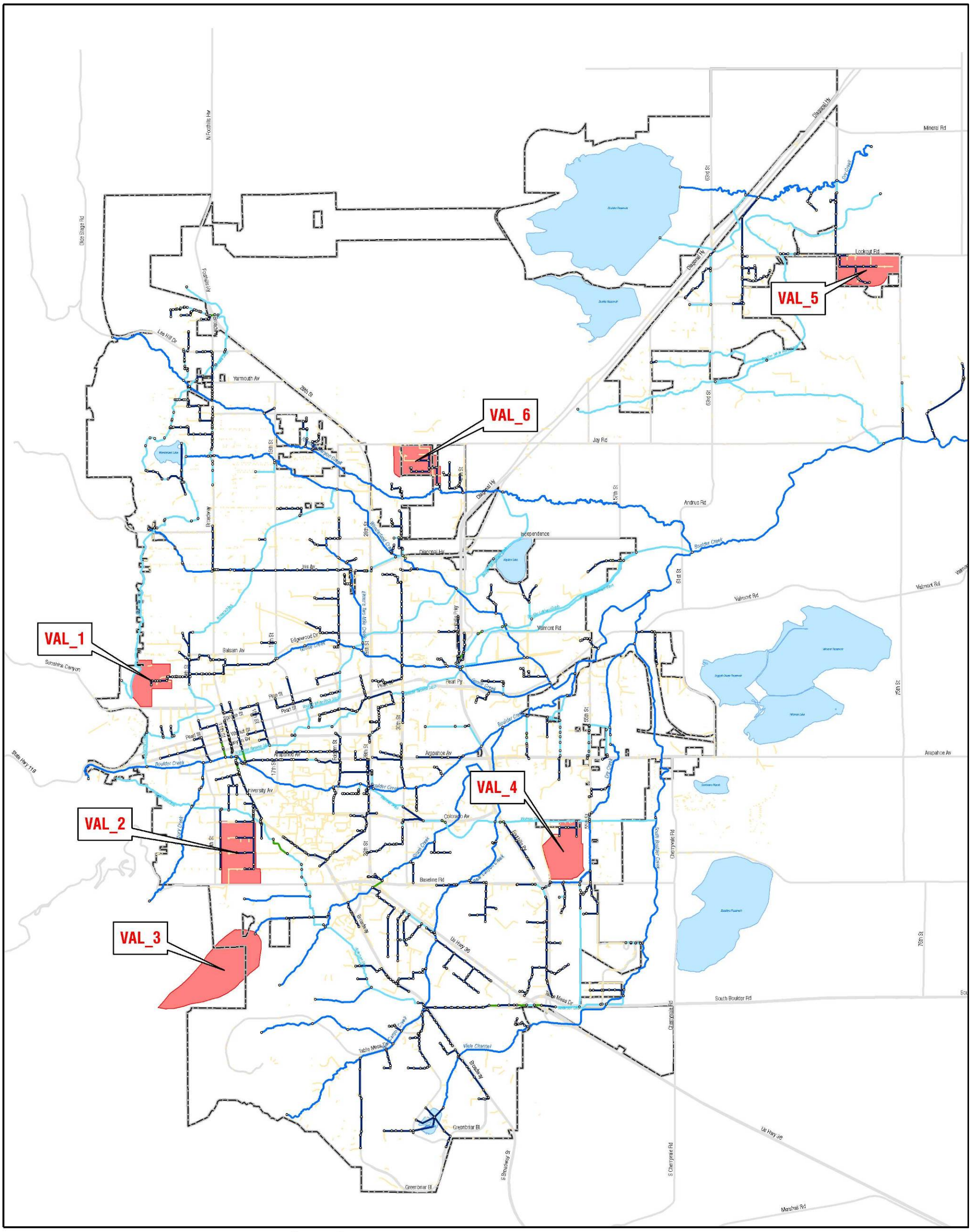
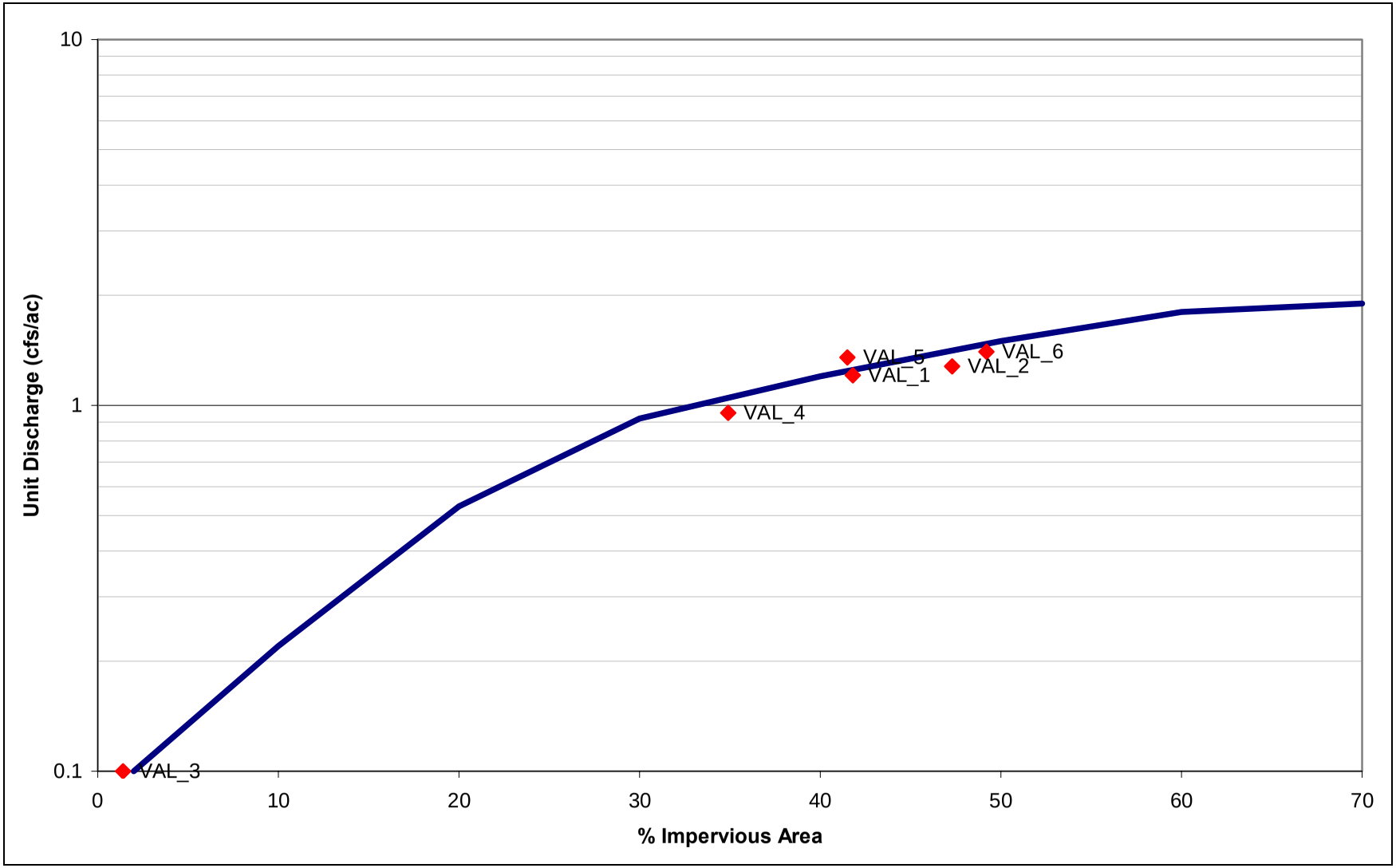


Model Verification Location map

Figure 3-8

Stormwater Master Plan | City of Boulder

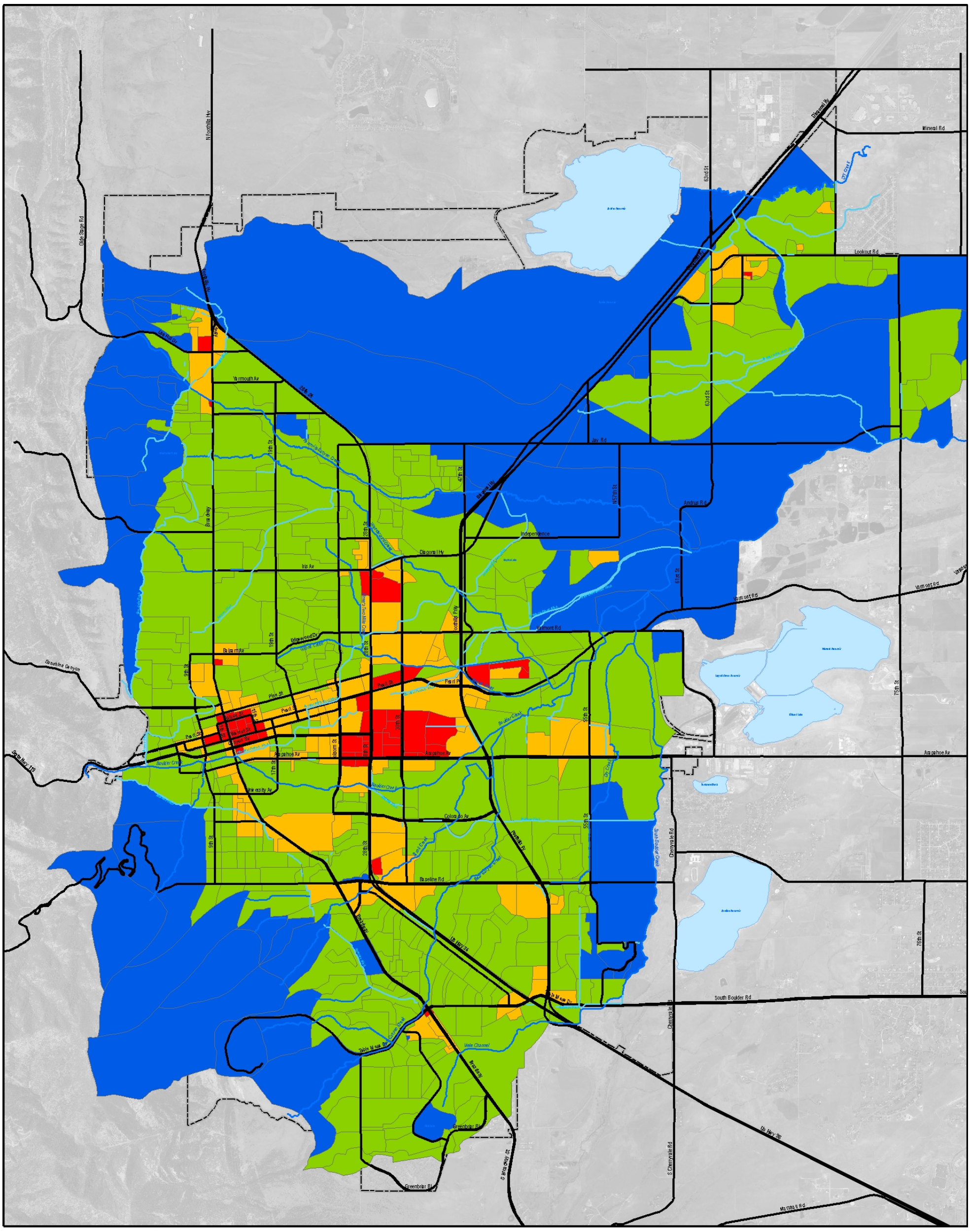
HDR
ONE COMPANY | *Many Solutions* SM



Unit Discharge vs. Percent Impervious Area, 5-year Frequency

Figure 3-9

HDR ONE COMPANY | *Many Solutions* SM



Legend

- Major Roads
- Canals
- Major Drainageways
- Lakes
- CityLimits

Impervious Percentage

- 0 - 20%
- 20 - 40%
- 40 - 60%
- 60 - 80%
- 80 - 100%

0 4,000

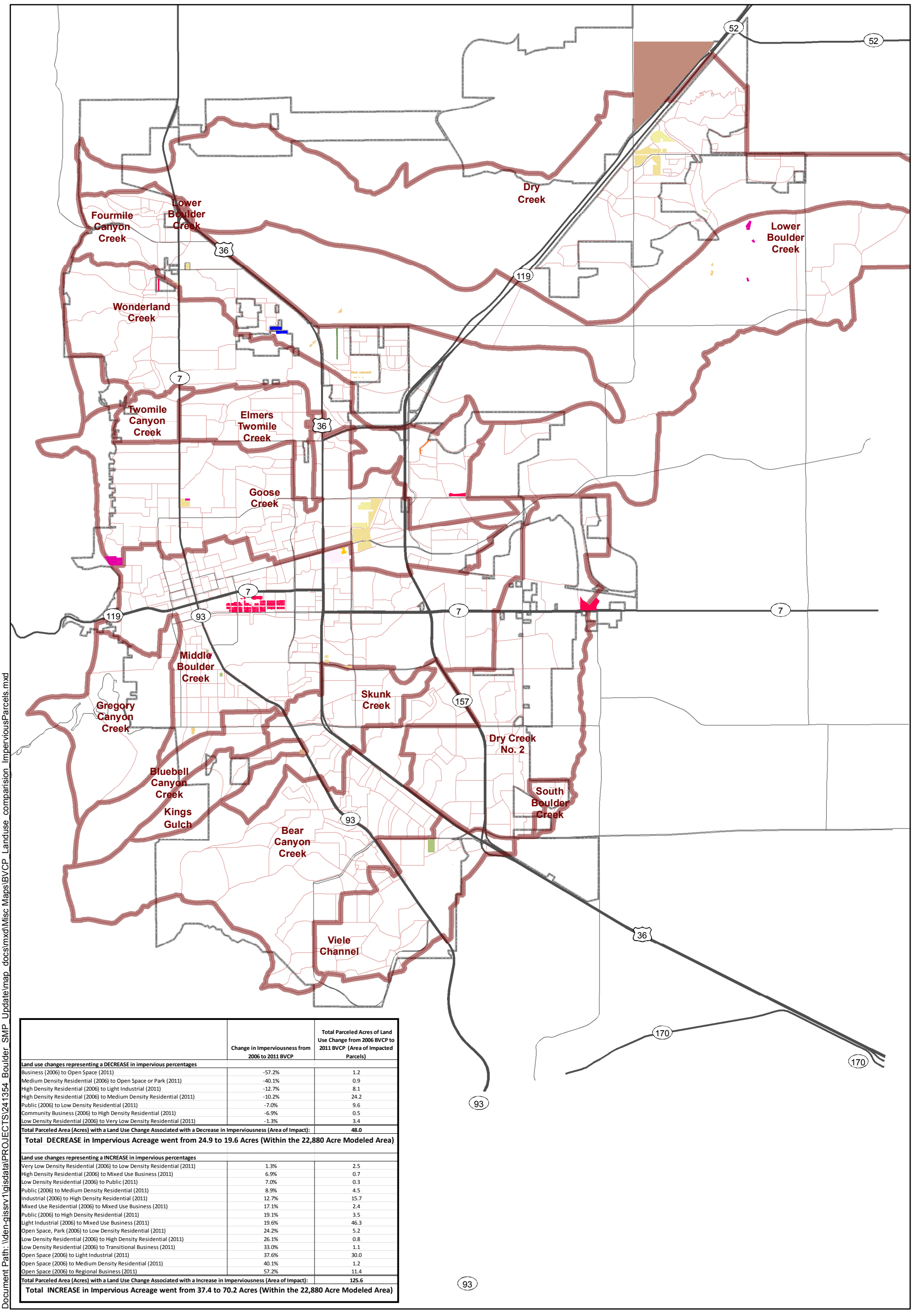
1 inch equals 4,000 feet

N

Future Impervious Percentage by Subcatchment

Figure 3-10

HDR ONE COMPANY | *Many Solutions* SM



	Change in Imperviousness from 2006 to 2011 BVCP	Total Parceled Acres of Land Use Change from 2006 BVCP to 2011 BVCP (Area of Impacted Parcels)
Land use changes representing a DECREASE in impervious percentages		
Business (2006) to Open Space (2011)	-57.2%	1.2
Medium Density Residential (2006) to Open Space or Park (2011)	-40.1%	0.9
High Density Residential (2006) to Light Industrial (2011)	-12.7%	8.1
High Density Residential (2006) to Medium Density Residential (2011)	-10.2%	24.2
Public (2006) to Low Density Residential (2011)	-7.0%	9.6
Community Business (2006) to High Density Residential (2011)	-6.9%	0.5
Low Density Residential (2006) to Very Low Density Residential (2011)	-1.3%	3.4
Total Parceled Area (Acres) with a Land Use Change Associated with a Decrease in Imperviousness (Area of Impact):		**48.0**
Total DECREASE in Impervious Acreage went from 24.9 to 19.6 Acres (Within the 22,880 Acre Modeled Area)		
Land use changes representing a INCREASE in impervious percentages		
Very Low Density Residential (2006) to Low Density Residential (2011)	1.3%	2.5
High Density Residential (2006) to Mixed Use Business (2011)	6.9%	0.7
Low Density Residential (2006) to Public (2011)	7.0%	0.3
Public (2006) to Medium Density Residential (2011)	8.9%	4.5
Industrial (2006) to High Density Residential (2011)	12.7%	15.7
Mixed Use Residential (2006) to Mixed Use Business (2011)	17.1%	2.4
Public (2006) to High Density Residential (2011)	19.1%	3.5
Light Industrial (2006) to Mixed Use Business (2011)	19.6%	46.3
Open Space, Park (2006) to Low Density Residential (2011)	24.2%	5.2
Low Density Residential (2006) to High Density Residential (2011)	26.1%	0.8
Low Density Residential (2006) to Transitional Business (2011)	33.0%	1.1
Open Space (2006) to Light Industrial (2011)	37.6%	30.0
Open Space (2006) to Medium Density Residential (2011)	40.1%	1.2
Open Space (2006) to Regional Business (2011)	57.2%	11.4
Total Parceled Area (Acres) with a Land Use Change Associated with a Increase in Imperviousness (Area of Impact):		**125.6**
Total INCREASE in Impervious Acreage went from 37.4 to 70.2 Acres (Within the 22,880 Acre Modeled Area)		

Document Path: \\den-gissrv1\gisdata\PROJECTS\241354_Boulder_SMP_Update\map_docs\mxd\Misc Maps\BVCP_Landuse_comparision_ImperviousParcels.mxd

Parcels (2007) with Projected Landuse Differences Between 2006 and 2011 BVCP (with Parcel Count)

DECREASES in projected impervious percentages (magnitude of decrease)
- -57.2% (2)
- -40.1% (2)
- -12.7%; -10.2% (186)
- -7.0%; -6.9% (15)
- -1.3% (4)

INCREASES in projected impervious percentages (magnitude of increase)
- 1.3% (10)
- 6.9%; 7.0%; 8.9% (5)
- 12.7% (9)
- 17.1%; 19.1%; 19.6% (48)
- 24.2%; 26.1% (34)
- 33.0% (1)
- 37.6% (1)
- 40.1% (40)
- 57.2% (2)

Major Basins
- Major Basins
- Future Base Catchments
- City Limits

N

0 2,000 4,000 Feet

Projected Land Use Differences Between 2006 and 2011 BVCP

Figure 3-11

4 Collector Storm Sewer System Analysis and Results

This section presents a characterization of the existing and future hydraulic and water quality problem areas within the existing stormwater drainage system that will be used as a baseline for the development of recommended improvements.

4.1 System Description

As previously noted, the focus of the SMP is the collector stormwater drainage system, which includes pipe 18” in diameter and larger and primary open channel systems that are not part of the city’s major drainageways. The following sections provide an overview of those portions of the city’s stormwater drainage system that were included in the model and analyzed as part of this project.

4.1.1 Major Drainageways

From a storm drainage perspective, the city is generally split north-south by Boulder Creek, which is the ultimate discharge point for much of the city’s stormwater runoff. In addition to Boulder Creek, the city’s other major creeks include Gregory Creek, Bluebell Creek, Skunk Creek, Bear Canyon Creek and South Boulder Creek to South and Goose Creek, Twomile Canyon Creek, Elmer’s Two Mile Creek, Wonderland Creek and Fourmile Canyon Creek to the North. Although the major drainageways and creeks within the city were not evaluated as part of this plan, they were still incorporated into the hydraulic analysis to provide system connectivity and serve as boundary conditions at outfalls and other points of discharge. Figure 4-1 illustrates the major drainageways.

4.1.2 Irrigation Ditches

The presence of irrigation ditches within the city plays an important role in the collection and conveyance of stormwater runoff. Because the ditches tend to run perpendicular to the surrounding ground slope, they can often intercept a substantial portion of runoff and transfer it to neighboring basins. The major irrigation ditches within the city, including Farmers Ditch, Silver Lake Ditch, Boulder White Rock Ditch, North Boulder Farmers Ditch, Anderson Ditch and Wellman Ditch were included in the hydraulic analysis and evaluated for flooding problems. Figure 4-1 illustrates the primary irrigation ditches as included in the hydraulic analysis.

4.1.3 Storm Sewers

The existing stormwater drainage system within the city includes nearly 160 miles feet of sewer ranging in size from less than 12” to 72” in diameter. Of that, approximately 52 miles of 18” in diameter and larger sewer was included in the hydraulic model and evaluated for system problems. Figure 4-1 identifies the modeled and non-modeled storm sewers.

4.2 Storm Sewer Problem Identification

Utilizing the XPSWMM model, runoff, hydraulic, and water quality calculations were completed for two different land use scenarios: existing conditions and future conditions, and three different design

storms: the 2- and 5-yr events and the water quality storm. These results were then evaluated with respect the problem identification criteria to identify specific system deficiencies within the city's stormwater drainage system.

Initially, a comparison of hydraulic problems for the existing and future land use condition scenario was performed. Model results indicated no additional problems areas resulted from the slight increase in imperviousness between the existing and future condition land use scenarios. However, it was observed that there was a slight increase in problem severity. *As a result, the collector storm sewer system problem identification used only the future condition land use scenario.*

Model results indicate that 572 nodes out of 1635 nodes within the city violate one or more of the SMP system analysis criteria provided in Section 2.2. In most cases, a number of these deficient nodes and links were grouped together into a single problem area. This resulted in 50 hydraulic problem locations as shown on Figure 4-2.

In general, the collector storm sewer system areas that were identified as most severely under capacity or the areas that potentially flood the most include:

- Upper Goose Creek between North Boulder Park and Folsom St,
- Spine Road and N. 63rd Street in the Gunbarrel part of town,
- Spruce St between 18th St and Boulder White Rock Ditch, and
- 28th St. between Arapahoe Ave and Boulder Creek.

4.3 Storm Sewer Problem Prioritization

Due to the large number of problem locations and limitations within the city's capital budget, a ranking was performed on the problem areas to group the conveyance problems into three tiers defined as: Tier 1 = severe problem area, Tier 2 = major problem area, and Tier 3 = minor problem area. Detailed alternatives and design solutions were developed for the Tier 1 and Tier 2 priority problems areas. However, storm sewer sizes and design criteria are also provided for the Tier 3 problem area based on a pipe replacement improvement. The following paragraphs summarize the criteria used to identify and rank the high priority conveyance problems within the city's collector system.

As noted above, model results identified 572 problem nodes that were either surcharged or flooding based on the project hydraulic criteria. Further investigation of the problem nodes showed locations where the hydraulic criteria were violated by matter of inches and/or for a relatively short duration. Considering those nodes that were only slightly exceeding the project hydraulic criteria were not identified as system problem locations by the city, an additional screening criterion was developed to remove these minor capacity restrictions from the problem identification list.

Prior to ranking and identification each problem area, a *problem override criterion* was applied to nodes that were either 1) flooded or surcharged for less than 15 minutes and/or 2) only violated the HGL surcharge criteria by less than two tenths of a foot and were isolated with respect to other flooded problem areas. The problem override criterion and removed 60 model nodes, or 4% of the total model nodes, from the problem identification process.

4.3.1 Criteria and Definitions

The process of prioritizing system problems into tiers utilized a point-based matrix using a weighted criteria approach. The problem prioritization criteria and their definitions are presented in Table 4.3-1. The process of prioritizing the identified hydraulic problem locations assigned a relative score of 1 to 10 to each of the prioritization criterion. The following sections describe the criteria scoring process and graphically compare the relative score for each problem location.

Table 4.3-1: Problem Prioritization Criteria and Definitions

Criterion	Definition
Problem Extent	Length of the stormwater drainage system that is identified as a hydraulic problem. This is intended to be a measure of the extent of the street and associated inlets that are impacted by the surcharged hydraulic grade line. This criterion is determined for each problem location by calculating the length of the stormwater drainage system between surcharged and/or flooded nodes.
Flooded Volume	Volume of flow that exceeds the rim elevation. This is intended to be a measure of the problem severity by evaluating the volume of runoff that could potentially escape the stormwater drainage system into the street and result in localized flooding. This criterion is determined as direct output from XPSWMM summed for all flooded nodes with in a problem location. Note this does not include surcharged nodes (HGL within 1-ft of the rim) and identifies locations with severe flooding potential.
Structure Impact	Number of buildings or structures potentially impacted by system flooding. This measures the problem severity for flooded nodes by differentiating node flooding in densely developed areas or where development is well above the rim of the stormwater drainage system. This criterion is calculated using flooded node HGL elevations intersected with the surrounding building elevations in the project GIS.
Length of High Q_{Ratio}	The Q_{Ratio} is defined as the peak system flow divided by the manning's full flow capacity of the pipe. The higher the Q_{Ratio} the more severe the capacity problem is in the pipe segment. This is intended to be another measure of problem severity for a surcharged or flooded system and typically identifies the cause of the flooded volume and problem extent criterion. This criterion is calculated as direct output from XPSWMM by multiplying the Q_{Ratio} by length for each pipe segment where the Q_{Ratio} is greater than 1.1.
Data Confidence	General ranking of the amount of data gaps remaining that are adjacent to a problem node or pipe. This would be a measure of the level of confidence in how the model is predicting actual system hydraulics with respect to the best available data. For example, if a problem location is a result or partial result of a model element that was not able to be surveyed, it would rank as a less severe issue. A resulting recommendation would be for additional data collection in that area.
Water Quality Area of Concern	Identifies problem locations that may have multi-objective solutions. This identifies if the hydraulic problem area is adjacent to or contains a Water Quality Area of Concern.

4.3.2 Criteria Weights and Ranking

Weighting factors were used to identify those criteria that are of a higher concern with respect to basin characteristics and the level of service provided by the city's collector system. For example, the *Length of* Q_{Ratio} criterion is a representation of amount of under-capacity pipe within a problem location but does not necessarily indicate a problem. Therefore, this criterion would be weighted less than *Flooded Volume* or *Structural Flooding* for example, which represent the severity of a system deficiency and the potential impacts created by system flooding. Weighting factors were developed on a percentage basis for each of the six criteria such that the sum of all the weights totaled 100%. The ranking scores for each problem location were calculated by multiplying the criteria scores by the criteria weight percentages and converted to a percentage. In theory, the maximum rank a problem area could attain would be 100% thus attaining the maximum score for all of the criteria. Table 4.3-2 provides a summary of the weighting criteria.

Table 4.3-2: Weighting Criteria

Scoring Criteria	Weight
Problem Extent	13%
Flooded Volume	25%
Structure Impact	31%
Length of High Q_{Ratio}	6%
Data Confidence	9%
Water Quality Area of Concern	16%

4.3.3 Problem Area Priorities

The process of identifying the Tier 1, 2 and 3 priority locations was developed to identify the severe, major and minor problems within the city's collector storm sewer system. This approach was necessitated due to the large number of problem locations, the anticipated high cost associated by addressing all problems and the limited budget available within the city's stormwater utility.

Identifying the breakpoint between the Tier 1, 2 and 3 problem locations was intended to identify the point of diminishing returns with respect to capital expenditures and problem severity. A comparison of the ranking score for each of the problem locations was made to identify if there were breakpoints in the distribution problem location score. This comparison of ranking score for each problem location was made graphically using a histogram. A natural break was observed between the problem locations scores around 25% thus indicating the problem severity significantly decreases past a 25% score. In addition, there is another grouping of scores above the 45% point indicating a series of very severe problem locations. With observed breakpoints identified, Table 4.3-3 was used to identify the Tier 1, 2 and 3 problem locations. This is also shown on Figure 4-3.

Table 4.3-3: Summary of Problem Area Ranking Results

Problem ID	Score	Rank	Tier 1	Tier 2	Tier 3
HYD#16	73.1	1	×		
HYD#34	50.0	2	×		
HYD#55	49.7	3	×		
HYD#8	48.8	4	×		
HYD#42	40.6	5		×	
HYD#41	40.0	6		×	
HYD#19	39.1	7		×	
HYD#24	35.9	8		×	
HYD#29	35.0	9		×	
HYD#47	35.0	9		×	
HYD#27	33.4	11		×	
HYD#21	32.5	12		×	
HYD#9	31.3	13		×	
HYD#15	30.6	14		×	
HYD#20	30.6	14		×	
HYD#22	29.7	16		×	
HYD#38	29.4	18		×	
HYD#35	27.8	19		×	
HYD#18	27.5	20		×	
HYD#49	27.2	21		×	
HYD#48	26.3	22			×
HYD#50	25.9	23			×
HYD#30	21.6	25			×
HYD#46	20.9	26			×
HYD#7	19.4	27			×
HYD#23	19.4	27			×
HYD#32	19.1	29			×
HYD#2	18.8	30			×
HYD#3	18.8	30			×
HYD#33	18.8	30			×
HYD#17	18.1	33			×
HYD#52	18.1	33			×
HYD#11	17.8	35			×
HYD#1	16.9	36			×
HYD#5	16.9	36			×
HYD#12	16.9	36			×
HYD#14	16.9	36			×
HYD#28	16.9	36			×
HYD#37	16.9	36			×
HYD#45	16.9	36			×

Table 4.3-3: Summary of Problem Area Ranking Results

Problem ID	Score	Rank	Tier 1	Tier 2	Tier 3
HYD#51	16.9	36			×
HYD#53	16.9	36			×
HYD#54	16.9	36			×
HYD#13	16.3	48			×
HYD#31	15.9	49			×
HYD#39	15.0	50			×
HYD#40	15.0	50			×
HYD#44	15.0	50			×
HYD#36	14.1	53			×
HYD#25	13.1	54			×
HYD#4	8.4	55			×

4.4 Irrigation Ditch Problem Identification

Irrigation ditch segments were added to the problem identification list if the corresponding design storm causes the channel to overtop its banks and flood the surrounding area. These processes identified approximately 13 locations where ditch flooding might occur. Figure 4-4 illustrates these ditch flooding locations graphically.

4.5 Water Quality Areas of Concern

The primary goal of the water quality model development and analysis was to identify areas within the city having comparatively higher pollutant concentrations and/or loads. With this information, specific capital projects or BMPs could be selected and located within the city to maximize their system-wide water quality benefit. A detailed presentation of the water quality analysis approach and problem identification process is included in TM 3.5 Water Quality Model and Construction Results.

Initially, the pollutant loadings for both the existing and future land use conditions were evaluated. However, by considering the limited amount of new development or redevelopment expected within the city, and by acknowledging that the city's Design and Construction Standards tend to mitigate pollutant loading from new impervious surfaces, it was recognized that both scenarios would produce similar water quality results. This conclusion was supported by the model, which indicated a difference of less than 2 percent in city-wide total pollutant washoff between the two scenarios. Consequently, it was determined that a single scenario would provide an appropriate basis for comparison in the subsequent analysis. *Therefore, all water quality problem area identifications and improvements utilize the future conditions land use scenario.*

4.5.1 Catchments

Identifying the catchments that generate the highest pollutant loadings per acre was an important first step in selecting specific sites where water quality treatment would be most beneficial. Figure 4.-5 illustrates the normalized pollutant loads (per acre) for each of the subcatchments used in the SWMM model.

In general, the highest pollutant loadings are located in the central core of the city, between Valmont Road and Arapahoe Avenue (north-south) and 28th Street and 55th Street (east-west). This area includes significant industrial developments, high-traffic-volume roadways, and the proposed Boulder Transit Village site. In addition to this central core area, two other areas were identified as having comparatively high pollutant loads. These include 63rd Street and the Diagonal Highway in the Gunbarrel area and Broadway and Fourmile Creek in the northwestern corner of the city.

4.5.2 Outfalls

Although identifying the catchments with the highest comparative washoff load is important from a source control standpoint, identifying the specific outfalls that are discharging these high concentration pollutants can help to identify site-specific locations where water quality treatment facility would be most beneficial and could be included in the city's capital improvement program. The storm sewer outfalls with the highest pollutant load concentrations were identified as the Water Quality Areas of Concern and are shown on Figure 4-6 and summarized in Table 4.5-1 listed by outfall location.

Table 4.5-1: Top 12 Pollutant Contributing Outfalls

Rank	Location	Pollutant Load (lbs/ac/yr)				
		TSS	P	Cu	Pb	Zn
1	Broadway & Fourmile Canyon Creek	1,970	3.16	0.35	0.52	2.13
2	49th Street & Goose Creek	1,249	1.39	0.25	0.39	1.55
3	Foothills and Wonderland Creek	1,334	1.77	0.17	0.33	0.71
4	Pearl Parkway & Wonderland Creek	980	1.29	0.20	0.29	1.22
5	Diagonal Highway & Boulder Creek	957	1.30	0.20	0.28	1.18
6	Arapahoe and Range Street	912	1.55	0.16	0.24	0.99
7	Pearl Street & Goose Creek	806	0.96	0.17	0.24	1.05
8	Broadway & Skunk Creek	763	0.85	0.16	0.24	0.99
9	Broadway at Boulder Creek	730	1.66	0.11	0.14	0.68
10	56th Street & Dry Creek	712	1.20	0.13	0.19	0.81
11	28th Street & Boulder Creek	687	1.32	0.13	0.17	0.75
12	63rd Street & Boulder White Rock Ditch	682	0.84	0.15	0.22	0.94

The existing 36-inch storm sewer running south along Broadway and discharging into Fourmile Canyon Creek was predicted to have the highest pollutant loadings with 1,970 pounds of TSS per acre per year. The next six highest contributing outfalls are all located in the central downtown area of the city, and discharging into Goose Creek, Boulder Creek, and North Boulder Farmer's Ditch.

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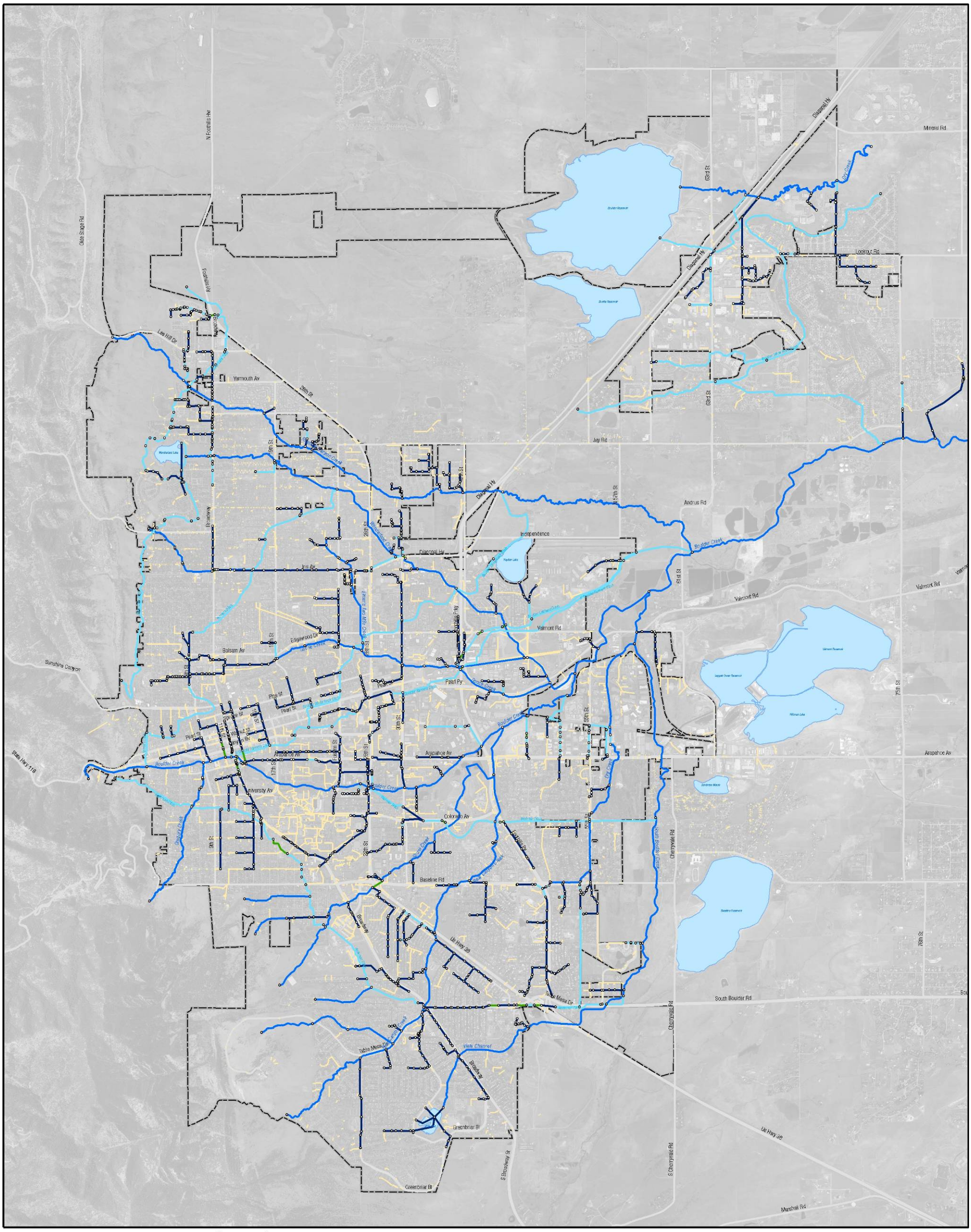


Legend

Modeled network

- Pipe
- Culvert
- Ditch
- Major drainageway

- Model nodes
- Local Storm Sewer (not modeled)
- Major Roads
- Lakes
- City Limits

0 4,000

1 inch equals 4,000 feet

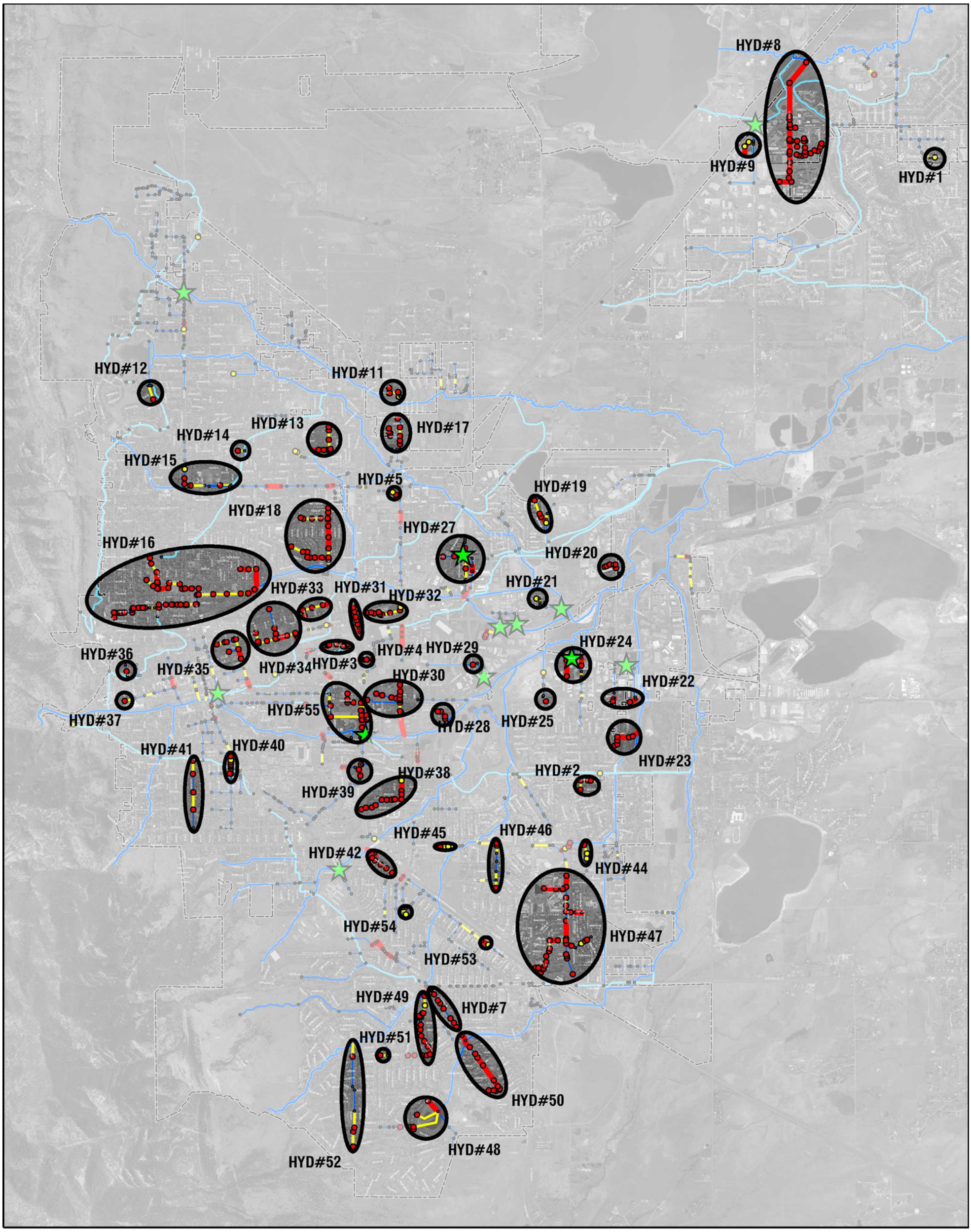
N

Hydraulic Model Network Map

Figure 4-1

HDR ONE COMPANY | *Many Solutions* SM

Stormwater Master Plan | City of Boulder



Legend

- Hydraulic Problem Areas
  - Flooded
  - Surcharged
  - OK
- Conveyance Capacity
  - Sufficient Capacity
  - Under Capacity
  - Severely Under Capacity
- Modeled network
  - Ditch
  - Major drainageway
  - Major Roads
- City Limits
- Lakes
- Water Quality Areas of Concern

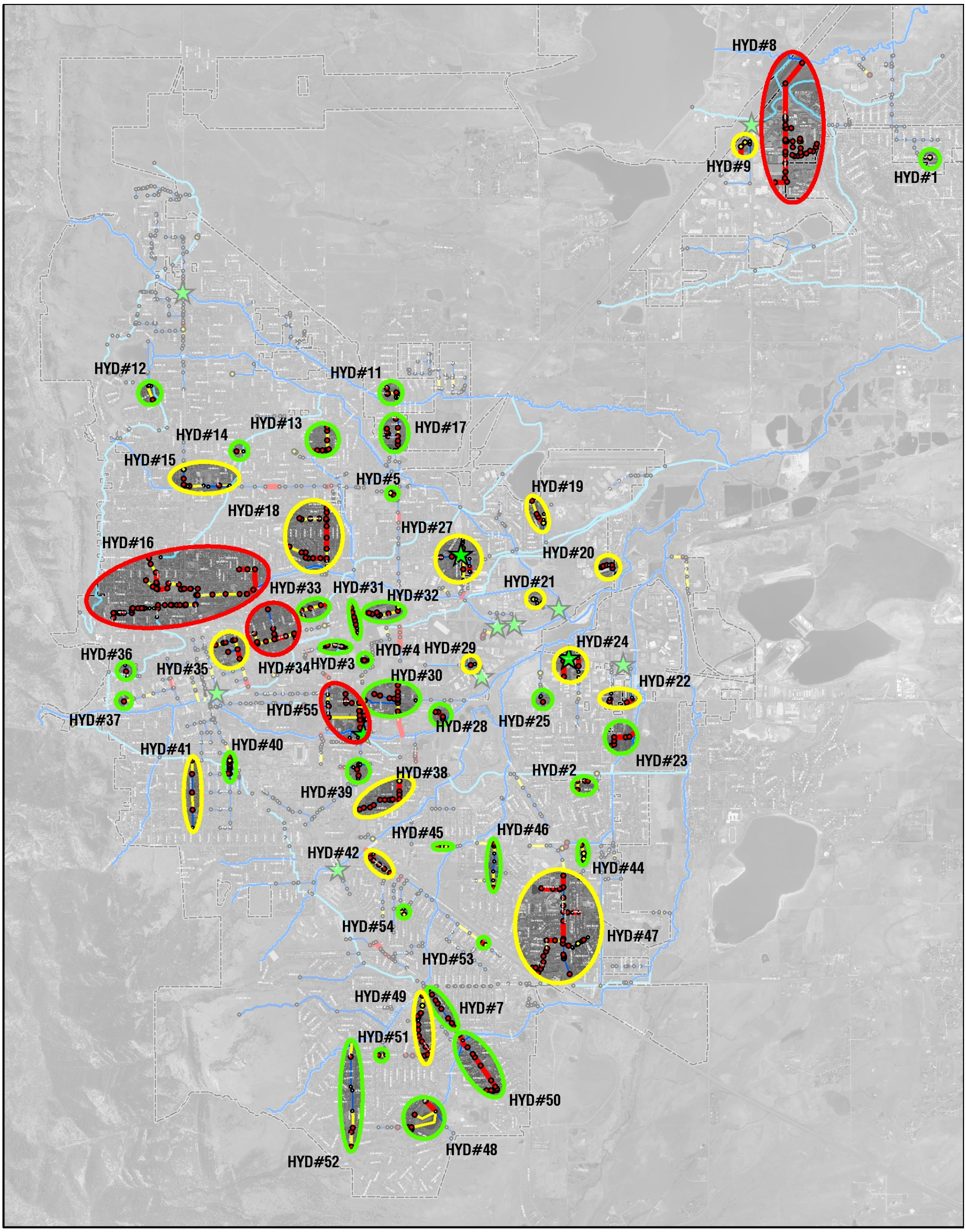
0 4,000
1 inch equals 3,500 feet

N

Collector System
Summary Map of Hydraulic Problem Areas

Figure 4-2

HDR
ONE COMPANY | *Many Solutions*℠



Legend

Hydraulic Problem Area

Tier 1 | Tier 2 | Tier 3

- Flooded
- Surcharged
- OK

Conveyance Capacity
- Sufficient Capacity
- Under Capacity
- Severely Under Capacity

Modeled network
- Ditch
- Major drainageway
- Major Roads

- City Limits
- Lakes
- Water Quality Areas of Concern

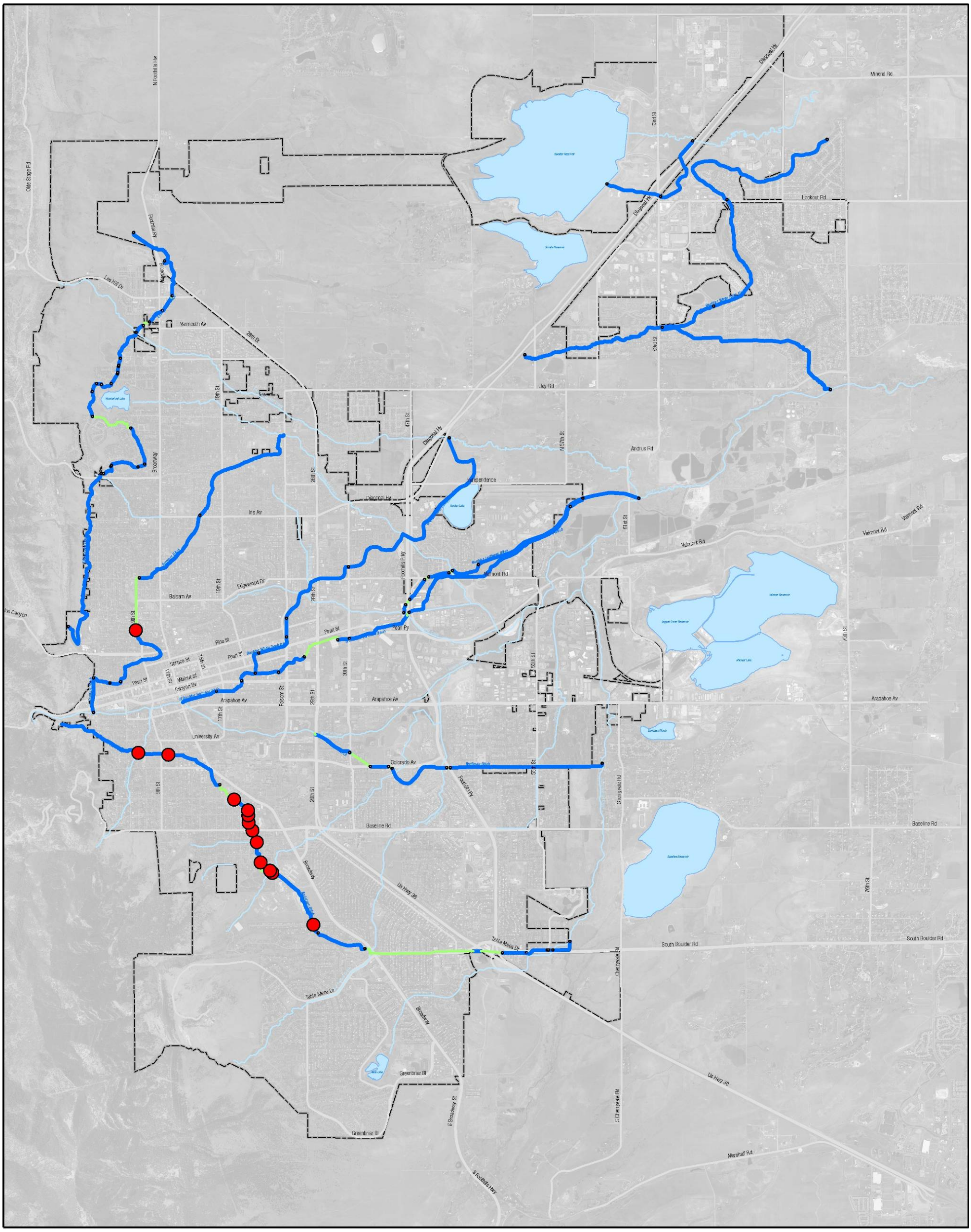
0 4,000
1 inch equals 3,500 feet

N

Collector System
Summary of Problem Area Ranking Results

Figure 4-3

HDR
ONE COMPANY | *Many Solutions* SM



Legend

Hydraulic Condition in Canal (2-yr)

- Sufficient Capacity
- Flooded

Conveyance Type

- Closed Conduit
- Open Channel

- Major Roads
- City Limits
- Lakes

0 4,000

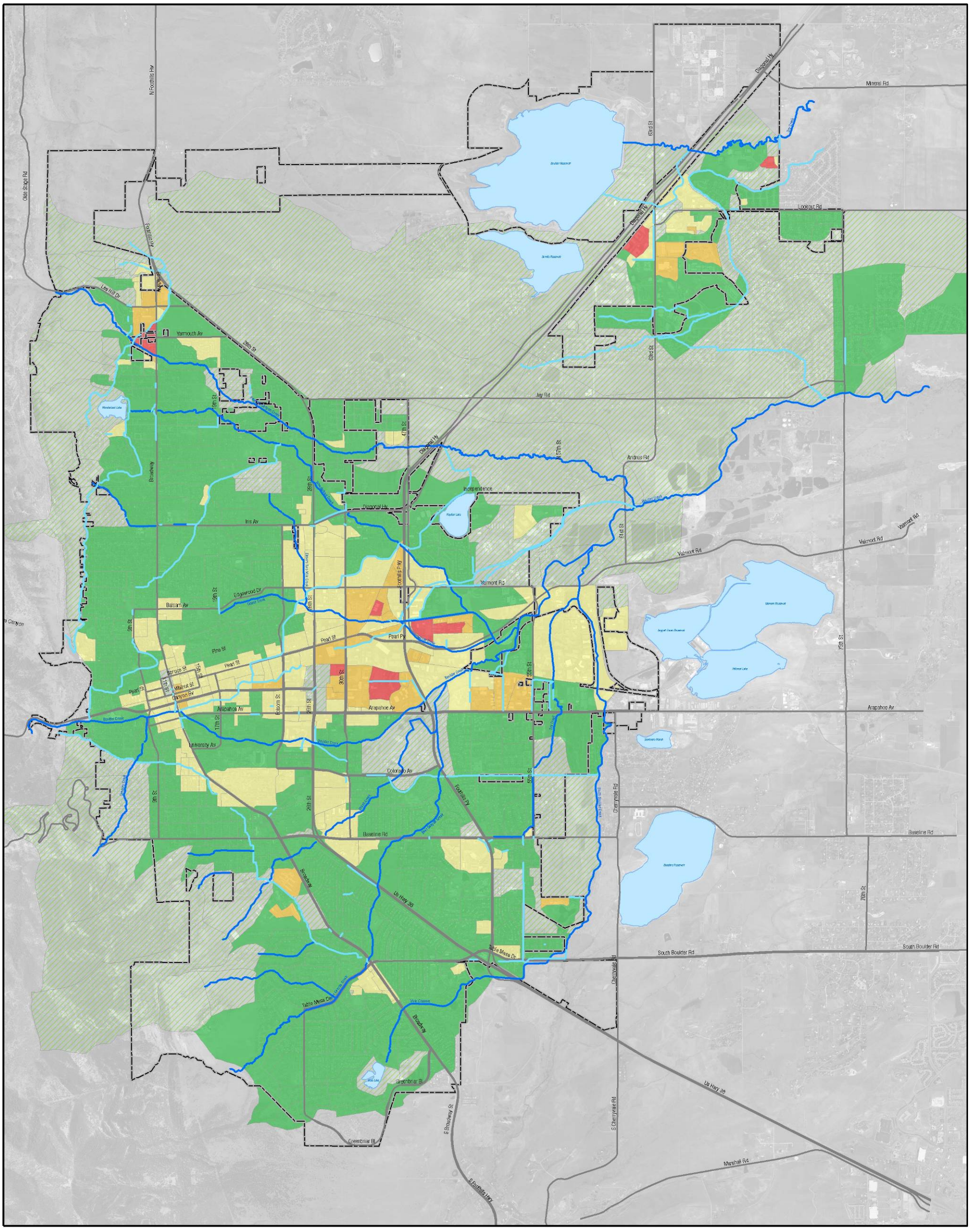
1 inch equals 4,000 feet

N

Summary of Ditch Problem Areas

Figure 4-4

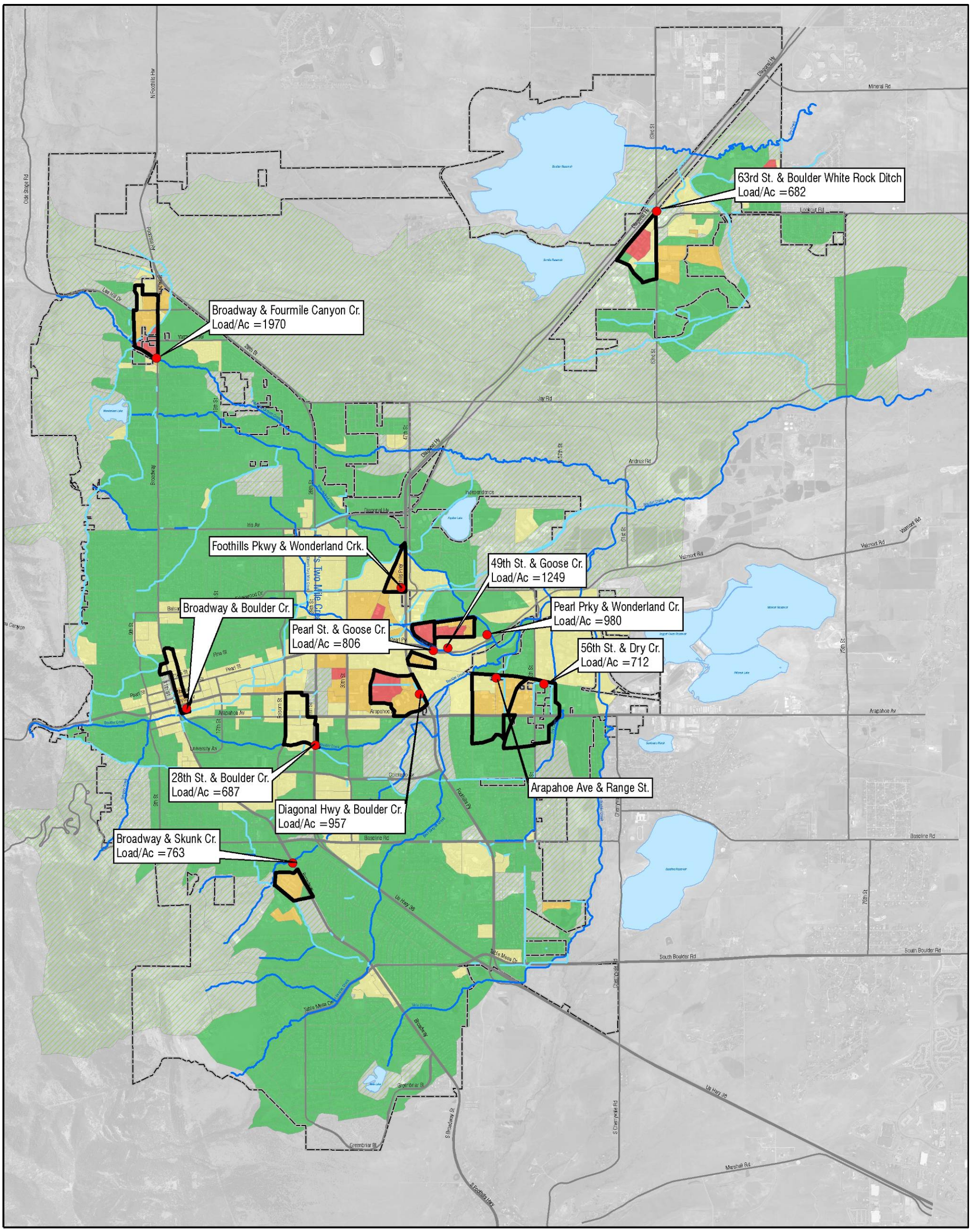
HDR ONE COMPANY | *Many Solutions* SM



Summary of Water Quality Areas of Concern (Catchments)

Figure 4-5

HDR
ONE COMPANY | *Many Solutions* SM



Legend

- Key Pollutant Load Outfalls
- Outfall Catchments
- Modeled network
- Canal/ Ditch
- Major drainageway

Load (Lbs TSS/Ac/Yr)

- 0 - 250
- 251 - 500
- 501 - 750
- 751 - 1000
- 1001 +

- Major Roads
- Lakes
- City Limits

0 4,000

1 inch equals 4,000 feet

N

Summary of Water Quality Areas of Concern (Outfalls)

Figure 4-6

HDR ONE COMPANY | *Many Solutions*℠

5 Local System Analysis and Results

A GIS-based desktop analysis was conducted to provide a more detailed understanding of the local system problem area characteristics. The analysis reviewed the existing storm sewer network, irrigation and open channel systems, topography via 2013 1-ft LiDAR contours, and aerial photography. For the Type A areas, city staff provided problem descriptions based on CRM database information. For the Type B problem areas, problem descriptions were based on 2013 flood observation data combined with a review of the storm sewer network and area topography. Based on this analysis, modeled subcatchments tributary to the Type A and Type B problem areas were refined to better represent the local drainage conditions. Figure 5-1 provides an overview of the Type A and Type B problem areas.

5.1 Type A Problem Area Characterization

Fact sheets are provided in this section summarize information regarding each local system problem area to facilitate development of improvement alternatives. These fact sheets are grouped together by drainage basin and include the following information:

- ***Problem Location***. Summarizes the location and extent of the problem with respect to city streets and other key landmarks.
- ***Problem Description***. Summarizes the type and extend of the drainage system problems as initially provided by city staff and expended upon through further investigations by HDR staff.
- ***Constraints***. Identifies issues that would affect implementation of improvements. Issues include storm sewer depth, major utility relocations, construction impacts to stakeholders, etc.
- ***Opportunities***. Identifies potential opportunities for developing improvement alternatives. The preferred alternative is shown in italics.
- ***Land Ownership.*** Summarizes existing land ownership and potential land acquisition required to resolve local system problems.

5.1.1 Wonderland Creek

Problem ID and Name	Wonderland Creek – 1
Problem Location	Broadway from Rosewood Avenue to Violet Avenue
Problem Description	Due to a lack of stormwater infrastructure along the east side of Broadway Street from Fourmile Creek to Violet Ave, and poor capture of stormwater by the existing storm sewer system north of Fourmile creek, runoff continues across Violet Ave and has the potential to flood properties on the south side of the street. Runoff also continues east along Violet and spills south along 13th Avenue. The contributing area to the identified problem area is approximately 2 acres.
Constraints	Capacity constraints were identified within the collector portion of the downstream system just south of the intersection of Violet Ave and Broadway Street within the previous 2007 SMP Update. The capacity required for the additional drainage area may not be available within downstream drainage system, potentially requiring additional system upgrades.
Opportunities	*Provide collection and conveyance infrastructure (inlets, manholes, and storm sewer) along the east side of Broadway and convey to the existing system along the west side of Broadway.* If the downstream system cannot receive the additional flow, the new collection and conveyance system could discharge to a detention system at the northwest corner of Broadway and Violet for control of runoff west of Broadway. Add inlets along the east side of Broadway, north of Fourmile Creek and connect into the existing storm sewer system along the west side of Broadway with discharge to Fourmile Creek. Note this option would reduction the identified drainage problem but may not be a sole solution as the drainage area below Fourmile Creek is contributor to the problem area.
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way. If detention is pursued, land acquisition will likely be required.

Problem ID and Name	Wonderland Creek – 2
Problem Location	Intersection of 19th Street and Sumac Avenue
Problem Description	During larger storm events, runoff from Sumac Ave flows across 19th Street and has the potential to flood properties that are below road grade on the east side of 19th Street. Currently, there is existing storm sewer on the north side of the intersection, but none provided on the south where the issue is predominantly observed. The contributing area to the identified problem area is approximately 70 acres.
Constraints	Information pertaining to the depth of existing storm sewer and roadside ditch system is not recorded in the available GIS data. Connection of proposed collection and conveyance features to the existing downstream system could be limited if the downstream system is discovered to be too shallow. Capacity of the existing system in 19th Street is unknown and may be limited by the driveway culverts and roadside ditch.
Opportunities	*Provide collection and conveyance infrastructure (inlets and conveyance pipe) at the southwest corner of intersection and extending west in Sumac Ave to collect and convey into the existing system along the west side of 19th Street. Depending on the capacity of the existing system along 19th Street, the capacity of the existing system may need to be increased to discharge into Wonderland Creek.* Provide a detention and water quality facility located at the southwest corner of Crestview Park, adjacent to Sumac Avenue that detains stormwater conveyed in Tamarac Avenue that appears to discharge currently into the park property.
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way. Proposed detention and water quality facility is located on Parks Department property.

5.1.2 Elmer's Twomile Creek

Problem ID and Name	Elmer's Twomile Creek – 1
Problem Location	Catalpa Way south of Clover Circle and Clover Circle cul-de-sac
Problem Description	Runoff flowing south along Catalpa Way, east from Clover Circle, flows south to the Catalpa Way dead-end. Catalpa Way south of Clover Circle does not have an existing storm system which causes potential flooding of the southern most homes on Catalpa Way. An irrigation lateral runs east-west along the south side of the parcels and it is presumed this small basin drained to that facility when the area was originally developed. The contributing area to the identified problem area is approximately 1 acre.
Constraints	The introduction of the additional drainage area could compromise the existing downstream conveyance system and require additional upgrades to the downstream system. Connection of the proposed collection and conveyance features to the existing downstream system could be limited if the downstream system is discovered to be too shallow.
Opportunities	*Provide collection and conveyance infrastructure (inlets and storm sewer) at the southern end of Catalpa Way and convey runoff via open channel to the existing system in 19th Street.* Collect runoff at the cul-de-sac low point and pipe to the irrigation lateral.
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way.

Problem ID and Name	Elmer's Twomile Creek – 2
Problem Location	Farmer's Ditch - Iris Avenue to Linden Avenue and Broadway Street to Cloverleaf Drive
Problem Description	Entire neighborhood bounded to the north, west, and south by Cloverleaf Drive, Broadway Street, and Kalmia Ave, respectively drains easterly to the Farmer's irrigation ditch. Specifically, runoff from the area described above is discharged to the ditch via four outfalls of 12, 18, 21, and 48-inches in diameter. The ditch system can become overwhelmed during heavy rains and cause potential overflows, causing flooding of downstream properties. The total contributing area is approximately 76 acres.
Constraints	Providing conveyance of flow from the existing discharge locations to the stormwater conveyance system to the east of the irrigation ditch would require the system to either be piped underneath the existing irrigation ditch via gravity flow or siphon. Some of the storm sewer outfall alignments are located on existing side lot lines. The existing storm sewer system downstream of Farmer's Ditch in 19th Street is relatively small (size range) and would likely require upsizing to accommodate additional flow. The closest major drainageway to accept additional flow is Elmer's Twomile Creek approximately 2,500 ft east of the Farmer's Ditch.
Opportunities	*Remove stormwater outfalls to the ditch. Construct new collection system in the problem area with a new storm sewer in Kalmia with outfall to Elmer's Twomile Creek.* Introduce a flow control weir within Farmers Ditch upstream of the existing outfalls for diversion of an equivalent amount of flow to the existing stormwater conveyance system within Iris Avenue, providing the necessary conveyance system capacity for inflows at the identified problem location. Limit discharge to Famer's Ditch. Provide additional collection and conveyance infrastructure (inlets, manholes, and conveyance pipe) within the upstream subbasin and convey flow south in 16th St to and connect to the existing storm sewer in Iris Ave. Control ditch capacity at the Boulder Creek headgate via automated system based on ditch flow depth/capacity and rainfall gages.
Land Ownership	This reach of the Farmer's Ditch is located along private property and is assumed to be contained within an easement.

5.1.3 Twomile Canyon Creek

Problem ID and Name	Twomile Canyon Creek – 1
Problem Location	Kalmia Avenue and Juniper Avenue west of Broadway Street
Problem Description	Kalmia Avenue and Juniper Avenue do not have curb and gutter and surface runoff collects in irrigation ditch laterals which parallel these roads. During heavy rains runoff can overwhelm the laterals if they are not operated properly to convey runoff rather than irrigation water.. The approximate contributing area to the identified Kalmia Ave and Juniper Ave problem areas are 30 and 21 acres, respectively.
Constraints	Any new storm water infrastructure would have to accommodate the continued operation and capacity of the existing irrigation ditch lateral.
Opportunities	*Provide increased overall system capacity through retrofitting the existing open channel conveyance network from Twomile Creek to Broadway Street along Kalmia Ave and Juniper Ave.* *Introduce sewer collection and conveyance (inlets and pipes) from Twomile Creek to Broadway Street along Kalmia Ave and Juniper Ave.*
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way.

5.1.4 Goose Creek

Problem ID and Name	Goose Creek – 1
Problem Location	Intersection of 8th Street and Dellwood Avenue
Problem Description	The existing local stormwater conveyance system is undersized and reported as reaching capacity during relatively minor storm events. The inadequacy of the system has lead to frequent roadway flooding, to the point that the crown of the road is inundated several inches. This intersection is a low point, creating an exacerbated flooding condition during storm events. The total contributing area to the problem area described above is approximately 32 acres.
Constraints	The existing system located within Dellwood Avenue is assumed to be shallow and could therefore create problems for potential extensions/connections of proposed collection and conveyance features. Capacity constraints were identified within the collector portion of the downstream system just south of the intersection of 8th Street and Dellwood Avenue within the previous 2007 SMP Update. The downstream system capacity will not be able to accommodate increased peak flows resulting from upstream conveyance improvements.
Opportunities	*Improve/provide a stormwater collection and conveyance system along Dellwood Avenue between 3rd to 8th Street, eventually connecting into the existing conveyance system at the intersection of 8th Street and Dellwood Avenue. Upsize existing system south of Dellwood Avenue through North Boulder Park to just south of Balsam Street..* Create detention and water quality facility in North Boulder Park to mitigate increased runoff peaks associated with improved upstream conveyance in Dellwood Ave.
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way. A detention/water quality facility at the downstream area would be located on Parks Department property.

Problem ID and Name	Goose Creek – 2
Problem Location	Alpine Avenue to Dellwood Ave and 3rd Street to 7th Street
Problem Description	Steep slopes and an inadequate existing storm sewer network cause high surface runoff flows, threatening pedestrians and residences at intersections where runoff is currently unmanaged. Many alleys contain low points, localized to the center of the block, and have been observed to collect runoff and spill it into adjacent residences. The total

	contributing area to the problem area described above is approximately 48 acres.
Constraints	Portions of the conveyance system within the extent of the problem area described above do not have elevation information attributed to conveyance features within available city GIS data. Therefore, these portions of the existing system (Balsam Avenue and Dellwood Avenue) are assumed to be shallow and could therefore create problems for potential connections of proposed collection and conveyance features. Capacity constraints were identified within the collector portion of the downstream system at North Boulder Park within the previous 2007 SMP Update. The downstream system capacity may not be available to accommodate increased peak flows resulting from upstream conveyance improvements and removal of existing inadvertent detention. Numerous existing utilities may affect the design and construction of a new storm sewer system in the developed neighborhood.
Opportunities	*Extend the existing stormwater collection and conveyance system along Balsam Avenue and Alpine Avenue west to 4th Street, connecting to the existing systems.* *Formalize the existing inadvertent detention that occurs in North Boulder Park and increase the volume to mitigate the increased runoff peaks created by improving the upstream storm sewer conveyance.*
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way.

Problem ID and Name	**Goose Creek – 3**
Problem Location	Dewey Avenue from 4th Street to 9th Street
Problem Description	The existing stormwater infrastructure along 4th Street from Maxwell Avenue to Dewey Avenue has been identified as insufficient through observations of runoff bypassing the inlets during high rainfall storm events. Additionally, a bottleneck in the storm sewer at 6th Street and North Street where the storm sewer transitions from 30” to 12” sewer has been identified, which creates a local roadway flooding condition as a result of back-ups within the system. The area of concern is also perceived to receive a significant portion of runoff from adjacent impervious areas, exacerbating the flooding condition. The total contributing area to the problem area described above is approximately 64 acres.
Constraints	Capacity constraints were identified within the collector portion of the downstream system at North Boulder Park within the previous 2007 SMP Update. The downstream system capacity may not be available to accommodate increased peak flows resulting from upstream conveyance improvements and removal of existing inadvertent detention. The drop in elevation required over the significant distance of new conveyance system required could potentially inhibit effective tie-in to the existing downstream system.
Opportunities	*Remove orifice plate in manhole in 6th Street just south of North Street. Provide additional stormwater infrastructure (inlets and conveyance pipe) from 6th Street to North Street then extending east in North Street to 9th Street. Connect to existing system at intersection of 9th Street and North Street. Existing system from 6th Street to 9th Street between North Street and Dewey Avenue to remain in service.* Introduce new stormwater collection and conveyance systems along Concord Avenue and Maxwell Avenue from 4th Street and connecting to the existing system in 9th Street. Separation of runoff tributary to these local areas would alleviate the stress currently experienced on the Dewey Ave system during significant storm events. Develop a detention facility west of 3rd Street at the T-intersection with Dewey Avenue.
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way. Detention would be located on private property requiring land acquisition.

5.1.5 Middle Boulder Creek

Problem ID and Name	Middle Boulder Creek – 1
Problem Location	Boulder High School - Grandview Avenue from 13th Street to 15th Street
Problem Description	Roadway runoff and an existing storm sewer discharge to the hillside to the south of the Boulder High School football field. The existing downstream open channel system to Boulder Creek has been determined to have insufficient conveyance capacity, creating a localized flooding condition during heavy rains, potentially flooding Boulder High School property. The total contributing area to the problem area described above is approximately 11 acres.
Constraints	Due to the small diameter conveyance pipe and anticipated shallow grades, the existing downstream system may not have the available capacity required if additional drainage area is directed toward that system. Increasing the existing storm sewer size would require construction adjacent to Colorado University (CU) classroom/office buildings. Terrain east of the football field, between Grandview and Boulder Creek, is steep making a proposed open channel system problematic.
Opportunities	*Construct an open channel system to intercept runoff with an alignment on the south side of the football field bleachers to the existing storm sewer outlet conveying runoff to Boulder Creek. Extend the storm sewer system from the existing outlet to Boulder Creek.*
Land Ownership	Review of the GIS parcel data revealed that the land required for the potential projects is comprised of both city right-of-way and private property. The existing storm sewer is shown to be on private property but assumed to be contained within an easement.

5.1.6 Bluebell Canyon Creek

Problem ID and Name	Bluebell Canyon Creek – 1
Problem Location	Intersection of 20th Street and Mariposa Avenue
Problem Description	The Anderson Ditch culvert under Mariposa Avenue is too tall, causing a crown perpendicular to the slope on the east side of the intersection. This crown impedes conveyance of gutter flow and surface runoff, creating a localized flooding condition within the intersection and adjoining properties. The total contributing area to the culvert is approximately 65 acres.
Constraints	Removal of the existing crown in the road/gutter profile would pass additional flow east, down Mariposa that would exceed current conditions. However, the steep roadway grade and downstream inlet system were adequate to convey 2013 flood flows.
Opportunities	*Construct a new storm sewer in 20th from Bluebell Ave north to Mariposa, then east in Mariposa connecting to the existing system in Broadway. Inlets would be located upstream of the Anderson Ditch intercepting flow before entering the ditch and sized such that intersection ponding would not create flooding.*
Land Ownership	This reach of Anderson Ditch is located on both city right-of-way and private property with private property areas assumed to be contained within an easement.

5.1.7 Dry Creek No. 2

Problem ID and Name	**Dry Creek No. 2 – 1**
Problem Location	Intersection of Chippewa Drive and Caddo Parkway east of Inca Parkway
Problem Description	Chippewa Drive and Caddo Parkway, east of Inca Parkway, are currently graded such that runoff is collected primarily along the north side of the roadway. During heavy rains the inlets on the north side of the roadway become overwhelmed, causing localized flooding of adjacent properties. The total contributing area to the problem area described above is approximately 15 acres.
Constraints	Capacity constraints were identified within the collector portion of the downstream system at Baseline Road in the 2007 SMP Update. Improvements within this local area may need to be connected with collector system improvements.
Opportunities	*Provide a new storm sewer system in Chippewa Drive and Caddo Parkway that drains to a new system Mohawk Drive that discharges to Thunderbird Lake. Combine this improvement with the Type B problem area improvement opportunity that also increases flows to the lake and improves water quality in the lake which has had issues with insufficient replenishment and stagnation.* Provide inlets and storm sewer in Chippewa Drive and Caddo Parkway to convey flow to the existing system in Inca Parkway.
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way.

Problem ID and Name	**Dry Creek No. 2 – 2**
Problem Location	Intersection of Erie Drive and Pinon Drive
Problem Description	The Pinon Drive roadway section currently acts as dam, impeding runoff from Erie Drive to be effectively conveyed to the existing downstream drainage system, and leading to a flooding condition at properties adjacent to the intersection. The total contributing area to the problem area described above is approximately 5 acres.
Constraints	A significant amount of stormwater infrastructure would be required (approximately 1,600 lineal feet of storm sewer) to provide connection into the existing downstream system. The drop in elevation required over the significant distance of new conveyance system could potentially inhibit effective tie-in to the existing downstream system. Capacity constraints were identified within the collector portion of the downstream system at Baseline Road in the 2007 SMP Update. Improvements within this local area may need to be connected with collector system improvements.
Opportunities	*Provide a storm sewer system in Pinon Drive west of Erie Drive to Meadowbrook and then north in Meadowbrook extending to the existing system in Baseline Road.* Provide a stormwater collection and conveyance system along Erie Drive from Chippewa to Pinon Drive and along Pinon Drive from Erie Drive to Inca Parkway, connecting into the existing conveyance system within Inca Parkway. Provide a storm sewer system in Erie Drive from Chippewa to Pinion, then extending north of Pinon across the existing parking lot and across Baseline Road with discharge to Bear Canyon Creek.
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way with the exception of a system extending north at Erie Drive/Pinon Drive intersection which would require land acquisition. Infiltration facilities would likely require additional land acquisition.

Problem ID and Name	Dry Creek No. 2 – 3
Problem Location	Baseline and 55th Street from Foothills Hwy to Arapahoe Avenue
Problem Description	Several sections of the existing open channel system on the north side of Baseline Road and Dry Creek Ditch #2 along 55th St north of Baseline are capacity limited and can cause stormwater to back up into the upstream conveyance and detention facilities. The total contributing area to the problem area described above is approximately 314 acres. The 2007 SMP identified the existing storm sewer systems are under capacity in Manhattan, under Foothills Parkway, near Broadway, and south along Foothills Parkway.
Constraints	Capacity constraints were identified within the collector portion of the downstream system at Baseline Road in the 2007 SMP Update. The capacity required for the potential additional drainage areas discussed in other problem areas may not be available within downstream drainage system, potentially requiring additional system upgrades.
Opportunities	*Construct new storm sewer in Baseline from Brooklawn Drive to 55th Street and within 55th Street from Baseline to approximately 300 feet north of Pennsylvania Avenue with a new outfall to Wellman Ditch.* Increase the capacity of the open channel conveyance system on the north side of Baseline Road between Brooklawn Drive and Dry Creek No. 2 and portion of Dry Creek No. 2 along 55th Street north of Baseline.
Land Ownership	This portion of the open channel conveyance system and Dry Creek No. 2 reach is located on both city right-of-way and private property. The portion of the problem area located on private property is assumed to be contained within an easement.

5.1.8 Bear Canyon Creek

Problem ID and Name	Bear Canyon Creek – 1
Problem Location	Bear Canyon Creek, downstream of Stony Hill Court crossing, located approximately 250 feet east of the intersection of Stony Hill Drive and Rockmont Circle.
Problem Description	A 48-inch diameter storm sewer culvert under Stony Hill Drive providing conveyance for a tributary ofBear Canyon Creek was not built as specified on the original design plans. Specifically, the outlet is aligned directly at residences located along the right bank instead of down the creek main channel. During significant storms events, flow from the outlet has to the potential to overshoot the creek and flood adjacent properties. In addition to the misalignment of the culvert, creek excavation may not have been done according to the original design, further exacerbating the flooding condition. Potentially, six properties may flood during heavy rainfall. The total contributing area to the culvert is approximately at 104 acres.
Constraints	The culvert and channel are located in a designated wetland and high quality natural area. Environmental impacts need to be addressed, avoided or mitigated with additional permitting requirements.
Opportunities	*Maintain existing culvert alignment and introduce a structure at the location of the originally designed center of the downstream channel and provide 42-inch-diameter conveyance pipe oriented with a properly determined alignment. This option would also require realignment of the downstream channel and sufficient downstream channel protection.*
Land Ownership	The problem area is located on private property in an open space subdivision tract owned by the Devil's Thumb Homeowner's Association.

5.1.9 Viele Channel

Problem ID and Name	Viele Channel – 1
Problem Location	Longwood Ave and Lafayette Drive from Lehigh Street to Greenbriar Boulevard
Problem Description	Runoff from the local roadway and residential parcels is currently conveyed easterly towards Greenbriar Boulevard via roadway section along Lafayaette Drive and Longwood Avenue. The roadway section contains no stormwater infrastructure and has been identified as having insufficient capacity to convey runoff through frequent observations of flooding of local sidewalks. The problem is exacerbated by the pitch and crown of the roads which causes almost all runoff to flow on the north side of Longwood Ave. The total contributing area to the system described above is approximately 21 acres.
Constraints	Capacity constraints were identified within the collector portion of the downstream system near Viele Lake in the 2007 SMP Update. Impacts on the downstream drainage system will need to be evaluated to ensure capacity is available.
Opportunities	*Provide a stormwater collection and conveyance system in Lafayette Drive 160 feet north of Longwood Avenue and eastward along Longwood Avenue from Lafayette Drive to Greenbriar Boulevard to alleviate local flooding through effective conveyance of runoff to the existing downstream system.*
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way with the exception of the existing storm sewer that cut across the high school parking lot. The parking lot alignment is assumed to be contained within an easement.

5.2 Type B Problem Characterization

Similar to the Type A problem areas, Type B problem areas utilize fact sheets to summarize the analysis of problem area characterization and facilitate development of alternatives for improvements. The information provided within the Type B problem area fact sheets are listed and described below:

- ***Problem Location.*** Summarizes the location and extent of the problem with respect to city streets and other key landmarks.
- ***Underserved Area.*** Identifies if the problem area has a current widespread lack of existing stormwater infrastructure. An area which has existing stormwater system that may be under-sized due to development or introduction of other additional stormwater flows is not considered an underserved area.
- ***2013 Flood Reports.*** Describes the nature of the flooding issues experienced during the 2013 storm event, including types of damages and range of flooding depths.
- ***2013 Flood Report Area with 2007 SMP Improvement.*** Identifies problem areas containing both observations of flooding during the 2013 event and locations of 2007 SMP recommended stormwater infrastructure improvements.
- ***Problem Description.*** Summarizes the potential source/cause of the drainage problem based on a review of the base GIS data and 2013 flood reports.
- ***Opportunities.*** Identifies potential opportunities for developing improvement alternatives. The preferred alternative is shown in italics.
- **Irrigation Ditch Storm Flow Reduction**. Summarizes the potential for removing stormwater entering the existing ditch system through local system improvements within the local problem area.

Following the Type B problem area analysis and fact sheet summaries, a site visit was performed by city and HDR staff to validate the identified problem areas and assess potential solutions. This site visit resulted in several Type B problem areas being removed from further consideration where the actual street, storm sewer and drainage ditch conveyance system characteristics did not provide evidence of drainage problems. These problem areas were included in the following tables to provide a record that they were investigated but are identified by a "Field Observation Overrides" statement to indicate that further analysis was not deemed necessary at this time.

5.2.1 Fourmile Canyon Creek

Problem Name and ID	**Fourmile Canyon Creek – 1 (FCC-1)**
Problem Location	Vicinity of Jay Road and 26th Street.
Underserved Areas	Yes, considering the 43 +/- acres of tributary area. The existing drainage system is limited, mainly consisting of roadside ditches and driveway culverts.
2013 Flood Reports	Yes, one instance of shallow localized flooding during the 2013 event was reported. The reported flood depth was estimated at about 1 inch with reported damages mainly to house features such as drywall and carpet.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	Limited drainage infrastructure, combined with the potentially capacity-limited roadside ditch and culvert system, was presumed to contribute to 2013 flooding reports.
Opportunities	*Provide a stormwater collection and closed conveyance system along 26th Street from Jay Rd to approximately 300 feet south of Topaz Drive, discharging to the Fourmile Canyon Creek Drainageway.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.

5.2.2 Wonderland Creek

Problem Name and ID	**Wonderland Creek – 3 (WC-3)**
Problem Location	Boulder Open Space to the northeast of the cul-de-sac located at the eastern extent of Utica Avenue.
Underserved Areas	No, the subbasin has an existing drainage system of surface conveyance and storm sewers which appear to be adequate for the subbasin and land use. The problem appears to be caused by an isolated area of run-on from an adjacent parcel and not a basin-wide lack of drainage infrastructure.
2013 Flood Reports	Yes, three instances of shallow localized flooding during the 2013 event were reported. Reported flood depths were estimated at about 2 feet with reported damages mainly to house features such as drywall, carpet, and paint.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	During the 2013 flood, runoff from Boulder Open Space appears to have travelled across the private properties and inundated homes.
Opportunities	*Provide open channel conveyance to the west of the residences where flooding during the 2013 event was observed to collect surface runoff from hillside. Route flows northeasterly, eventually connecting to the existing system located approximately 100 feet northwest of the intersection of 6th Street and Locust Avenue.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed. Storm flow does not enter the Silver Lake Ditch.

Problem Name and ID	**Wonderland Creek – 4 (WC-4)**

Problem Location	Promontory Court and Poplar Avenue.
Underserved Areas	No, the subbasin is served by an existing drainage system, however, it appears to be undersized and catch basins are not located in low-lying areas. The problem also appears to be caused by an isolated area of run-on from an adjacent parcel and not a basin-wide lack of drainage infrastructure.
2013 Flood Reports	Yes, four instances of shallow localized flooding during the 2013 event were reported within the problem area. Reported flood depths were estimated from 4 inches to 3 feet with reported damages mainly to house features such as drywall, carpet, and insulation.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	During the 2013 flood, runoff from Boulder Open Space appears to have travelled across the private properties and inundated homes. The northern cul-de-sac also does not appear to have adequate drainage to convey runoff from the originating from the southern portion of Promontory Ct causing street and property flooding. Current inlets are also not located in low-lying areas.
Opportunities	*Provide open channel conveyance to the west of the residences where flooding during the 2013 event was observed to collect surface runoff from hillside. Route flows northeasterly to Silver Lake Ditch.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed. Storm flow does not enter the Silver Lake Ditch.

Problem Name and ID	**Wonderland Creek – 5 (WC-5) Field Observation Override**
Problem Location	Vicinity of 19th Street and Quince Avenue.
Underserved Areas	No, area is served by roadside ditches which appear adequate for the subbasin and land use..
2013 Flood Reports	Yes, two instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 4 inches to 1.5 feet with damages mainly to house features such as walls and carpet. Groundwater issues were reported at one location as well.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	Problem appears to be due to lack of maintenance of ditches on private property.
Opportunities	*Provide a stormwater collection and closed conveyance system along Quince Avenue from 17th Street to 19th Street and along 19th Street from Quince Avenue to approximately 150 feet north of Redwood Avenue, eventually discharging to the Wonderland Creek Drainageway.* Retrofit existing open channel conveyance features along the south wide of Quince Avenue from 17th Street to 19th Street and along 19th Street from Quince Avenue to approximately 150 feet north of Redwood Avenue, eventually discharging to the Wonderland Creek Drainageway.
Irrigation Ditch Storm Flow Reduction	No opportunities observed.
Field Observation Override	Site visit identified the drainage issue as a maintenance issue of drainage features on private property and not a utilities conveyance issue.

Problem Name and ID	**Wonderland Creek – 6 (WC-6)**

Problem Location	Vicinity of Poplar Avenue and 20th Street.
Underserved Areas	Yes, considering the 30 +/- acres of tributary area. The existing drainage system is limited, mainly consisting of roadside ditches and driveway culverts that may be inadequate for the subbasin and land use.
2013 Flood Reports	Yes, one instance of shallow localized flooding during the 2013 event was reported within the problem area. Based on the available flood survey data, observed flood depths were estimated at 4 inches with reported damages mainly to house features such as drywall and carpet.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	Limited drainage infrastructure, combined with the potentially capacity-limited roadside ditch and culvert system, was presumed to contribute to 2013 flooding reports.
Opportunities	*Provide a stormwater collection and closed conveyance system along 20th Street from Orchard Avenue to approximately 170 feet north of Poplar Avenue, eventually discharging to the Wonderland Creek Drainageway.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.

Problem Name and ID	**Wonderland Creek – 7 (WC-7)**
Problem Location	Vicinity of Oak Avenue and 21st Street.
Underserved Areas	Yes, considering the 53 +/- acres of tributary area. The existing drainage system is limited, mainly consisting of roadside ditches and driveway culverts that may be inadequate for the subbasin and land use.
2013 Flood Reports	Yes, two instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 3 to 6 inches with damages mainly to house features such as walls, drywall, and carpet.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	Limited drainage infrastructure, combined with the potentially capacity-limited roadside ditch and culvert system, was presumed to contribute to 2013 flooding reports. Roadway flooding of Norwood Ave has also been observed by city staff during other heavy rainfalls.
Opportunities	*Provide a stormwater collection and closed conveyance system along Oak Avenue from Oak Place to 21st Street and along Norwood Avenue from 21st Street to 26th Street, eventually discharging to the Wonderland Creek Drainageway.*
Irrigation Ditch Storm Flow Reduction	Yes, stormwater discharge to the Farmer's Ditch can be reduced through implementation of the proposed conveyance system discussed above.

Problem Name and ID	**Wonderland Creek – 8 (WC-8)** **Field Observation Override**

Problem Location	Vicinity of Wright Avenue and Franklin Drive.
Underserved Areas	No, the subbasin has an existing drainage system of surface conveyance and storm sewers which appear to be adequate for the subbasin and land use.
2013 Flood Reports	Yes, five instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 1 inch to 1 foot with damages mainly to house features such as walls, drywall, carpet, and flooring.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	The problem may be attributable to irrigation ditch overtopping.
Opportunities	*Provide a stormwater collection and closed conveyance system along Franklin Drive from Tesla Court to Wright Avenue and upgrade current system along Franklin Drive from Wright Avenue to approximately 200 feet south of Noble Court, eventually discharging to the Wonderland Creek Drainageway. Additionally, provide collection and closed conveyance along Noble Court and Wright Avenue from Franklin Drive to the proposed system discussed above within Franklin Drive.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.
Field Observation Override	Field observations and review of 2013 Flood data indicate this is a potential irrigation ditch capacity/overtopping issue and not a local drainage system conveyance issue.

5.2.3 Goose Creek

Problem Name and ID	**Goose Creek – 4 (GC-4)**
Problem Location	Vicinity of Forest Avenue between 3rd Street and Broadway Street
Underserved Areas	Yes, considering the 98 +/- acres of tributary area. The existing drainage system is limited, mainly consisting of curb and gutter, roadside ditches and driveway culverts.
2013 Flood Reports	Yes, ten instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 1 inch to 5 feet with damages mainly to house features such as walls, drywall, carpet, and flooring. Additionally, damage to electrical systems, water heaters, and landscaping was reported.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	Limited drainage infrastructure, yielding relatively no removal of surface waters from the roadway was presumed to contribute to 2013 flooding reports.
Opportunities	*Construct a new storm sewer system in Forest Avenue from 4th Street to Broadway Street and Hawthorn Avenue, from 4th Street and connecting to the proposed system in Forest Avenue, eventually discharging to the existing system in Broadway Street.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.

Problem Name and ID	**Goose Creek – 5 (GC-5)**

Problem Location	Vicinity of Cedar Avenue and 19th Street
Underserved Areas	No, the subbasin is served by an existing drainage system, however, it may be inadequate for the subbasin and land use.
2013 Flood Reports	Yes, nine instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 2 inches to 2 feet with damages mainly to house features such as walls, drywall, carpet, and flooring.
2013 Flood Report Area with SMP Improvement	Yes, the problem area is located within the vicinity of a 2007 SMP project recommendation.
Problem Description	2013 flooding reports exceeded the level of service of the drainage system along local collector streets.
Opportunities	*Per the recommendations provided in the 2007 SMP, construct a new storm sewer system in Elder Avenue from Broadway Street to 19th Street and along Floral Drive from 19th Street to approximately 300 feet south of Edgewood Drive, eventually discharging to the Goose Creek Drainageway.* Also per the 2007 SMP, upgrade the existing storm sewer system along Cedar Avenue and 19th Street between 17th Street and 19th Street and Cedar Avenue and Balsam Street, respectively.
Irrigation Ditch Storm Flow Reduction	No opportunities observed.

Problem Name and ID	**Goose Creek – 6 (GC-6)**
Problem Location	Vicinity of Cedar Avenue and 19th Street
Underserved Areas	Yes, considering the 55 +/- acres of tributary area. The existing drainage system is limited, mainly consisting of curb and gutter and minimal closed conveyance.
2013 Flood Reports	Yes, four instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 2 inches to 5 feet with damages mainly to house features such as walls, drywall, carpet, and flooring.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	Limited drainage infrastructure along local collector streets, combined with the potentially capacity-limited downstream conveyance system, was presumed to contribute to 2013 flooding reports. Overland spill from Twomile Canyon Creek also contributed to flooding of this problem location.
Opportunities	*Extend existing storm sewer system in Glenwood Drive west along Grape Avenue and Hawthorn Avenue to Hawthorn Place. Additionally, provide local collection and conveyance along Hawthorn Place and Garland Lane with connections to the proposed system mentioned above. Improve existing system in Glenwood Drive from 20th Street to 23rd Street. Addressing overland spill of Twomile Canyon Creek may eliminate need for or reduce extent of these improvements.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.

Problem Name and ID	**Goose Creek – 7 (GC-7)**

Problem Location	Vicinity of Glenwood Drive and Folsom Street.
Underserved Areas	No, the subbasin is served by an existing drainage system, however, it may be inadequate for the subbasin and land use.
2013 Flood Reports	Yes, two instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 4 inches to 3 feet with damages mainly to house features such as walls, drywall, carpet, and flooring. Additionally damage to furnaces and water heaters were reported.
2013 Flood Report Area with SMP Improvement	Yes, the problem area is located within the vicinity of a 2007 SMP project recommendation.
Problem Description	2013 flooding was reported to exceed the level of service of the drainage system along local collector streets which may have been exacerbated by the potentially capacity-limited downstream conveyance system.
Opportunities	*Per the recommendations provided in the 2007 SMP, upgrade the existing storm sewer system along Glenwood Drive and Folsom Street between 23rd Street and Folsom Street and Hawthorn Avenue and Glenwood Drive, respectively. Additionally, the plan also called for construction of a new storm sewer along Glenwood Drive between Folsom Street and Westwood Court. This alternative would route a portion of the flow within the Folsom Street system east to Elmer's Two Mile Creek, alleviating the pressure experienced in the existing Folsom Street system.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.

Problem Name and ID	**Goose Creek – 8 (GC-8)**
Problem Location	Vicinity of 22nd Street between Forest Avenue and Valmont Road.
Underserved Areas	Yes, considering the 65 +/- acres of tributary area. The existing drainage system is limited, mainly consisting of curb and gutter and minimal closed conveyance.
2013 Flood Reports	Yes, six instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 3 inches to 1.5 feet with damages mainly to house features such as walls, drywall, carpet, and flooring. Additionally, damage to furnaces and water heaters was reported.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	Limited drainage infrastructure along local collector streets, combined with the potentially capacity-limited downstream conveyance system, was presumed to contribute to 2013 flooding reports.
Opportunities	*Provide new collection and conveyance system in Fremont Street, connecting to the existing Folsom Street system. Additionally, provide new collection and conveyance within 23th Street and 24th Street, extending to the existing system in Edgewood Drive.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.

5.2.4

5.2.5 Middle Boulder Creek

Problem Name and ID	Middle Boulder Creek – 2 (MBC-2)
Problem Location	Vicinity of Spruce Street and Pearl Street near 18th Street.
Underserved Areas	No, the subbasin is served by an existing drainage system, however, it may be inadequate for the subbasin and land use.
2013 Flood Reports	Yes, four instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 9 inches to 2.5 feet with damages mainly to house features such as walls, drywall, carpet, and flooring. Additionally damage to furnaces and water heaters were reported.
2013 Flood Report Area with SMP Improvement	Yes, the problem area is located within the vicinity of a 2007 SMP project recommendation.
Problem Description	2013 flooding was reported to exceed the level of service of the drainage system along local collector streets which may have been exacerbated by the potentially capacity-limited downstream conveyance system.
Opportunities	*Improve existing storm sewer in 18th Street from Pine Street to Spruce Street, in 20th Street from Spruce Street north halfway to Pine Street, and in Spruce Street from 18th Street to the manhole east of 21st Street.* *Introduce new storm sewer system along Pearl Street from 18th Street to 21st Street, conveying flows easterly into the Boulder White Rock Ditch.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.

Problem Name and ID	Middle Boulder Creek – 3 (MBC-3)
Problem Location	Vicinity of Cascade Avenue from College Avenue to Chautauqua Reservoir Road.
Underserved Areas	No, the subbasin is served by an existing drainage system, however, it may be inadequate for the subbasin and land use.
2013 Flood Reports	Yes, fifteen instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 1 inch to 1.5 feet with damages mainly to house features such as walls, drywall, carpet, and flooring.
2013 Flood Report Area with SMP Improvement	Yes, the problem area is located within the vicinity of a 2007 SMP project recommendation.
Problem Description	2013 flooding reports exceeded the level of service of the drainage system along local collector streets and combined with the potentially capacity-limited downstream conveyance system.
Opportunities	*Construct new collection and conveyance system along Baseline Road from Grant Place to 13th Street and along 13th Street between Baseline Road and Cascade Avenue, eventually discharging to the existing system within 13th Street.* Per the recommendations provided in the 2007 SMP, upgrade existing storm sewer system along Lincoln Place between Aurora Avenue and Euclid Avenue.
Irrigation Ditch Storm Flow Reduction	No opportunities observed.

5.2.6 Bear Canyon Creek

Problem Name and ID	Bear Canyon Creek – 2 (BCC-2) Field Observation Override
Problem Location	Vicinity of Mohawk Drive from Pitkin Drive to Talbot Drive
Underserved Areas	No, the existing drainage system appears adequate for the subbasin and land use.
2013 Flood Reports	Yes, three instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 3 inches to 3 feet with damages mainly to house features such as walls, drywall, carpet, and flooring.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	Bear Canyon Creek may have spilled south of Baseline and contributed to flood report problems.
Opportunities	*Improve existing collection and conveyance system in Mohawk Drive and extend further south. Construct laterals in Inca Parkway and Talbot Drive. Improvement in Inca Parkway will route runoff to discharge in Bear Canyon Creek downstream of problem area.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.
Field Observation Override	Field observations noted adequate street grade to convey flow to existing storm sewer system and houses are well above street grade. In the 2013 Flood, the Bear Canyon Creek major drainageway may have spilled and contributed to the local flooding reports. Considered an isolated incident during a historic event.

Problem Name and ID	Bear Canyon Creek – 3 (BCC-3)
Problem Location	Vicinity of Kohler Drive from south of Dartmouth Avenue
Underserved Areas	Yes, considering the steep grades and 36 +/- acres of tributary area. The existing drainage system is limited, mainly consisting of curb and gutter, shallow open channels and minimal closed conveyance.
2013 Flood Reports	Yes, two instances of localized flooding during the 2013 event were reported uphill of Anderson Ditch and four instances downhill. Based on the available flood survey data, reported flood depths of only a few inches were estimated uphill of Anderson Ditch, however downhill of the ditch, depths up to 6 feet were reported. Damages mainly to house features such as walls, drywall, carpet, and flooring as well as furniture.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	Steep terrain drains to sump condition in Kohler Drive with stormwater discharging to Anderson Ditch. Closed conveyance is inadequate and overflow path runs to properties downhill in Dover Drive.
Opportunities	*Improve existing collection and conveyance system in sump condition of Kohler Drive. Route to Dartmouth Avenue and connect to system in Broadway Street. Improvements in Kohler will alleviate downhill flooding in Dover.* *Additionally, upsize portions of the existing system where throttling occurs due to reduced pipe diameters.*
Irrigation Ditch Storm Flow Reduction	Yes, improvements will remove stormwater from Anderson Ditch.

Problem Name and ID	Bear Canyon Creek – 4 (BCC-4)
Problem Location	Vicinity of Yale Road and Hartford Drive
Underserved Areas	Yes, entire 27 +/- acres of the subbasin are routed to series of only six inlets at the intersection of Baylor Drive and Yale Road.
2013 Flood Reports	Yes, four instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 1/2 to 12 inches with damages mainly to house features such as walls, drywall, carpet, and flooring.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	Potential flooding from surface run-off.
Opportunities	*Construct collection and conveyance system in Hartford Drive and Baylor Drive to reduce volume of surface flow through the neighborhood to existing collection point.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.

Problem Name and ID	Bear Canyon Creek – 5 (BCC-5)
Problem Location	Vicinity of Wildwood Road
Underserved Areas	No, the existing drainage system appears adequate for the subbasin and land use, however, localized hydraulic issues at the downstream end of the system may be causing the problem.
2013 Flood Reports	Yes, five instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 1/2 to 6 inches with damages mainly to house features such as walls, drywall, carpet, and flooring.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	Runoff to Wildwood Drive sump/sag locations may exceed storm sewer capacity and major storm overflow paths.
Opportunities	*Install and/or improve discharge locations to Bear Canyon Creek.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.

5.2.7 Dry Creek No. 2

Problem Name and ID	Dry Creek No. 2 – 4 (DC2-4)
Problem Location	Vicinity of Mohawk Drive and Sioux Drive north of US-36
Underserved Areas	Yes, no local collection and conveyance system exists. On-street drainage appears to be only method of conveyance to Thunderbird Lake/existing system in Thunderbird Drive.
2013 Flood Reports	Yes, five instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 2 to 6 inches with damages mainly to house features such as walls, drywall, carpet, and flooring.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	Collection and conveyance system appears to be undersized in Type A problem areas downhill of subbasin
Opportunities	*Improvements proposed in Dry Creek No.2-1 may alleviate or address flood report issues. Provide local collection and conveyance system in Pawnee Drive discharging into existing Thunderbird Lake.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.

Problem Name and ID	Dry Creek No. 2 – 5 (DC2-5)
Problem Location	Vicinity of Eisenhower Drive and 48th Street south of Arapahoe Avenue
Underserved Areas	Yes, no local collection and conveyance system exists for 56 +/- acre subbasin.
2013 Flood Reports	Yes, seven instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 1 to 4 inches and one case of 2 feet with damages mainly to house features such as walls, drywall, carpet, and flooring.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	Large subbasin with no collection and conveyance system. Overflow of Wellman Ditch to the south may have added to the flooding.
Opportunities	*Construct collection and conveyance system in McKinley Drive, Eisenhower Drive and 48th Street and extend laterals into cross streets.* *Additionally construct collection and conveyance system in Harrison Avenue. Connect to existing system discharging to Bear Canyon Creek.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.

Problem Name and ID	Dry Creek No. 2 – 6 (DC2-6)
Problem Location	Vicinity of Merritt Drive south of Arapahoe Avenue
Underserved Areas	Yes, no local collection and conveyance system exists for 20 +/- acre subbasin.
2013 Flood Reports	Yes, two instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 1 to 4 inches with damages mainly to house features such as walls, drywall, carpet, and flooring.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	Large subbasin with no collection and conveyance system. Overflow of Wellman Ditch to the south may have added to the flooding.
Opportunities	*Construct collection and conveyance system in Merritt Drive with collection from Arapahoe Ridge Park. Extend laterals into cross streets. Connect to existing system north of Patton Drive.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.

Problem Name and ID	Dry Creek No. 2 – 7 (DC2-7)
Problem Location	Vicinity of Lodge Lane and 55th Street south of Arapahoe Avenue
Underserved Areas	No, the subbasin is served by an existing drainage system, however, it may be inadequate for the subbasin and land use.
2013 Flood Reports	Yes, seven instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 1 to 21 inches with damages mainly to house features such as walls, drywall, carpet, and flooring as well as personal property and furniture.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	Existing collection and conveyance system assumed to be undersized to handle the level of service required for the 2013 flooding.
Opportunities	*Improve existing collection and conveyance system to address capacity issues.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.

Problem Name and ID	Dry Creek No. 2 – 8 (DC2-8)
Problem Location	Vicinity of White Place and 55th Street south of Arapahoe Avenue
Underserved Areas	No, the subbasin is served by an existing drainage system, however, it may be inadequate for the subbasin and land use.
2013 Flood Reports	Yes, four instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 2 to 24 inches with damages mainly to house features such as walls, drywall, carpet, and flooring as well as personal property and furniture.
2013 Flood Report Area with SMP Improvement	Yes, 2007 SMP improvement at the downstream end of the problem.
Problem Description	Existing collection and conveyance system assumed to be undersized to handle the level of service required for the 2013 flooding.
Opportunities	*Construct new collection and conveyance system in Holmes Place and White Place. Connect to existing system in 55th Street.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.

5.2.8 Viele Channel

Problem Name and ID	Viele Channel – 2 (VC-2) Field Observation Override
Problem Location	Vicinity of Lehigh Street from Galena Way to Hardscrabble Drive
Underserved Areas	No, the existing drainage system appears adequate for the subbasin and land use.
2013 Flood Reports	Yes, four instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 1 to 8 inches with damages mainly to house features such as walls, drywall, carpet, and flooring.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	Subdivision green space/private open space may have drained into back of lots.
Opportunities	*Construct channels along back of lots to route surface flow around neighborhood.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.
Field Observation Override	Field observations noted adequate street grade to convey flow to existing storm sewer system and houses are well above street grade. Considered an isolated incident during the historic 2013 Flood event.

Problem Name and ID	Viele Channel – 3 (VC-3) Field Observation Override
Problem Location	Vicinity of Iliff Street and Juilliard Street from Ithaca Drive to Lehigh Street.
Underserved Areas	No, the existing drainage system appears adequate for the subbasin and land use.
2013 Flood Reports	Yes, three instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 3 to 4 inches with damages mainly to house features such as walls, drywall, carpet, and flooring.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	Overland flows from south may have sheeted across roads and private property impacting homes.
Opportunities	*Extend collector and conveyance system from Ithaca Drive west in Juilliard Street.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.
Field Observation Override	Field observations noted adequate street grade to convey flow to existing storm sewer system. Considered an isolated incident during the historic 2013 Flood event. Flood impacts may have been a result of groundwater.

Problem Name and ID	**Viele Channel – 4 (VC-4) Field Observation Override**
Problem Location	Vicinity of Emerson Avenue and Heidelberg Drive from Gillaspie Drive to Lehigh Street.
Underserved Areas	No, the existing drainage system appears adequate for the subbasin and land use.
2013 Flood Reports	Yes, one instance of significant flood depth, 6 feet 7 inches, reported from the 2013 flood event.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	Source not apparent. Flood depth of 6 feet 7 inches to be investigated.
Opportunities	*Improvement to be determined once source is identified.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.
Field Observation Override	Considered an isolated incident during the historic 2013 Flood event.

Problem Name and ID	**Viele Channel – 5 (VC-5) Field Observation Override**
Problem Location	Vicinity of Grinnell Avenue and Ludlow Street from Knox Drive to Broadway Street
Underserved Areas	No, the existing drainage system appears adequate for the subbasin and land use.
2013 Flood Reports	Yes, two instances of shallow localized flooding during the 2013 event were reported within the problem area. Based on the available flood survey data, reported flood depths were estimated from 1 to 4 inches with damages mainly to house features such as walls, drywall, carpet, and flooring.
2013 Flood Report Area with SMP Improvement	No, the problem area is not located within the vicinity of a 2007 SMP project recommendation.
Problem Description	Offsite flows south of Ludlow Street and from Broadway Street entered back of homes.
Opportunities	*Construct channel or extend storm drain south of private properties on south side of Ludlow Street to the west. 2007 SMP improvement can be relocated to Toedtli Drive south of Ludlow Street.*
Irrigation Ditch Storm Flow Reduction	No opportunities observed.
Field Observation Override	Field observations noted adequate street grade to convey flow to existing storm sewer system. Considered an isolated incident during the historic 2013 Flood event. Flood reports may likely be a result of groundwater and/or major drainageway impacts. Location where improvements could have positive impact is on school and/or private property, outside of city Public Works jurisdiction.

5.3 Type A and Type B Problem Priorities

To assist in the analysis and development of improvement recommendations for the Type A and B problem areas, a prioritization process was used to assess the risk of future drainage related impacts. Problem prioritization criteria and the associated criteria weight for this process are summarized below.

Table 5.3-1: Local System Problem Prioritization Criteria

Criteria	Description	Weight
Type A Problem Areas - CRM	Known problem areas identified by city staff through Community Relations Management (CRM) database reports.	3
Type A Problem Areas – 2013 Flood Report Area with SMP Improvement	Type A problem areas containing observations of flooding during the 2013 event and/or modeled collector storm sewer system problem areas.	4
Type A and B Problem Areas – Irrigation Ditch Storm Flow Reduction	Type A and B problem areas where improvements have the potential to remove stormwater from irrigation ditches	2
Type A and B Problem Areas – Underserved Area	Type A and B problem areas that have been identified as having an observed lack of existing stormwater infrastructure.	4
Type B Problem Areas – 2013 Flood Reports	Type B problem areas containing observations of flooding during the 2013 event	2
Type B Problem Area – 2013 Flood Report Area with SMP Improvement	Type B problem areas containing observations of flooding during the 2013 event and within modeled collector storm sewer system problem areas.	3
Severity and Consequence of Flooding	Projects ranked by city staff based on field observations and system knowledge. Scored as High = 3, Medium = 2, and Low = 1	10

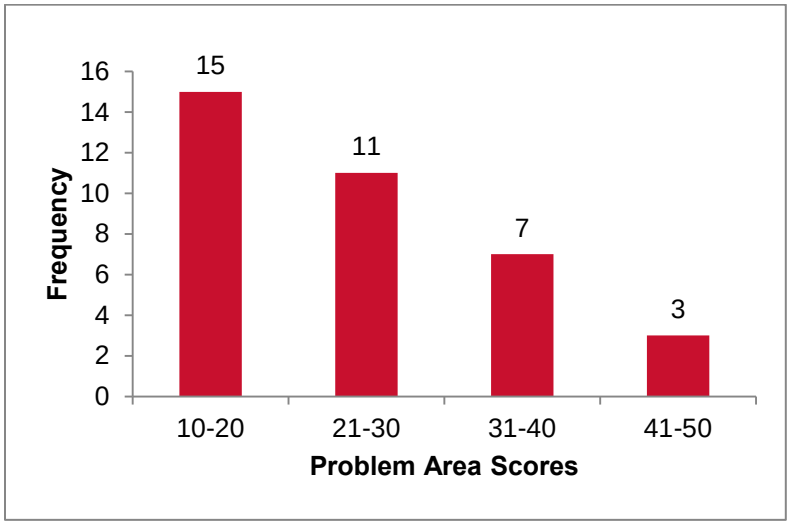
Problem areas that met the criteria noted above were assigned an individual scope of 1 where those that did not were assigned a score of 0, with the exception of Severity and Consequence of Flooding criteria. A tabular summary of the individual criteria scoring and weighted score results are summarized in the following table.

Table 5.3-2: Local System Problem Area Scoring

Type	Problem ID	Severity and Consequence of Flooding	Type A Problem Areas - CRM	Type A Problem Areas – 2013 Flood Report Area with SMP Improvement	Type A and B Problem Areas – Underserved Area	Type B Problem Area – 2013 Flood Report Area with SMP Improvement	Type B Problem Areas – 2013 Flood Reports	Type A and B Problem Areas – Irrigation Ditch Storm Flow Reduction	Weighted Totals
	Characteristic Weight	*10*	*3*	*4*	*4*	*3*	*2*	*2*	
A	Elmer's Twomile Creek - 2	3	1	1	1	0	0	1	43
A	Goose Creek - 1	3	1	1	1	0	0	0	41
A	Goose Creek - 2	3	1	1	1	0	0	0	41
A	Dry Creek No. 2 - 3	3	1	1	0	0	0	1	39
B	Bear Canyon Creek - 3	3	0	0	1	0	1	1	38
A	Dry Creek No. 2 - 1	3	1	1	0	0	0	0	37
A	Goose Creek - 3	3	1	1	0	0	0	0	37
B	Middle Boulder Creek - 2	3	0	0	0	1	1	0	35
A	Wonderland Creek - 1	3	1	0	0	0	0	0	33
B	Bear Canyon Creek - 5	3	0	0	0	0	1	0	32
B	Goose Creek - 5	2	0	0	1	1	1	0	29
B	Wonderland Creek - 7	2	0	0	1	0	1	1	28
A	Twomile Canyon Creek - 1	2	1	1	0	0	0	0	27
A	Viele Channel - 1	2	1	1	0	0	0	0	27
A	Wonderland Creek - 2	2	1	0	1	0	0	0	27
B	Bear Canyon Creek - 4	2	0	0	1	0	1	0	26
B	Goose Creek - 4	2	0	0	1	0	1	0	26
B	Middle Boulder Creek - 3	2	0	0	0	1	1	0	25
B	Fourmile Canyon Creek - 1	2	0	0	1	0	0	0	24
A	Bear Canyon Creek - 1	2	1	0	0	0	0	0	23
A	Bluebell Canyon Creek -1	2	1	0	0	0	0	0	23
A	Dry Creek No. 2 - 2	1	1	1	0	0	0	0	17
B	Dry Creek No. 2 - 4	1	0	0	1	0	1	0	16
B	Dry Creek No. 2 - 5	1	0	0	1	0	1	0	16
B	Dry Creek No. 2 - 6	1	0	0	1	0	1	0	16
B	Goose Creek - 6	1	0	0	1	0	1	0	16
B	Goose Creek - 8	1	0	0	1	0	1	0	16
B	Wonderland Creek - 6	1	0	0	1	0	1	0	16
B	Dry Creek No. 2 - 8	1	0	0	0	1	1	0	15
B	Goose Creek - 7	1	0	0	0	1	1	0	15
A	Elmer's Twomile Creek - 1	1	1	0	0	0	0	0	13
A	Middle Boulder Creek - 1	1	1	0	0	0	0	0	13
B	Dry Creek No. 2 - 7	1	0	0	0	0	1	0	12
B	Wonderland Creek - 3	1	0	0	0	0	1	0	12
B	Wonderland Creek - 4	1	0	0	0	0	1	0	12

In an effort to assist in prioritizing the Type A and B problem areas for future improvement priorities and determine the level of analysis necessary within the context of the SMP scope of work, a histogram approach was used to determine if there were break points in the scoring distribution for the problem areas.

In reviewing the histogram chart below and individual scores in the preceding table, it was observed that 25% of the total project areas had scores above 30 while the remaining 75% were distributed across a range from 12 to 30 increasing in frequency as the score dropped. This would indicate the more acute problem areas (higher scores) are fewer and more isolated within the city where the lower scored problem areas may be generally less severe but have a greater frequency of occurrence.



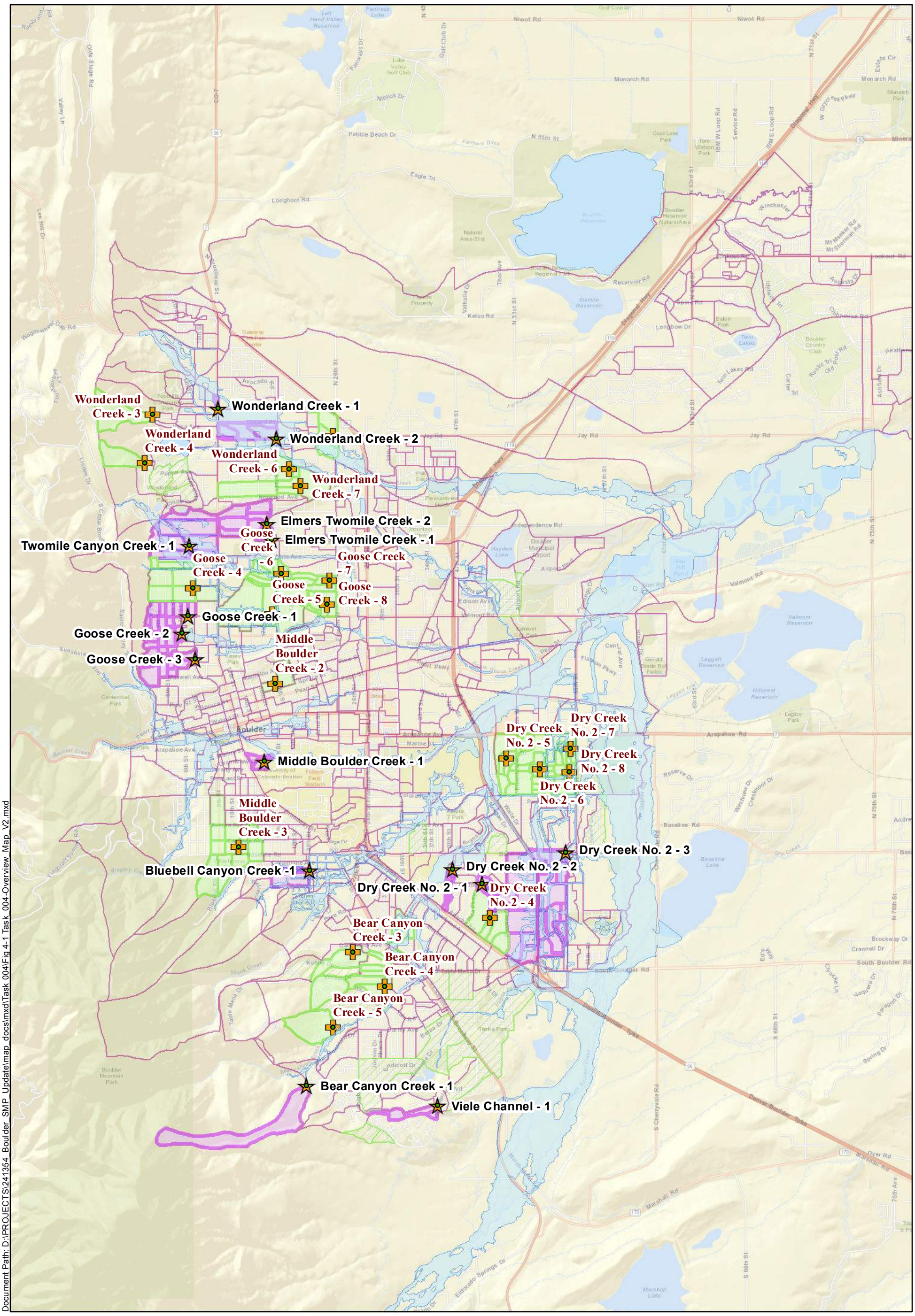
Based on the problem area characterization, problem area scoring process, and results problem area score histogram, it is recommended that problem areas with score of 30 and greater be identified as Tier I local drainage problems with Tier II and Tier III local drainage problems being separated at a problem score of 20 with problem areas with a score below 20 making up the lowest-priority Tier III.

Within the context of the SMP scope of work, the Tier I problems would receive additional modeling and analysis to develop a recommended improvement size and alignments and ultimately refine the planning level construction cost estimate.

The Tier II and Tier III problem areas would not be explicitly modeled within the XPSWMM hydrologic and hydraulic model; rather those improvements would be estimated on existing condition model flows, unit flow per acre estimates, and other approximate methods to estimate the conveyance system size. These estimates of conveyance system size would be combined with the improvement alignments to develop an order-of-magnitude level estimate of construction cost. A summary of the resulting Tier I, II and III improvement priorities are listed in the following table and shown on Figure 5-2.

Table 5.3-3: Local System Tier I, II and III Problem Area Priorities

Problem ID	Local System Problem Priorities
Elmer's Twomile Creek - 2	Tier I
Goose Creek - 1	Tier I
Goose Creek - 2	Tier I
Dry Creek No. 2 - 3	Tier I
Bear Canyon Creek - 3	Tier I
Dry Creek No. 2 – 1	Tier I
Goose Creek – 3	Tier I
Middle Boulder Creek - 2	Tier I
Wonderland Creek - 1	Tier I
Bear Canyon Creek - 5	Tier I
Goose Creek - 5	Tier II
Wonderland Creek - 7	Tier II
Twomile Canyon Creek - 1	Tier II
Viele Channel - 1	Tier II
Wonderland Creek - 2	Tier II
Bear Canyon Creek - 4	Tier II
Goose Creek - 4	Tier II
Middle Boulder Creek - 3	Tier II
Fourmile Canyon Creek - 1	Tier II
Bear Canyon Creek - 1	Tier II
Bluebell Canyon Creek -1	Tier II
Dry Creek No. 2 - 2	Tier III
Dry Creek No. 2 - 5	Tier III
Dry Creek No. 2 - 6	Tier III
Goose Creek - 6	Tier III
Goose Creek - 8	Tier III
Wonderland Creek - 6	Tier III
Dry Creek No. 2 - 8	Tier III
Goose Creek - 7	Tier III
Elmer's Twomile Creek - 1	Tier III
Middle Boulder Creek - 1	Tier III
Dry Creek No. 2 - 4	Tier III
Dry Creek No. 2 - 7	Tier III
Wonderland Creek - 3	Tier III
Wonderland Creek - 4	Tier III



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0 4,000 8,000 Feet

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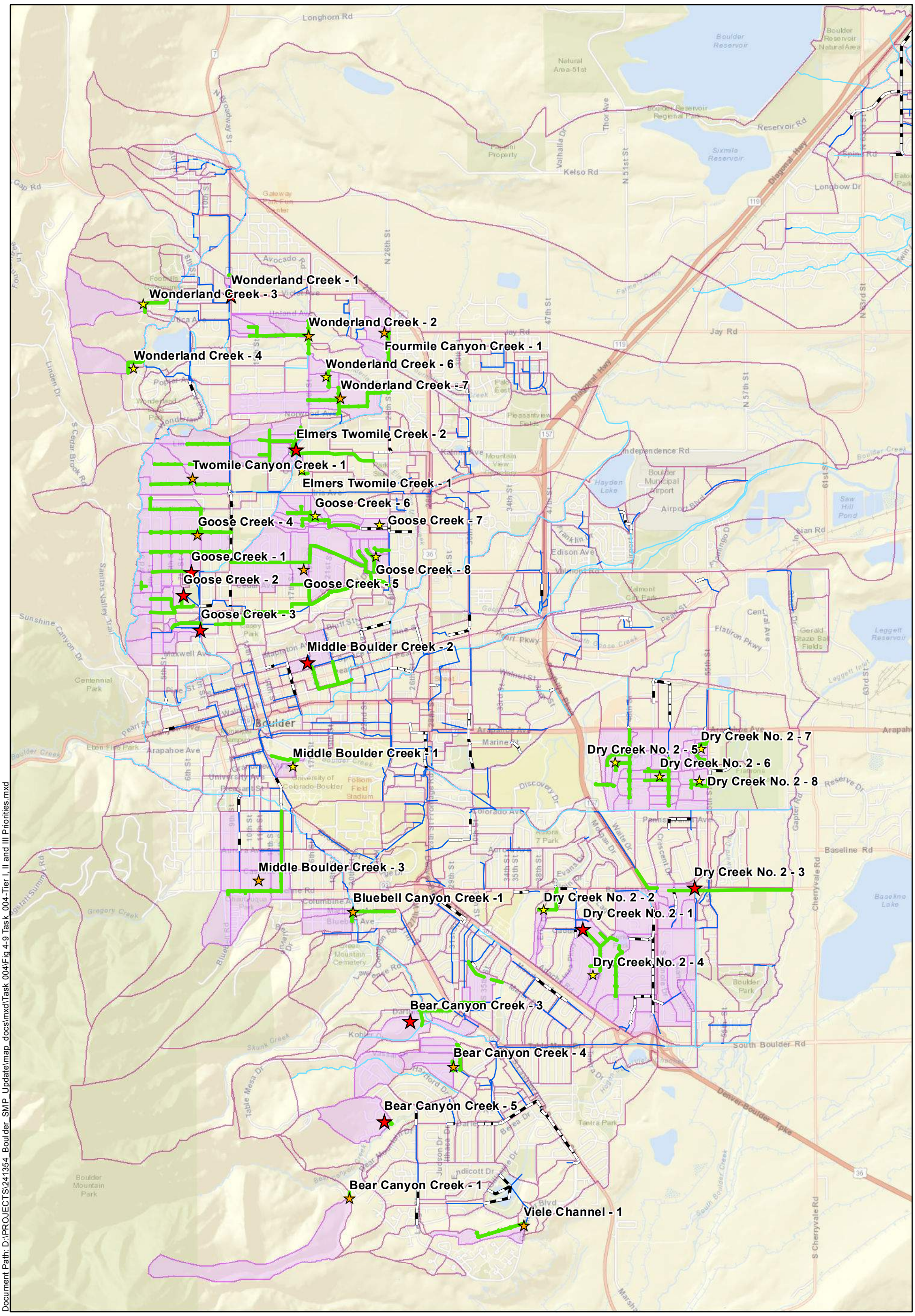
- Type A - Local Drainage Problem Area
- Type B - Local Drainage Problem Area
- 2013 Flood Extents
- Subcatchment
- Type A Priority Subcatchment
- Type B Priority Subcatchment
- Type B Override

Local System Problem Area Overview Map

Figure 5-1

Date: 1/8/2016



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Local System Improvement Priorities

- Tier I
- Tier II
- Tier III
- Proposed Local System Improvements
- 2007 SMP Proposed STM
- Modeled Collector Storm Sewer
- Modeled Open Channel
- Subcatchment
- Local Improvement Subcatchment

Local System Tier I, II and III Problem Area Priorities Overview Map

Figure 5-2

Date: 1/8/2016

6 Collector Storm Sewer System Improvement Recommendations

This section summarizes the development and evaluation of various alternatives intended to resolve the collector storm sewer deficiencies. In addition, this section presents the recommended plan for storm sewer and water quality improvements.

6.1 Collector System Hydraulic Alternatives

Improvement alternatives were developed for the Tier 1 and Tier 2 priority problem areas and the identified irrigation ditch problem areas. Detailed summaries of the alternatives are included in TM 5.1 – Conceptual Hydraulic Alternatives, which includes improvement descriptions, design data, benefits and issues.

6.1.1 Alternative Development Process

Conceptual alternatives for the hydraulic problem areas were developed and evaluated using a combination of the project GIS and the XPSWMM model. Conceptual alternatives include pipe replacement, hydraulically parallel storm sewers, flow diversions and detention. The alternatives for each of the Tier 1 and 2 problem areas were summarized in a fact sheet format. Alternatives for the Tier 3 problem areas were not developed; rather, the Tier 3 problem areas were resolved via pipe replacement.

Multiple factors were considered in developing each alternative. Although each problem area had unique constraints and required a different set of improvements, a number of common themes were followed:

- To minimize capital expenditures, the existing infrastructure was used to the maximum extent possible.
- Land acquisition, in terms of size and ownership and potential development pressures, was considered when locating system improvements.
- Where feasible, system improvements were located in public property, right-of-way.
- Where irrigation ditch capacity problems exist, storm drain flows entering the ditch system were eliminated if practical.
- For problem areas that discharge to an irrigation ditch, alternatives were investigated that remove the outfall to the ditch by diverting flow to a major drainageway or storm drain with sufficient capacity.

Tier 1 problem areas received a more detailed analysis at this concept alternative stage as the problems are generally more severe. Alternatives for Tier 1 problem areas were modeled using XPSWMM and mapped in GIS to more clearly define the alignments of the alternatives. The Upper Goose Creek problem area (Tier 1) was further analyzed using a 2-dimensional model to optimize the system improvement with respect to major drainageway conveyance issues. Alternatives for Tier 2 problem areas were sized based on normal depth calculations using future base condition model results stored in the GIS with the alignments described in the fact sheets.

6.1.2 Alternative Evaluation Process

Fact sheets were used to summarize information regarding each alternative and then to used that information to qualitatively evaluate the alternatives. Each fact sheet includes the problem area identification code that can be referenced to TM 4.1b. Fact sheets also include the information regarding the following topics:

- ***Problem Location.*** Summarizes the location and extent of the problem with respect to city streets and other key landmarks.
- ***Problem Summary.*** Summarizes the system problems as developed using the problem identification criteria.
- ***Alternative Summary.*** Provides a narrative of the components for each alternative developed. This includes a description of alignment corridors, pipe diameters and lengths, and other improvement-related information needed to implement the project.
- ***Technical Data.*** Summarizes the hydraulic data needed to evaluate the viability of the conceptual alternative. This includes design flows, pipe slopes, pipe diameters and storage volumes.
- ***Benefits.*** Identifies if the problems are resolved. Also identifies the benefits relative to another alternative described for the same problem location.
- ***Land Ownership.*** Summarizes existing land ownership and any land acquisition required to implement the alternative.
- ***Permitting.*** Summarizes any permitting or mitigation issues likely to be associated with the alternative.
- ***Issues.*** Identifies issues that would affect construction and maintenance for each alternative. Examples include major utility relocations, high groundwater, significant roadway closures, etc. Also identifies special construction techniques necessary to implement the alternatives. Also identifies if the alternative does not alleviate deficiencies within a problem area.

The identification of the preferred alternative was based a qualitative assessment of the information presented in the fact sheets. In addition, factors including alignment opportunities, utility constraints, land ownership, perceived cost and whether the project could be connected with other planned city capital improvements were also considerations in identifying the preferred alternative.

6.1.3 Upper Goose Creek – Alternative Analysis

The Upper Goose Creek collector system extends west of 19th Avenue in Alpine Avenue and then branches near Broadway south toward Dewey Street and north toward North Boulder Park. Collector system improvement alternatives were developed, as described previously, to address the hydraulic problems within the Upper Goose Creek collector system. The alternative evaluation process identified the preferred alternative of tying into the future major drainageway open channel improvement (Edgewood reach channel improvements) as defined in the 1988 Major Drainageway Plan (Greenhorne and O'mara, Inc). The 1988 Major Drainageway Plan also required capacity improvements downstream in Goose Creek between 19th Avenue and Folsom, along Edgewood Avenue. The improvements along this 19th to Folsom reach present many challenges including

property acquisition and lack public support. As a result, a more detailed analysis of potential collector system improvements was required. The goals of the Upper Goose Creek alternative analysis were as follows:

- Develop collector system improvement alternatives upstream of 19th that are located within the ROW.
- Develop alternatives that minimize construction impacts in Goose Creek between 19th and Folsom.
- Identify collector system improvements that maximize storm conveyance and balances constructability, capital cost, private property concerns, and flooding risk.
- Minimize and reduce major storm flooding depths within the collector system upstream of 19th Avenue for storm events greater than the 5-yr collector system design storm requirement.

A 2-dimensional hydraulic model was developed to efficiently evaluate surface flow in conjunction with collector system improvement alternatives. The XP-2D module was added onto the XPSWMM collector system model as the analysis tool to assist in the alternative development and evaluation. The 2-D limits of the model extended from 19th Avenue 6th Avenue. Alternatives were developed and modeled using the 2-year, 5-year, 10-year and 100-year design storms to evaluate the flooding depths and downstream impacts. In addition, estimates of construction costs were developed for two alternatives.

The alternative evaluation process resulted in the least cost alternative that did not increase flooding risk to residents along the Edgewood reach of Goose Creek. Details regarding the model development, results, and alternatives are included in TM 5.1c Goose Creek 2-D Analysis.

The 2016 SMP further refined the Upper Goose Creek system analysis to more closely evaluate the local stormwater drainage system and reported problem areas. This analysis resulted in extending the storm sewer system into underserved areas of the basin.

6.1.4 Irrigation Ditch Separation Conceptual Alternatives

Potential locations to separate the storm sewer system from the irrigation ditches were also evaluated. The areas investigated were ditch reaches that are know system problem locations and/or that were identified in the hydraulic model as under capacity sections. In addition to identifying potential sites, a process of ranking each storm drain outfall that discharges to a ditch with respect to relocating the outfall to a neighboring major drainageway was also investigated.

Identifying the outfalls that discharge directly to the ditch system was accomplished in GIS by intersecting the storm drain (pipe) layer with the ditch layer. The resulting point database included 24 outfalls, had diameters greater than 18” and represents the collector system stormwater pipes that discharge directly into the ditch system.

The process used to identify the most opportune sites for separation involved four criteria. Each criterion was estimated using GIS, with the highest ranking sites identified qualitatively. The criteria include *Distance to major drainageway*, *existing problem area*, *contributing drainage area* and *known ditch flooding*.

By applying the criteria in GIS to each of the outfalls, a thematic map was created to illustrate which outfalls represent the best opportunity for separate from the ditch system. This GIS mapping process indicated the top four sites for separation were:

- Iris Ave and Farmer's Ditch
- 9th Street and Anderson Ditch
- Mapleton Ave and Boulder White Rock Ditch
- 5th St and Farmers Ditch.

Fact sheets, shown in TM 5.1b – Storm Drain / Canal Separation Alternatives, were developed to provide conceptual alternatives for improvements at 9th Street and Anderson Ditch (#2) and 5th Street and Farmers Ditch (#4). Conceptual alternatives were developed for these two sites as they provided the best opportunity for system improvements. Alternatives for the other site locations become more problematic to implement and have a reduced system benefit. However, the conceptual alternative fact sheets for the 9th Street and Anderson Ditch (#2) and 5th Street and Farmers Ditch (#4) sites provide an illustration of the general approach that could be applied to other sites if needed.

6.2 Water Quality Alternatives

The water quality analysis identified twelve (12) locations as Water Quality Areas of Concern (Figure 6-1). For these locations, improvement alternatives were developed to evaluate the most appropriate solution considering the contributing area and site constraints.

In addition to the Water Quality Areas of Concern, HDR performed an analysis of the 18 collector system outfalls on Boulder Creek, focusing on the use of proprietary BMPs (a.k.a. water quality manholes) that utilize hydrodynamic forces to remove TSS and associated pollutants from stormwater runoff. This second approach to addressing stormwater quality was developed to evaluate the potential benefit of focusing on a single, high priority stream system instead of a city-wide approach.

A summary of the key elements of the water quality alternatives analysis and recommendations is presented below. The analysis is described in more detail in TM 3.6.2 Water Quality Alternatives and Recommendations and in TM 3.6.3 Water Quality Improvement Recommendations.

6.2.1 Alternative Development – Water Quality Areas of Concern

Conceptual alternatives were developed to address the modeled stormwater pollutants using aerial photography and GIS data, and summarized in a fact sheet format. The BMP Toolbox developed for this project (TM 4.3 – Structural BMP Toolbox) was used as a list of potential BMPs which resulted in primary BMP recommendations consisting of constructed wetland detention ponds (extended detention basins), grass swales with check structures, and proprietary BMPs. Constructed wetland detention ponds were recommended because they are large enough to provide water quality treatment for an entire basin. Grass swales with check structures are recommended for situations where the available area is a long, thin strip of land. Proprietary BMPs are listed as alternatives for each of the sites because of their ability to be constructed in a retro-fit application with minimal site impacts or land acquisition requirements.

The fact sheets include the problem location (illustrated with a map), problem summary, benefits, technical data, land ownership, implementation issues, and capital costs.

For the twelve (12) Water Quality Areas of Concern, there are six particular basins that are expected to undergo significant redevelopment: sites 1, 2, 6, 8, 9, and 10. In these basins, HDR accounted for the possibility of stormwater BMPs being built as part of the development process, and, in some cases, these sites were given lower priority for city constructed BMPs due to their potential for re-development.

6.2.2 Alternative Development Process – Boulder Creek Outfalls

In addition to the twelve (12) sites identified as Water Quality Areas of Concern by the XP-SWMM model, HDR conducted an analysis of seventeen (17) proprietary BMPs at outfalls on Boulder Creek (Figure 6-1). Two of these outfalls overlap with the water quality area of concern approach; these are listed in Table 6.2-1. Note there is an existing proprietary BMP located Broadway and Boulder Creek and was identifies as site BC3.

Table 6.2-1: Common Water Quality Area of Concern and Boulder Creek Outfalls

WQ Area of Concern ID	WQ Area of Concern Description	Boulder Creek Site Number
WQ4	Broadway and Boulder Creek	BC6
WQ5	28th Street and Boulder Creek	BC11

Fact sheets were developed for each site and are included in TM 3.6.3 – Water Quality Improvement Recommendations. The fact sheets show conceptual locations for the water quality manholes. Siting these facilities assumed the water quality manhole would be an off-line system and therefore would require a diversion manhole and connecting influent and effluent pipes.

6.2.3 Alternative Evaluation and Recommendations

Alternatives for the 27 sites (12 Water Quality Areas of Concern and 15 Boulder Creek outfalls) were further evaluated and recommendations for each site were developed. The recommended BMPs are the result of a field visit as well as workshops with city staff.

To assist in the prioritization of improvements, a cost/benefit analysis was performed for the Water Quality Areas of Concern as well as the Boulder Creek outfalls. Each of the 27 sites and the respective recommended BMPs were analyzed in terms of pollutant loading at the outfall and pollutant removal by the BMP. TSS was used as the representative pollutant for the analysis. Annual loading of TSS to each of the sites was determined using the XPSWMM model and the annual rainfall series. Removal of TSS by recommended water quality BMPs was determined using the model results and an Excel spreadsheet tool.

The spreadsheet tool evaluated the water quality storm peak flow being diverted to a facility and then applied a removal effectiveness to arrive at a load reduction. Some of the BMPS were not sized for the entire water quality peak due to site constraints or other facility sizing issues. If the water quality peak flow in the system was greater than the size of the BMP, the spreadsheet tool accounted for the peak of the pollutograph not receiving pollution reduction through the BMP. The following quantities of removal effectiveness were used in the analysis through the spreadsheet tool as determined from a literature search,

- 80 percent removal of TSS for detention ponds and constructed wetland ponds.
- 50 percent removal of TSS for proprietary BMPs.
- 50 percent removal of TSS for vegetated swales with check structures.

For comparison purposes, conceptual construction costs for the recommended BMPs at each of the sites were estimated. Table 6.2-2 lists the TSS removal and costs for the recommended BMPs for the Water Quality Areas of Concern and the Boulder Creek Outfalls approaches. It should be noted that WQ4 is the same as BC6 and WQ5 is the same as BC11. All four rows are listed in this table to develop a cost/benefit for each approach; however, this redundancy is removed in the Recommended Plan in the following section. The results indicate the cost per pound of removal is comparable for the two approaches – approximately $5 per pound of TSS per year.

Table 6.2-2: TSS Removal and Costs for Recommended BMPs

Outfall ID	Annual TSS Removal (pounds)	Conceptual Capital Cost (1)	Cost per Pound (1)
Water Quality Area of Concern			
WQ1	14,831	$ 54,000	$ 3.64
WQ2	124,805	$ 635,000	$ 5.09
WQ3	14,970	$ 54,000	$ 3.61
WQ4	9,770	$ 81,000	$ 8.29
WQ5	15,854	$ 92,000	$ 5.80
WQ6	58,009	$ 289,000	$ 4.98
WQ7	7,924	$ 98,000	$ 12.37
WQ8	9,846	$ 137,000	$ 13.91
WQ9	20,128	$ 81,000	$ 4.02
WQ10	41,004	$ 54,000	$ 1.32
WQ11	25,472	$ 77,000	$ 3.02
WQ12	11,024	$ 73,000	$ 6.62
	353,637	$ 1,725,000	$ 4.88
Boulder Creek Outfalls			
BC1	11,690	$ 73,000	$ 6.24
BC2	7,242	$ 51,000	$ 7.04
BC4	21,749	$ 84,000	$ 3.86
BC5	17,956	$ 73,000	$ 4.07
BC6	9,770	$ 81,000	$ 8.29
BC7	19,530	$ 84,000	$ 4.30
BC8	13,503	$ 78,000	$ 5.78
BC9	2,542	$ 73,000	$ 28.72
BC10	26,193	$ 81,000	$ 3.09
BC11	15,854	$ 92,000	$ 5.80
BC12	13,215	$ 104,000	$ 7.87
BC13	1,391	$ 47,000	$ 33.79
BC14	4,830	$ 47,000	$ 9.73
BC15	5,438	$ 61,000	$ 11.22
BC16	8,628	$ 39,000	$ 4.52
BC17	22,036	$ 76,000	$ 3.45
BC18	29,036	$ 104,000	$ 3.58
	230,604	$ 1,248,000	$ 5.41

(1) Cost presented for analysis is in 2007 dollars

Based on the Cost/Benefit Analysis, neither the Boulder Creek approach nor the Water Quality Areas of Concern approach is significantly better than the other approach in terms of reducing TSS loading to Boulder Creek and its tributaries. However, there are specific outfalls in each approach that have a comparatively high cost per pound ratio which include Sites WQ7, WQ8, BC9, BC13 and

BC15. These high cost per pound sites do not provide a cost effective approach to addressing stormwater quality.

Several of the Water Quality Area of Concern sites have the potential to undergo significant redeveloped as identified by city Staff. When redevelopment occurs, stormwater quality improvements would be required by the city's DCS which would address a majority of the subcatchment contributing pollutants to the Water Quality Area of Concern outfall. The potential redeveloped sites were identified as WQ1, WQ6 and WQ10. These site locations are shown on Figure 6-1. As a result, it is recommended that a subset of these sites be included in the Recommended Plan. The recommended sites include WQ2, WQ3, WQ4, WQ5, WQ9, WQ11, and WQ12. Of note, WQ2 is considered a high priority because the project routes stormwater flow away from an irrigation ditch and is part of a larger project, which is a solution to a hydraulic problem. WQ9 is considered a high priority because it is an excellent spot for a wetland pond on open city property. An additional benefit is that both of these high priority projects may provide wetlands mitigation credits.

The project team recognizes that water quality in Boulder Creek itself is of primary importance, and treating stormwater at outfalls that flow directly into Boulder Creek may be the most direct way to improve water quality in the most heavily used and regulated creek in the city. Furthermore, the proprietary BMPs identified for the Boulder Creek Outfall approach tend to be easier to site in an urban environment than ponds and swales. Therefore, it is recommended that the BMPs for the Boulder Creek outfalls be constructed with the exception of Sites BC9 and BC13. These exceptions are identified as the Cost/Benefit analysis shows sites BC9 and BC13 have very high costs per pound of TSS removal.

Considering the site constraints for the BMPs analyzed and the cost/benefit analysis, the following table summarizes the following sites for incorporation into the Recommended Plan.

Table 6.2-3: Recommended Water Quality Sites

Improvement Site ID	Outfall ID	Improvement Description	Annual TSS Load (pounds)	Annual TSS Removal (pounds)	Cost [1]
WQIMP 1	WQ2	Constructed Wetland	166,516	124,805	$635,000
WQIMP 2	BC18	Proprietary BMP	61,928	29,036	$104,000
WQIMP 3	BC10	Proprietary BMP	56,517	26,193	$81,000
WQIMP 4	WQ11	Proprietary BMP	54,467	25,472	$77,000
WQIMP 5	BC17	Proprietary BMP	46,152	22,036	$76,000
WQIMP 6	BC4	Proprietary BMP	45,712	21,749	$84,000
WQIMP 7	WQ9	Constructed Wetland	27,444	20,128	$81,000
WQIMP 8	BC7	Proprietary BMP	41,533	19,530	$84,000
WQIMP 9	BC5	Proprietary BMP	38,418	17,956	$73,000
WQIMP 10	WQ5	Proprietary BMP	34,242	15,854	$92,000
WQIMP 11	WQ3	Proprietary BMP	31,797	14,970	$54,000
WQIMP 12	BC8	Proprietary BMP	29,039	13,503	$78,000
WQIMP 13	BC12	Proprietary BMP	27,770	13,215	$104,000
WQIMP 14	BC1	Proprietary BMP	24,183	11,690	$73,000
WQIMP 15	WQ12	Proprietary BMP	22,814	11,024	$73,000
WQIMP 16	WQ4	Proprietary BMP	20,318	9,770	$81,000
WQIMP 17	BC16	Proprietary BMP	18,295	8,628	$39,000
WQIMP 18	BC2	Proprietary BMP	14,988	7,242	$51,000
WQIMP 19	BC14	Proprietary BMP	10,560	4,830	$47,000

(1) Cost presented for analysis is in 2007 dollars

6.3 Collector System Recommendations Summary

The collector system improvement plan is a compilation of all hydraulic and water quality improvements developed in this study. Figure 6-2 provides an overview of the recommended plan improvements with corresponding improvement project IDs. Improvement project IDs were assigned based on the subbasin the project was located in and a numerical identifier. Note the numerical identifiers within each subbasin were assigned spatially from upper left to lower right and do not indicate the improvement priority. The following table correlates improvement project ID with the hydraulic problem ID and/or the water quality problem outfall ID. This table can be used to reference the recommended improvement with the problem location and alternatives presented in this report and within the technical memoranda included in the report appendices.

Table 6.3-1: Collector System Improvement Summary

Hyd/WQ Problem ID	Rank	Project ID	Subbasin	Improvement Type	Priority
HYD#52	33	BCC_01	Bear Canyon Creek	Hydraulic Improvement	Tier 3
HYD#51	36	BCC_02	Bear Canyon Creek	Hydraulic Improvement	Tier 3
HYD#49	21	BCC_03	Bear Canyon Creek	Hydraulic Improvement	Tier 2
HYD#7	27	BCC_04	Bear Canyon Creek	Hydraulic Improvement	Tier 3
HYD#54	36	BCC_05	Bear Canyon Creek	Hydraulic Improvement	Tier 3
HYD#53	36	BCC_06	Bear Canyon Creek	Hydraulic Improvement	Tier 3
HYD#45	36	BCC_07	Bear Canyon Creek	Hydraulic Improvement	Tier 3
HYD#8, 9 & WQIMP 01	4	DC_01	Dry Creek	Hydraulic/Water Quality Improvement	Tier 1&2
HYD#1	36	DC_02	Dry Creek	Hydraulic Improvement	Tier 3
HYD#46	26	DC2_01	Dry Creek No. 2	Hydraulic Improvement	Tier 3
HYD#47	9	DC2_02	Dry Creek No. 2	Hydraulic Improvement	Tier 2
HYD#44	50	DC2_03	Dry Creek No. 2	Hydraulic Improvement	Tier 3
HYD#2	30	DC2_04	Dry Creek No. 2	Hydraulic Improvement	Tier 3
HYD#23	27	DC2_05	Dry Creek No. 2	Hydraulic Improvement	Tier 3
HYD#22 and WQIMP 04	16	DC2_06	Dry Creek No. 2	Hydraulic/Water Quality Improvement	Tier 2
HYD#15	14	ETC_01	Elmers Twomile Creek	Hydraulic Improvement	Tier 2
HYD#13	48	ETC_03	Elmers Twomile Creek	Hydraulic Improvement	Tier 3
HYD#11	35	FCC_01	Fourmile Canyon Creek	Hydraulic Improvement	Tier 3
HYD#16	1	GC_02	Goose Creek	Hydraulic Improvement	Tier 1
HYD#33	30	GC_03	Goose Creek	Hydraulic Improvement	Tier 3
HYD#31	49	GC_05	Goose Creek	Hydraulic Improvement	Tier 3
HYD#32	29	GC_06	Goose Creek	Hydraulic Improvement	Tier 3
HYD#5	36	GC_07	Goose Creek	Hydraulic Improvement	Tier 3

Table 6.3-1: Collector System Improvement Summary

Hyd/WQ Problem ID	Rank	Project ID	Subbasin	Improvement Type	Priority
HYD#27 and WQIMP 11	11	GC_08	Goose Creek	Hydraulic/Water Quality Improvement	Tier 2
HYD#21 and WQIMP 07	12	GC_09	Goose Creek	Hydraulic/Water Quality Improvement	Tier 2
WQIMP 15	8	KG_01	Kings Gulch	Water Quality Improvement	n/a
WQIMP 05	3	LBC_01	Lower Boulder Creek	Water Quality Improvement	n/a
WQIMP 02	1	LBC_02	Lower Boulder Creek	Water Quality Improvement	n/a
HYD#36	53	MBC_01	Middle Boulder Creek	Hydraulic Improvement	Tier 3
HYD#37	36	MBC_02	Middle Boulder Creek	Hydraulic Improvement	Tier 3
WQIMP 14	7	MBC_03	Middle Boulder Creek	Water Quality Improvement	n/a
HYD#41	6	MBC_04	Middle Boulder Creek	Hydraulic Improvement	Tier 2
WQIMP 18	10	MBC_05	Middle Boulder Creek	Water Quality Improvement	n/a
WQIMP 06 & WQIMP 09	4	MBC_06	Middle Boulder Creek	Water Quality Improvement	n/a
WQIMP 16	9	MBC_07	Middle Boulder Creek	Water Quality Improvement	n/a
HYD#40	50	MBC_08	Middle Boulder Creek	Hydraulic Improvement	Tier 3
HYD#35	19	MBC_09	Middle Boulder Creek	Hydraulic Improvement	Tier 2
WQIMP 08	5	MBC_11	Middle Boulder Creek	Water Quality Improvement	n/a
WQIMP 12	6	MBC_12	Middle Boulder Creek	Water Quality Improvement	n/a
HYD#3	30	MBC_13	Middle Boulder Creek	Hydraulic Improvement	Tier 3
HYD#55 and WQIMP 10	3	MBC_14	Middle Boulder Creek	Hydraulic/Water Quality Improvement	Tier 1
HYD#39	50	MBC_15	Middle Boulder Creek	Hydraulic Improvement	Tier 3
WQIMP 03	2	MBC_16	Middle Boulder Creek	Water Quality Improvement	n/a
HYD#4	55	MBC_17	Middle Boulder Creek	Hydraulic Improvement	Tier 3
HYD#30 and WQIMP 13	25	MBC_18	Middle Boulder Creek	Hydraulic/Water Quality Improvement	Tier 3
HYD#28 and WQIMP 19	36	MBC_19	Middle Boulder Creek	Hydraulic/Water Quality Improvement	Tier 3
HYD#29	10	MBC_20	Middle Boulder Creek	Hydraulic Improvement	Tier 2
HYD#25	54	MBC_21	Middle Boulder Creek	Hydraulic Improvement	Tier 3
HYD#24	8	MBC_22	Middle Boulder Creek	Hydraulic Improvement	Tier 2
HYD#20 and WQIMP 17	14	MBC_23	Middle Boulder Creek	Hydraulic/Water Quality Improvement	Tier 2
HYD#42	5	SC_01	Skunk Creek	Hydraulic Improvement	Tier 2
HYD#38	18	SC_02	Skunk Creek	Hydraulic Improvement	Tier 2

Table 6.3-1: Collector System Improvement Summary

Hyd/WQ Problem ID	Rank	Project ID	Subbasin	Improvement Type	Priority
HYD#48	22	VC_01	Viele Channel	Hydraulic Improvement	Tier 3
HYD#50	23	VC_02	Viele Channel	Hydraulic Improvement	Tier 3
HYD#12	36	WC_01	Wonderland Creek	Hydraulic Improvement	Tier 3
HYD#17	33	WC_02	Wonderland Creek	Hydraulic Improvement	Tier 3
HYD#19	7	WC_03	Wonderland Creek	Hydraulic Improvement	Tier 2

The process for developing the recommended plan involved refining the hydraulic alternative recommendations for the Tier 1 and 2 problems area to resolve conflicts with existing water and sewer utilities. Potential conflicts with sanitary sewers were resolved by identifying locations where storm sewer improvements cross sanitary sewers. At these sewer crossings, the proposed storm sewer was graded to provide a minimum of 18" of vertical clearance. There were several locations where this storm/sanitary sewer clearance could not be obtained and the existing sewer was re-graded and lowered to accommodate the proposed storm sewer improvement. Waterline lowerings were identified for locations where the new storm sewer crosses a water transmission line (16" diameter and greater) where the proposed storm sewer was within 4' of the ground surface. The focus on the transmission mains were identified as the larger lines are more problematic and expensive to relocate than smaller diameter water distribution lines.

In addition to resolving utility conflicts, development of the recommended plan included addition of Tier 3 hydraulic improvements and water quality improvements.

The following report sections and associated tables are intended to be a summary of the recommended plan for each subbasin and include a Project ID, along with a description of the project improvement and capital cost.

6.3.1 Recommendations – Bear Canyon Creek Subbasin

The recommended plan for the Bear Canyon Creek Subbasin includes seven individual CIP projects, which are summarized in the following table. All of the projects are hydraulic improvement projects.

Table 6.3-2: Summary of Recommended Improvements - Bear Canyon Creek Subbasin

ID	Improvement Category	Capital Cost ($)
BCC_01	Tier 3 Hydraulic Improvement Storm Sewer: Pipe Replacement	$1,132,000
BCC_02	Tier 3 Hydraulic Improvement Storm Sewer: Pipe Replacement	$184,000
BCC_03	Tier 2 and 3 Hydraulic Improvement Storm Sewer: Pipe Replacement	$1,512,000

ID	Improvement Category	Capital Cost ($)
	Storm Sewer Re-Routing/Extension	
BCC_04	Tier 3 Hydraulic Improvement Storm Sewer: Pipe Replacement	$540,000
BCC_05	Tier 3 Hydraulic Improvement Storm Sewer: Pipe Replacement	$200,000
BCC_06	Tier 3 Hydraulic Improvement Storm Sewer: Pipe Replacement	$373,000
BCC_07	Tier 3 Hydraulic Improvement Storm Sewer: Pipe Replacement	$428,000
	Total	**$4,369,000**

6.3.2 Recommendations – Dry Creek Subbasin

The recommended plan for the Dry Creek Subbasin includes two individual CIP projects, which are summarized in the following table. One project is a combined hydraulic/water quality improvement project and the other is a hydraulic improvement project.

Table 6.3-3: Summary of Recommended Improvements - Dry Creek Subbasin

ID	Improvement Category	Capital Cost ($)
DC_01	Tier 1 and 2 Combined Hydraulic/Water Quality Improvement Storm Sewer: Pipe Replacement Storm Sewer Re-Routing/Extension Constructed Wetland	$7,195,000
DC_02	Tier 3 Hydraulic Improvement Storm Sewer: Pipe Replacement	$411,000
	Total	**$7,606,000**

6.3.3 Recommendations – Dry Creek No. 2 Subbasin

The recommended plan for the Dry Creek No. 2 Subbasin includes six individual CIP projects, which are summarized in the following table. Five of the projects are hydraulic improvement projects and one is a combined hydraulic/water quality improvement project.

Table 6.3-4: Summary of Recommended Improvements - Dry Creek No. 2 Subbasin

ID	Improvement Category	Capital Cost ($)
DC2_01	Tier 3 Hydraulic Improvement Storm Sewer: Pipe Replacement	$1,226,000

ID	Improvement Category	Capital Cost ($)
DC2_02	Tier 2 Hydraulic Improvement Storm Sewer: Pipe Replacement	$5,364,000
DC2_03	Tier 3 Hydraulic Improvement Storm Sewer: Pipe Replacement	$603,000
DC2_04	Tier 3 Hydraulic Improvement Storm Sewer: Pipe Replacement	$664,000
DC2_05	Tier 3 Hydraulic Improvement Storm Sewer: Pipe Replacement	$770,000
DC2_06	Tier 2 Combined Hydraulic/Water Quality Improvement Storm Sewer: Pipe Replacement Proprietary BMP	$637,000
	Total	**$9,264,000**

6.3.4 Recommendations – Elmers Twomile Creek Subbasin

The recommended plan for the Elmers Twomile Creek Subbasin includes three individual CIP projects, which are summarized in the following table. All of the projects are hydraulic improvements projects.

Table 6.3-5: Summary of Recommended Improvements - Elmers Twomile Creek Subbasin

ID	Improvement Category	Capital Cost ($)
ETC_01	Tier 2 Hydraulic Improvement Storm Sewer: Pipe Replacement, Diversion to Major Drainageway	$639,000
ETC_03	Tier 3 Hydraulic Improvement Storm Sewer: Pipe Replacement	$1,109,000
	Total	**$1,748,000**

6.3.5 Recommendations – Fourmile Canyon Creek Subbasin

The recommended plan for the Fourmile Canyon Creek Subbasin includes one individual CIP project, which is summarized in the following table. It is a hydraulic improvement project.

Table 6.3-6: Summary of Recommended Improvements - Fourmile Canyon Creek Subbasin

ID	Improvement Category	Capital Cost ($)
FCC_01	Tier 3 Hydraulic Improvement Storm Sewer: Pipe Replacement	$836,000
	Total	**$863,000**

6.3.6 Recommendations – Goose Creek Subbasin

The recommended plan for the Goose Creek Subbasin includes seven individual CIP projects, which are summarized in the following table. Seven of the projects are hydraulics improvement projects and two are combined hydraulic/water quality projects.

Table 6.3-7: Summary of Recommended Improvements - Goose Creek Subbasin

ID	Improvement Category	Capital Cost ($)
GC_02	• Tier 1 • Hydraulic Improvement • Storm Sewer: • Pipe Replacement • New, Hydraulically Parallel Storm Sewer • Channel Improvement	$8,269,000
GC_03	• Tier 3 • Hydraulic Improvement • Storm Sewer: Pipe Replacement	$819,000
GC_05	• Tier 3 • Hydraulic Improvement • Storm Sewer: Pipe Replacement	$810,000
GC_06	• Tier 3 • Hydraulic Improvement • Storm Sewer: Pipe Replacement	$933,000
GC_07	• Tier 3 • Hydraulic Improvement • Storm Sewer: Pipe Replacement	$184,000
GC_08	• Tier 2 • Combined Hydraulic/Water Quality Improvement • Storm Sewer: Pipe Replacement • Proprietary BMP	$476,000
GC_09	• Tier 2 • Combined Hydraulic/Water Quality Improvement • Storm Sewer: Pipe Replacement • Constructed Wetland	$957,000
	Total	**$12,448,000**

6.3.7 Recommendations – Kings Gulch Subbasin

The recommended plan for the Kings Gulch Subbasin includes one individual CIP project, which is summarized in the following table. It is a water quality improvement project.

Table 6.3-8: Summary of Recommended Improvements - Kings Gulch Subbasin

ID	Improvement Category	Capital Cost ($)
WQIMP_15 (KG_01)	Water Quality Improvement Proprietary BMP	$93,000
	Total	**$93,000**

6.3.8 Recommendations – Lower Boulder Creek Subbasin

The recommended plan for the Lower Boulder Creek Subbasin includes two individual CIP projects, which are summarized in the following table. Both of the projects are water quality improvement projects.

Table 6.3-9: Summary of Recommended Improvements - Lower Boulder Creek Subbasin

ID	Improvement Category	Capital Cost ($)
WQIMP_05 (LBC_01)	Water Quality Improvement Proprietary BMP	$97,000
WQIMP_02 (LBC_02)	Water Quality Improvement Proprietary BMP	$133,000
	Total	**$230,000**

6.3.9 Recommendations – Middle Boulder Creek Subbasin

The recommended plan for the Middle Boulder Creek Subbasin includes twenty three individual CIP projects, which are summarized in the following table. Twelve of the projects are hydraulic improvement projects, seven are water quality improvement projects, and four are combined hydraulic/water quality improvement projects.

Table 6.3-10: Summary of Recommended Improvements - Middle Boulder Creek Subbasin

ID	Improvement Category	Capital Cost ($)
MBC_01	• Tier 3 • Hydraulic Improvement • Storm Sewer: Pipe Replacement	$177,000
MBC_02	• Tier 3 • Hydraulic Improvement • Storm Sewer: Pipe Replacement	$267,000
WQIMP_14 (MBC_03)	• Water Quality Improvement • Proprietary BMP	$93,000
MBC_04	• Tier 2 • Hydraulic Improvement • Storm Sewer: Pipe Replacement	$733,000
WQIMP_18 (MBC_05)	• Water Quality Improvement • Proprietary BMP	$65,000
WQIMP_06 WQIMP_09 (MBC_06)	• Water Quality Improvement • Proprietary BMP	$201,000
WQIMP_16 (MBC_07)	• Water Quality Improvement • Proprietary BMP	$104,000
MBC_08	• Tier 3 • Hydraulic Improvement • Storm Sewer: Pipe Replacement	$1,209,000
MBC_09	• Tier 2 • Hydraulic Improvement • Storm Sewer: Pipe Replacement	$1,224,000
WQIMP_08 (MBC_11)	• Water Quality Improvement • Proprietary BMP	$108,000
WQIMP_12	• Water Quality Improvement	$100,000

ID	Improvement Category	Capital Cost ($)
(MBC_12)	• Proprietary BMP	
MBC_13	• Tier 3 • Hydraulic Improvement • Storm Sewer: Pipe Replacement	$754,000
MBC_14	• Tier 1 • Combined Hydraulic/Water Quality Improvement • Storm Sewer: • Pipe Replacement • Storm Sewer Re-Routing/Extension • Proprietary BMP	$2,076,000
MBC_15	• Tier 3 • Hydraulic Improvement • Storm Sewer: Pipe Replacement	$139,000
WQIMP_03 (MBC_16)	• Water Quality Improvement • Proprietary BMP	$104,000
MBC_17	• Tier 3 • Hydraulic Improvement • Storm Sewer: Pipe Replacement	$480,000
MBC_19	• Tier 3 • Combined Hydraulic/Water Quality Improvement • Storm Sewer: Pipe Replacement • Proprietary BMP	$408,000
MBC_20	• Tier 2 • Hydraulic Improvement • Storm Sewer: Pipe Replacement	$88,000
MBC_21	• Tier 3 • Hydraulic Improvement • Storm Sewer: Pipe Replacement	$221,000
MBC_22	• Tier 2 • Hydraulic Improvement • Storm Sewer: Pipe Replacement	$2,298,000
MBC_23	• Tier 2 • Combined Hydraulic/Water Quality Improvement • Storm Sewer: Pipe Replacement • Proprietary BMP	$445,000
	Total	**$11,294,000**

6.3.10 Recommendations – Skunk Creek Subbasin

The recommended plan for the Skunk Creek Subbasin includes two individual CIP projects, which are summarized in the following table. Both of the projects are hydraulic improvement projects.

Table 6.3-11: Summary of Recommended Improvements - Skunk Creek Subbasin

ID	Improvement Category	Capital Cost ($)
SC_01	• Tier 2 • Hydraulic Improvement • Storm Sewer: • Pipe Replacement • Diversion to Major Drainageway	$1,250,000
SC_02	• Tier 2 • Hydraulic Improvement	$1,135,000

ID	Improvement Category	Capital Cost ($)
	• Storm Sewer: Pipe Replacement	
	Total	**$2,385,000**

6.3.11 Recommendations – Viele Channel Subbasin

The recommended plan for the Viele Channel Subbasin includes two individual CIP projects, which are summarized in the following table. Both of the projects are hydraulic improvement projects.

Table 6.3-12: Summary of Recommended Improvements - Viele Channel Subbasin

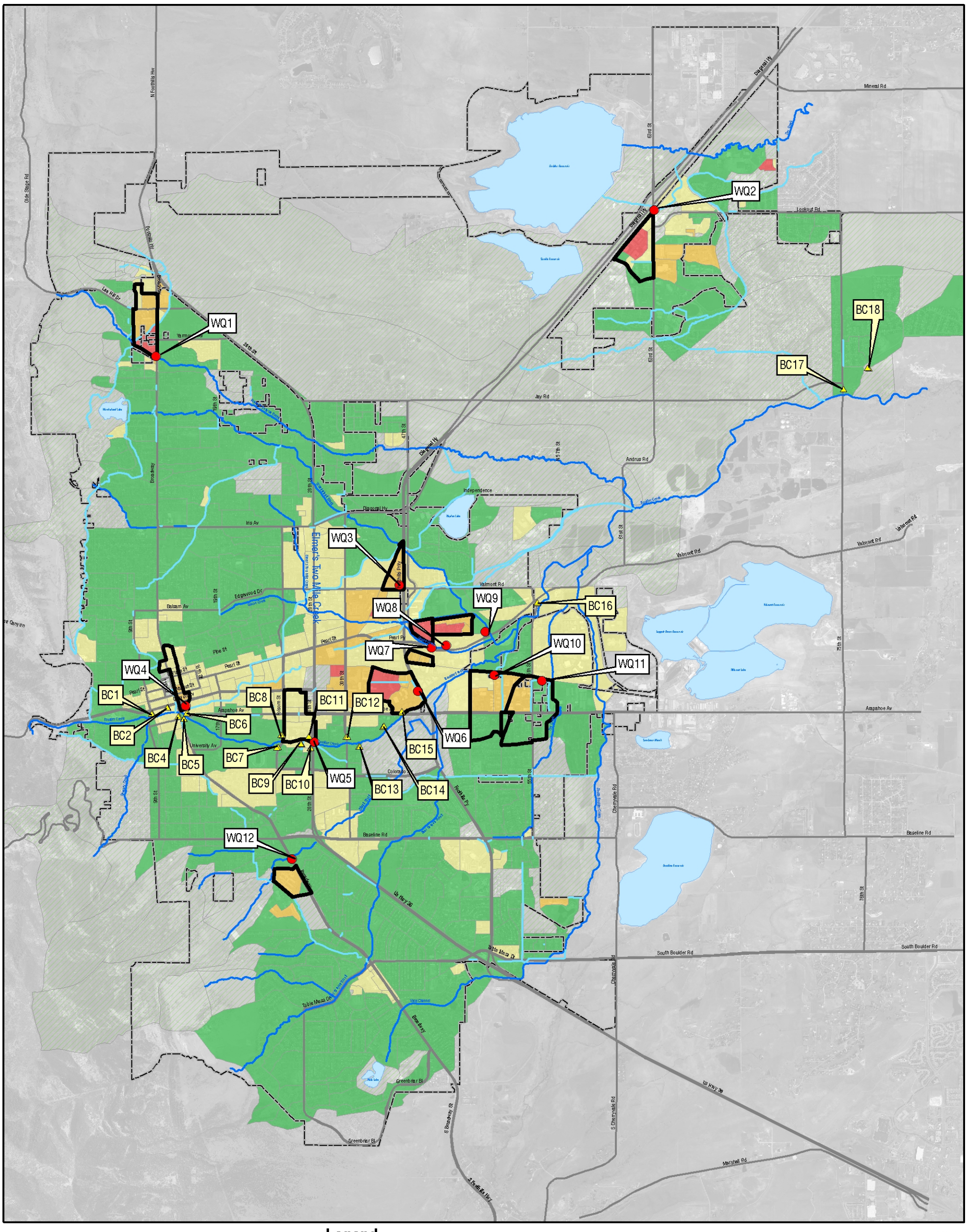
ID	Improvement Category	Capital Cost ($)
VC_01	Tier 3 Hydraulic Improvement Storm Sewer: Pipe Replacement	$1,296,000
VC_02	Tier 3 Hydraulic Improvement Storm Sewer: Pipe Replacement	$1,655,000
	Total	**$2,951,000**

6.3.12 Recommendations – Wonderland Creek Subbasin

The recommended plan for the Wonderland Creek Subbasin includes three individual CIP projects, which are summarized in the following table. All three of the projects are hydraulic improvement projects.

Table 6.3-13: Summary of Recommended Improvements - Wonderland Creek Subbasin

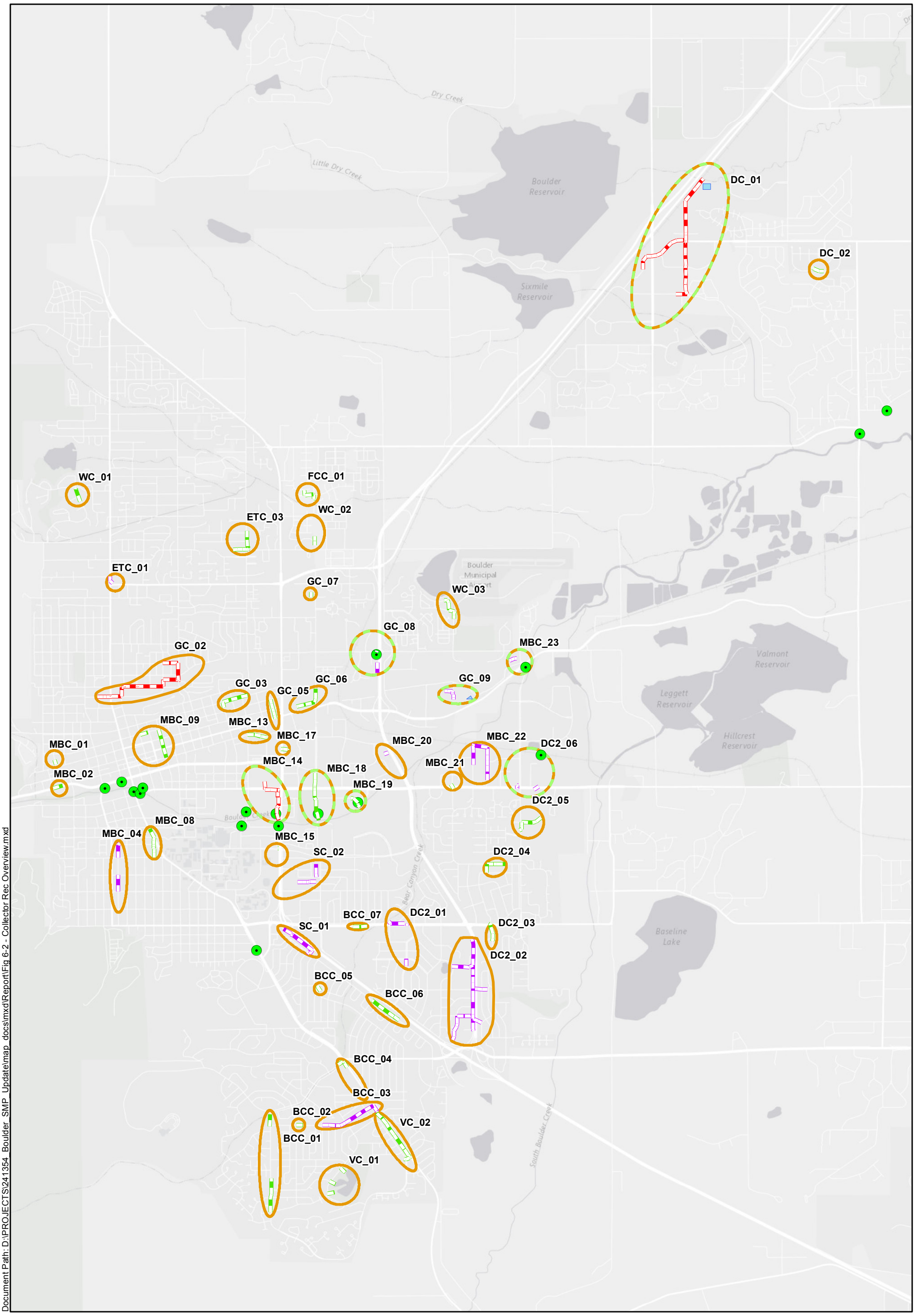
ID	Improvement Category	Capital Cost ($)
WC_01	• Tier 3 • Hydraulic Improvement • Storm Sewer: Pipe Replacement	$324,000
WC_02	• Tier 3 • Hydraulic Improvement • Storm Sewer: Pipe Replacement	$402,000
WC_03	• Tier 2 • Hydraulic Improvement • Storm Sewer: Pipe Replacement	$810,000
	Total	**$1,536,000**



Collector System
Water Quality Improvement Summary Map

HDR
ONE COMPANY | *Many Solutions* SM

Figure 6-1



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2007 SMP Collector System Improvements (Updated)

- Tier 1 Pipes
- Tier 2 Pipes
- Tier 3 Pipes
- Water Quality Manhole
- Water Quality Surface BMP
- Collector System Improvement Area
- Combined Collector and WQ Improvement Area

Collector System Recommended Plan Overview Map

Figure 6-2

7 Local System Improvement Recommendations Summary

Recommended improvements for the local system problem areas were developed and are presented in on Figure 7-1. Consistent with the collector system recommendations, itemized cost estimates were developed for each improvement recommendation with an anticipated level of accuracy of +50% to –30% (order-of-magnitude cost estimates). The cost estimate worksheets are included in the appendix for reference.

The local system improvements were prioritized through a series of evaluation criteria with the result being the Tier I projects having the highest priority in this analysis. As a result, the Tier I improvement projects received additional modeling and analysis using the XPSWMM model in an effort to refine recommended improvement size, alignment, and profile. In addition, the modeling approach evaluated if downstream problems were created by the proposed local system improvements as a result of increased flows. This downstream analysis evaluated the capacity of the existing system and improvements to the collector syste. If downstream conveyance problems were created in the existing system, improvements to those downstream conveyances were developed and added to the overall project recommendation. Similarly, if capacity increases were required in the 2007 SMP collector system recommendations as a result of these local system improvements, those collector system improvements were updated to account for peak flow increases.

The sizing of the recommended improvements for the Tier II and Tier III problem areas were not based on the results of the XPSWMM hydrologic and hydraulic model in an effort to minimize the level of effort associated with developing planning level, order-of-magnitude costs for these relatively lower problem priority areas. Rather, these improvements have been estimated on existing condition modeled flows, unit flow per acre estimates, and other approximate methods to estimate the conveyance system size. These estimates of conveyance system size were combined with the improvement alignments to develop a conceptual or order-of-magnitude level estimate of construction cost.

7.1 Tier I Improvements

The following tables provide a summary of the recommended plan for each subbasin and include a Project ID, a description of the project improvement, technical and implementation comments, and planning level capital cost estimate.

Table 7.1-1: Tier I Improvement Summary

	Problem Name	ID	Improvement Type	Priority	Cost
1	Wonderland Creek - 1	WC_LI1	New and Replacement Storm Sewer	Tier I	$318,000
2	Elmer's Twomile Creek - 2	ETC_LI2	New and Replacement Storm Sewer	Tier I	$3,874,000
3	Goose Creek - 1	GC_LI1	New and Replacement Storm Sewer	Tier I	$1,585,000
4	Goose Creek - 2	GC_LI2	New and Replacement Storm Sewer	Tier I	$2,417,000
5	Goose Creek - 3	GC_LI3	New and Replacement Storm Sewer	Tier I	$984,000
6	Middle Boulder Creek - 2	MBC_LI2	New and Replacement Storm Sewer	Tier I	$3,175,000
7	Dry Creek No. 2 - 1	DC2_LI1	New and Replacement Storm	Tier I	$1,837,000

			Sewer		
8	Dry Creek No. 2 - 3	DC2_LI3	New and Replacement Storm Sewer	Tier I	$6,505,000
9	Bear Canyon Creek - 3	BrCC_LI3	Hydraulic Improvement	Tier I	$2,265,000
10	Bear Canyon Creek - 5	BrCC_LI5	Hydraulic Improvement	Tier I	$267,000
	TOTAL				**$23,227,000**

7.2 Tier II Improvements

The following tables provide a summary of the recommended plan for each subbasin and include a Project ID, a description of the project improvement, technical and implementation comments, and planning level capital cost estimate.

Table 7.2-1: Tier II Improvement Summary

	Problem Name	ID	Improvement Type	Priority	Cost
11	Goose Creek - 5	GC_LI5	New Storm Sewer	Tier II	$5,484,000
12	Wonderland Creek - 7	WC_LI7	New Storm Sewer	Tier II	$2,452,000
13	Twomile Canyon Creek - 1	TCC_LI1	New Storm Sewer	Tier II	$2,939,000
14	Viele Channel - 1	VC_LI1	New Storm Sewer	Tier II	$936,000
15	Wonderland Creek - 2	WC_LI2	New Storm Sewer	Tier II	$1,925,000
16	Bear Canyon Creek - 4	BrCC_LI4	New Storm Sewer	Tier II	$726,000
17	Goose Creek - 4	GC_LI4	New Storm Sewer	Tier II	$4,885,000
18	Middle Boulder Creek - 3	MBC_LI3	New and Replacement Storm Sewer	Tier II	$2,826,000
19	Fourmile Canyon Creek - 1	FCC_LI1	New Storm Sewer	Tier II	$688,000
20	Bear Canyon Creek - 1	BrCC_LI1	New Storm Sewer	Tier II	$69,000
21	Bluebell Canyon Creek - 1	BbCC_LI1	New and Replacement Storm Sewer	Tier II	$1,137,000
	TOTAL				**$24,067,000**

7.3 Tier III Improvements

The Tier III improvements are the lowest priority improvements and are shown on Figure 7-1. The following summary table provides a brief description of the recommended improvement and planning level capital cost estimate for each subbasin.

Table 7.3-1: Tier III Improvement Summary

	Problem Name	ID	Improvement Type	Improvement Description	Cost
22	Dry Creek No. 2 - 2	DC2_LI2	New and Replacement Storm Sewer	New system in Pinon and Meadowbrook, connect to existing system in Baseline Rd	$726,000
23	Dry Creek No. 2 - 5	DC2_LI5	New Storm Sewer	New system in McKinley, Eisenhower, and 4th St, connect to existing system in Arapahoe Ave	$2,386,000
24	Dry Creek No. 2 - 6	DC2_LI6	New Storm Sewer	New system in Merritt Dr with collection from	$1,689,000

				Arapahoe Ridge Park, connect to existing system north of Patton Dr	
25	Goose Creek - 6	GC_LI6	New and Replacement Storm Sewer	New system west of 20th St. Replace existing system in 20th St and Glenwood Dr west of 23rd St	$1,946,000
26	Goose Creek - 8	GC_LI8	New and Replacement Storm Sewer	New systems in 23rd and 24th St. Replace and extend existing system in Fremont St	$932,000
27	Wonderland Creek - 6	WC_LI6	New Storm Sewer	New system in 20th St north of Orchard Ave discharging into Wonderland Creek	$366,000
28	Dry Creek No. 2 - 8	DC2_LI8	New and Replacement Storm Sewer	New system in Holmes and White Place, connect to existing system in 55th St	$604,000
29	Goose Creek - 7	GC_LI7	New and Replacement Storm Sewer	New system in Glenwood Dr East of Folsom St. Replace system in Glenwood Dr west of Folsom and system in Folsom north of Glenwood Dr	$1,913,000
30	Elmers Twomile Creek - 1	ETC_LI1	New Storm Sewer and Open Channel	New storm sewer and open channel between residential parcels northwest of Del Rosa Ct and 19th St	$98,000
31	Middle Boulder Creek - 1	MBC_LI1	New Storm Sewer and Open Channel	New storm sewer and open channel north of Grandview Ave, discharging into Boulder Creek	$176,000
32	Dry Creek No. 2 - 4	DC2_LI4	New Storm Sewer	New system in Pawnee Dr discharging into existing Thunderbird Lake	$976,000
33	Dry Creek No. 2 - 7	DC2_LI7	Replacement Storm Sewer	Replace existing system in Lodge Lane	$801,000
34	Wonderland Creek - 3	WC_LI3	New Open Channel	New open channel in Boulder Open Space behind residential lots northwest of Utica Ave and Locust Pl	$24,000
35	Wonderland Creek - 4	WC_LI4	New Open Channel	New open channel in Boulder Open Space behind residential lots northwest of Promontory Ct	$20,000
	TOTAL				**$12,657,000**

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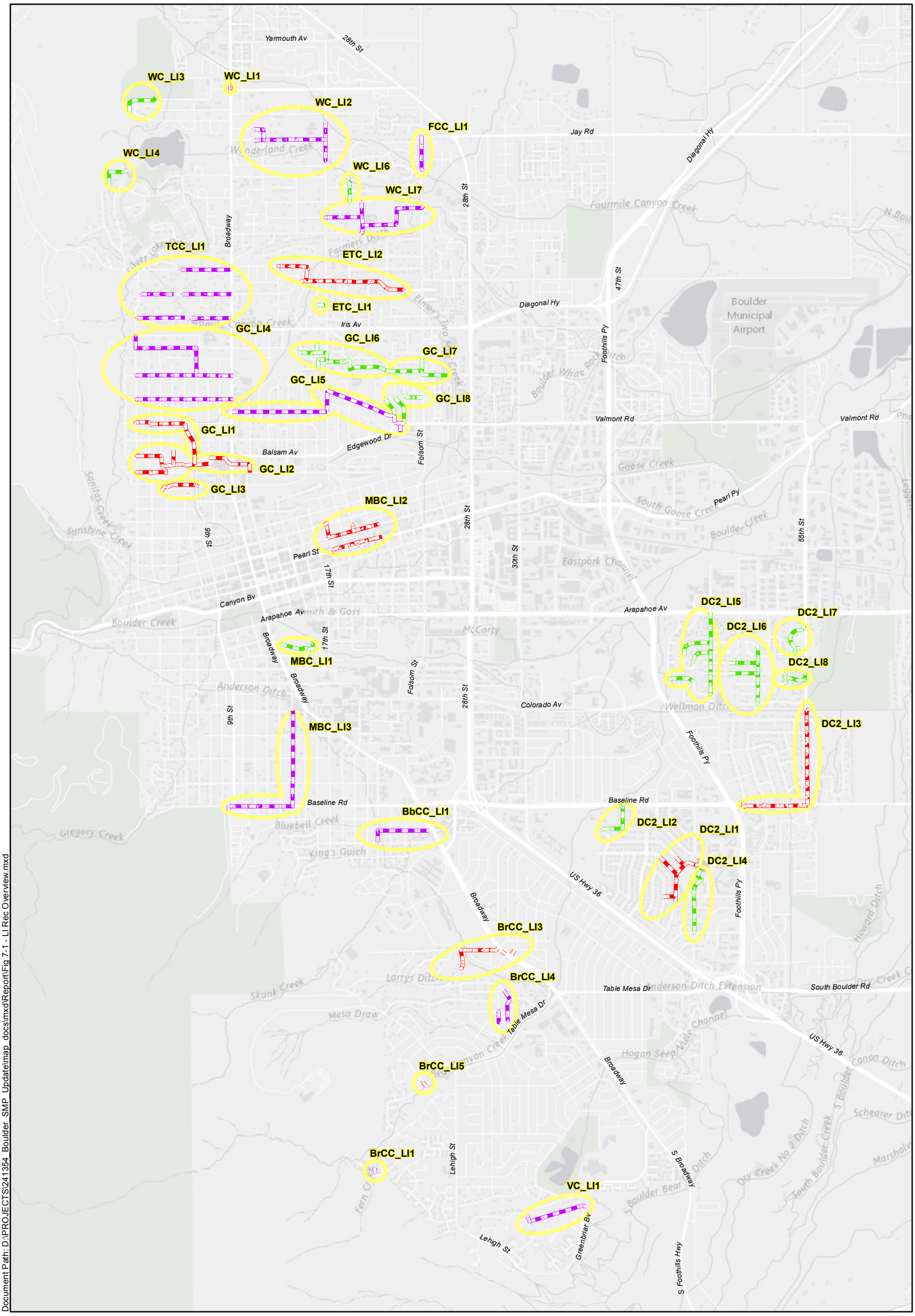

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Local Storm Drain System Improvements

- Tier I Pipes
- Tier II Pipes
- Tier III Pipes
- Local System Improvement Area

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Local System Recommended Plan Overview Map

Figure 7-1

8 Capital Improvement Program

The capital improvement program provides a summary of the recommended local and collector system improvements, their respective priorities, and associated capital costs.

8.1 Cost Estimating

Itemized cost estimates were developed for each CIP project with an anticipated level of accuracy of +50% to –30% (order-of-magnitude cost estimates). The cost estimate worksheets are included in the appendix for reference. The estimates include capital construction costs and land acquisition estimates. Unit costs were obtained from recent bid tabs and *Site Work and Landscape Cost Data, RSMeans*®, and equipment suppliers. Unit costs for pipeline construction, manholes and inlets include material, excavation, and backfill. Surface restoration was developed as a separate cost item. Utility relocation cost were developed as a separate item for sewer line relocations and for watermain lowerings 16" in diameter and greater. Minor utility relocations including, water and sewer service laterals, were accounted for as an allowance of the total construction cost. Quantities for pipes, inlets, manholes, and water quality facilities were obtained from the project GIS.

The cost estimates also include a 30% construction contingency and an 18% allowance for engineering and administration. All estimates are in 2015 dollars and equate to an *Engineering News Record, Construction Cost Index* of 10092,

8.2 Collector System Implementation Plan

The implementation plan for the Hydraulic and Combined Hydraulic/Water Quality CIP projects follows the Tier 1, 2 and 3 problem areas. Tier 1 CIP projects are considered high priority improvements as they resolve severe conveyance system problems and in some instances address stormwater quality problems. Table 7.2-1 identifies the Tier 1, Tier 2 and 3 CIP projects and are shown on Figures 8-1 through 8-3.

Table 8.2-1: Collector System Tier 1, Tier 2 and Tier 3 CIP Projects Implementation Plan

Problem Priority	Ranking	Improvement ID	Location	Improvement Type	Capital Cost
Tier 1	1	GC_02	Alpine Avenue , west of 19th Avenue, in and near Broadway south towards Dewey Street and north towards North Boulder Park	Pipe Replacement New Storm Sewer Channel Improvements	$8,269,000
Tier 1	3	MBC_14	Arapahoe and 28th Street	Pipe Replacement Storm Sewer Re-Routing/Extension Proprietary BMP	$2,076,000
Tier 1/2	4/13	DC_01	Gunbarrel – Spine Road, Lookout and 63rd Systems	Pipe Replacement Storm Sewer Re-Routing/Extension Constructed Wetland	$7,195,000

Table 8.2-1: Collector System Tier 1, Tier 2 and Tier 3 CIP Projects Implementation Plan

Problem Priority	Ranking	Improvement ID	Location	Improvement Type	Capital Cost
Tier 2	5	SC_01	Moorhead and Moorhead frontage	Pipe Replacement Diversion to Major Drainageway	$1,250,000
Tier 2	6	MBC_04	Lincoln	Pipe Replacement	$733,000
Tier 2	7	WC_03	Vail and Independence	Pipe Replacement	$810,000
Tier 2	8	MBC_22	Arapahoe, Commerce, and Range	Pipe Replacement	$2,298,000
Tier 2	9	MBC_20	Parking structure between Foothills and 38th	Pipe Replacement	$88,000
Tier 2	9	DC2_02	Thunderbird, Osage, and Foothills	Pipe Replacement	$5,364,000
Tier 2	11	GC_08	Foothills and Valmont	Pipe Replacement Proprietary BMP	$476,000
Tier 2	12	GC_09	Industrial area near Pearl Parkway and Wonderland Creek	Pipe Replacement Constructed Wetland	$957,000
Tier 2	14	ETC_01	Broadway and Iris	Pipe Replacement Diversion to Major Drainageway	$639,000
Tier 2	14	MBC_23	Access road and 55th St/Pearl and Boulder Creek	Pipe Replacement Proprietary BMP	$445,000
Tier 2	16	DC2_06	Arapahoe/56th Street and Dry Creek	Pipe Replacement Proprietary BMP	$637,000
Tier 2	18	SC_02	Euclid and 30th	Pipe Replacement	$1,135,000
Tier 2	19	MBC_09	16th St.	Pipe Replacement	$1,224,000
Tier 2/3	21/23	BCC_03	Gillaspie and Darley	Pipe Replacement Storm Sewer Re-Routing/Extension	$1,512,000
Tier 3	22	VC_01	Gillaspie and Heidelberg	Pipe Replacement	$1,296,000
Tier 3	23	VC_02	Broadway and Viele Channel	Pipe Replacement	$1,655,000
Tier 3	26	DC2_01	Baseline and Inca	Pipe Replacement	$1,226,000
Tier 3	27	BCC_04	Broadway and Bear Creek	Pipe Replacement	$540,000
Tier 3	27	DC2_05	55th and Dry Creek Number 2	Pipe Replacement	$770,000
Tier 3	29	GC_06	Pearl and 30th	Pipe Replacement	$933,000
Tier 3	30	DC2_04	Pennsylvania and Crescent	Pipe Replacement	$664,000
Tier 3	30	MBC_13	Folsom and Walnut	Pipe Replacement	$754,000
Tier 3	30	GC_03	23rd and Mapleton	Pipe Replacement	$819,000
Tier 3	33	WC_02	Island and Kalmia	Pipe Replacement	$402,000
Tier 3	33	BCC_01	Lehigh and Bear Creek	Pipe Replacement	$1,132,000
Tier 3	35	FCC_01	Hoya, Corriente and 30th	Pipe Replacement	$863,000

Table 8.2-1: Collector System Tier 1, Tier 2 and Tier 3 CIP Projects Implementation Plan

Problem Priority	Ranking	Improvement ID	Location	Improvement Type	Capital Cost
Tier 3	36	DC_02	Clubhouse and Augusta	Pipe Replacement	$411,000
Tier 3	36	GC_07	30th and Corona	Pipe Replacement	$184,000
Tier 3	36	WC_01	Wonderland Hill and Poplar	Pipe Replacement	$324,000
Tier 3	36	MBC_19	Marine Avenue and Boulder Creek	Pipe Replacement Proprietary BMP	$408,000
Tier 3	36	MBC_02	4th and Canyon	Pipe Replacement	$267,000
Tier 3	36	BCC_07	36th and Baseline	Pipe Replacement	$428,000
Tier 3	36	BCC_02	Hartford and Darley	Pipe Replacement	$184,000
Tier 3	36	BCC_06	42nd and Moorhead	Pipe Replacement	$373,000
Tier 3	36	BCC_05	Martin and Ash	Pipe Replacement	$200,000
Tier 3	48	ETC_03	26th and Kalmia	Pipe Replacement	$1,109,000
Tier 3	49	GC_05	27th and Spruce	Pipe Replacement	$810,000
Tier 3	50	MBC_15	28th and Colorado	Pipe Replacement	$139,000
Tier 3	50	MBC_08	13th and Broadway	Pipe Replacement	$1,209,000
Tier 3	50	DC2_03	Manhattan and Baseline	Pipe Replacement	$603,000
Tier 3	53	MBC_01	5th and Mountain View	Pipe Replacement	$177,000
Tier 3	54	MBC_21	48th and Arapahoe	Pipe Replacement	$221,000
Tier 3	55	MBC_17	28th, 500' north of Canyon	Pipe Replacement	$480,000

The implementation plan for the WQIMP projects were prioritized based on problem severity as identified by pollutant load. The WQIMP category was developed since many of the water quality project sites were not adjacent to hydraulic problem and improvement locations. In addition, many of these WQIMP projects could be defined as a small capital projects since the estimated construction costs are less than $100,000.

Table 8.2-2: Water Quality Improvements Implementation Plan

Improvement ID	Annual TSS Load (pounds)	Location	Capital Cost
WQIMP 2	61,900	Boulder Creek 1,400' East of 75th Street	$133,000
WQIMP 3	56,500	Boulder Creek & 28th Street	$104,000
WQIMP 5	46,200	Boulder Creek & 75th Street	$97,000
WQIMP 6 WQIMP 9	45,700 & 38,400	Boulder Creek & East Broadway Street & Arapahoe Avenue	$201,000
WQIMP 8	41,500	Boulder Creek 200' West of Folsom Street	$108,000

WQIMP 12	29,000	Boulder Creek & Folsom Street	$100,000
WQIMP 14	24,200	Boulder Creek & 9th Street	$93,000
WQIMP 15	22,800	Broadway & Skunk Creek	$93,000
WQIMP 16	20,300	Boulder Creek & 13th Street	$104,000
WQIMP 18	15,000	Boulder Creek & 11th Street	$65,000

8.3 Local System Implementation Plan

The implementation plan for the local drainage system CIP projects follows the Tier I, II and III problem areas. Tier I CIP projects are considered high priority improvements as they resolve more severe local system problems. The following table identifies the Tier I, Tier II and III local system CIP projects and are shown on Figures 8-4 and 8-5.

Table 8.3-3: Local System Tier I, Tier II and Tier III Projects Implementation Plan

Problem Priority	Ranking	Project ID	Location	Improvement Type	Capital Cost
Tier I	1	Wonderland Creek -1	Broadway Street from Rosewood Ave to Violet Ave	New Storm Sewer Replacement Storm Sewer	$318,000
Tier I	2	Elmer's Twomile Creek-2	Farmer's Ditch – Iris Ave to Linden Ave and Broadway St to Cloverleaf Drive	New Storm Sewer Replacement Storm Sewer	$3,874,000
Tier I	3	Goose Creek-1	Intersection of 8th St and Dellwood Ave	New Storm Sewer Replacement Storm Sewer	$1,585,000
Tier I	4	Goose Creek-2	Alpine Ave to Dellwood Ave and 3rd St to 7th St	New Storm Sewer Replacement Storm Sewer	$2,417,000
Tier I	5	Goose Creek-3	Dewey Ave from 4th St to 9th St	New Storm Sewer Replacement Storm Sewer	$984,000
Tier I	6	Middle Boulder Creek-2	Vicinity of Pine Street from 16th St to 21st St	New Storm Sewer Replacement Storm Sewer	$3,175,000
Tier I	7	Dry Creek No, 2-1	Intersection of Chippewa Dr and Caddo Pkwy east of Inca Pkwy	New Storm Sewer Replacement Storm Sewer	$1,837,000
Tier I	8	Dry Creek No 2-3	Intersection of Chippewa Dr Baseline and 55th St from Foothills Hwy to Arapahoe Ave	New Storm Sewer Replacement Storm Sewer	$6,505,000
Tier I	9	Bear Canyon Creek-3	Vicinity of Kohler Dr from south of Dartmouth Ave	Hydraulic Improvement	$2,265,000
Tier I	10	Bear Canyon Creek-5	Vicinity of Wildwood Rd	Hydraulic Improvement	$267,000

Table 8.3-3: Local System Tier I, Tier II and Tier III Projects Implementation Plan

Problem Priority	Ranking	Project ID	Location	Improvement Type	Capital Cost
Tier II	11	Goose Creek-5	Vicinity of Cedar Ave and 19th St	New Storm Sewer	$5,484,000
Tier II	12	Wonderland Creek-7	Vicinity of Oak Ave and 21st Ave	New Storm Sewer	$2,452,000
Tier II	13	Twomile Canyon Creek-1	Kalmia Ave and Juniper Av west of Broadway Ave	New Storm Sewer	$2,939,000
Tier II	14	Viele Channe-1	Longwood Ave an Lafayette Dr from Lehigh St to Greenbriar Blvd	New Storm Sewer	$936,000
Tier II	15	Wonderland Creek-2	Intersection of 19th St and Sumac Ave	New Storm Sewer	$1,925,000
Tier II	16	Bear Canyon Creek-4	Vicinity of Yale Rd and Hartford Dr	New Storm Sewer	$726,000
Tier II	17	Goose Creek-4	Vicinity of Forest Ave between 3rd St and Broadway St	New Storm Sewer	$4,885,000
Tier II	18	Middle Boulder Creek-3	Vicinity of Cascade Ave from College Ave to Chautauqua Reservoir Rd	New Storm Sewer Replacement Storm Sewer	$2,826,000
Tier II	19	Fourmile Canyon Creek-1	Vicinity of Jay Rd and 26th St	New Storm Sewer	$688,000
Tier II	20	Bear Canyon Creek-1	Bear Canyon Creek, downstream of Stony Hill Ct crossing	New Storm Sewer	$69,000
Tier II	21	Bluebell Canyon Creek-1	Intersection of 20th St and Mariposa Ave	New Storm Sewer Replacement Storm Sewer	$1,137,000
Tier III	22	Dry Creek No 2-2	Pinon and Meadowbrook	New Storm Sewer Replacement Storm Sewer	$726,000
Tier III	23	Dry Creek No 2-5	McKinley, Eisenhower, and 4th St	New Storm Sewer	$2,386,000
Tier III	24	Dry Creek No 2-6	Merritt Dr at Araphahoe Ridge Park	New Storm Sewer	$1,689,000
Tier III	25	Goose Creek-6	20th St and Glenwood Dr, west of 23rd St	New Storm Sewer Replacement Storm Sewer	$1,946,000
Tier III	26	Goose Creek-8	23rd St and 24th St at	New Storm Sewer Replacement Storm Sewer	$932,000
Tier III	27	Wonderland Creek-6	20th St north of Orchard Ave	New Storm Sewer	$366,000

Table 8.3-3: Local System Tier I, Tier II and Tier III Projects Implementation Plan

Problem Priority	Ranking	Project ID	Location	Improvement Type	Capital Cost
Tier III	28	Dry Creek No 2-8	Holmes and White Place	New Storm Sewer Replacement Storm Sewer	$604,000
Tier III	29	Goose Creek-7	Glenwood Dr east and west of Folsom St, Folsom St	New Storm Sewer Replacement Storm Sewer	$1,913,000
Tier III	30	Elmers Twomile Creek-1	Northwest of Del Rosa Ct and 19th St	New Storm Sewer New Open Channel	$98,000
Tier III	31	Middle Boulder Creek-1	North of Grandview Ave	New Storm Sewer New Open Channel	$176,000
Tier III	32	Dry Creek No 2-4	Pawnee Dr	New Storm Sewer	$976,000
Tier III	33	Dry Creek No 2-7	Lodge Lane	Replacement Storm Sewer	$801,000
Tier III	34	Wonderland Creek-3	Boulder Open Space northwest of Utica Ave and Locust Pl	New Open Channel	$24,000
Tier III	35	Wonderland Creek-4	Boulder Open Space northwest of Promontory Ct	New Open Channel	$20,000

8.4 Collector Storm Sewer System Recommended Plan Summary Tables

Summary tables were developed to provide details regarding each of the Tier 1 and Tier 2 problem priority areas. In addition, fact sheets were also developed for three Tier 3 problem priority areas that have associated WQIMP projects. These fact sheets provide the problem ID, improvement location and alignment, technical data for initiating the design process, land ownership and acquisition needs, implementation issues, and an estimate of the capital construction costs. The problem ID can be used with the technical memorandums TM 4.1a – Problem Prioritization and TM 5.1 Hydraulic Concept Alternatives, to research the problem causes and severity.

8.4.1 Tier 1 Priority Improvements

This section includes fact sheets that provide details for each of the Tier 1 problem priority areas in the Recommended Plan.

GC_02: UPPER GOOSE CREEK	
Subbasin/Outfall:	Goose Creek Subbasin, Outfall to Goose Creek
Problem ID:	**HYD#16 (Tier 1 Priority Level)**
Improvement Description	Construct a new collector storm sewer system from the outfall to the Upper Goose Creek channel (aka Edgewood Reach) at 19th Street extending west in Alpine Avenue to North Street and north to Cedar Street. The 19th Street to North Street system ranges from 4'x12' RCB to 48" RCP storm sewer. The 19th Street to Cedar Avenue system ranges in diameter from 60"x30" HERCP to 30" RCP storm sewer system. The existing system between North Street and Alpine Avenue is to remain in-service to provide local drainage conveyance for the private parcels/backyards.
Technical Data:	The system is required to convey the 5-yr storm (510 cfs at the 19th Street outfall).
Land Ownership:	All construction west of 19th Avenue would be within Public ROW.
Implementation Issues:	Restricted construction access for Edgewood reach channel improvements Large storm sewer sizes in an urbanized area will create traffic control and utility issues Phased construction due to high capital cost Potential for high groundwater
Capital Cost:	$8,269,000

MBC_14: ARAPAHOE AND 28TH STREET	
Subbasin/Outfall:	Middle Boulder Creek Subbasin, Outfall to Boulder Creek
Problem ID:	**HYD#55 (Tier 1 Priority Level), WQIMP 10 (Boulder Creek Outfall)**
Improvement Description	Construct a new diversion manhole on Folsom St, south of Arapahoe to tie the western storm sewer system into the existing 48" system along the west side of Folsom (with available capacity). Replace existing under capacity storm sewer along 26th, Arapahoe and 28th and construct a new 36" to 42" pipe along 28th Street between Arapahoe and Boulder Creek to convey both the eastern and western systems. Install a proprietary BMP along 28th Street near the outfall to Boulder Creek.
Technical Data:	The system is required to convey the 5-yr storm Q(wq) – 7.32 cfs Size of manhole: 10-foot Size of connector pipe: 30-inch
Land Ownership:	Public ROW and private property.
Implementation Issues:	Easement acquisition, approximately 500 ft, may be needed on the west side of 28th, south of the super market.
Capital Cost:	$2,076,000

DC_01: GUNBARREL – SPINE ROAD, LOOKOUT AND 63RD SYSTEMS	
Subbasin/Outfall:	Dry Creek Subbasin, Outfall to Dry Creek east of the Diagonal Highway
Problem ID:	**HYD#8 (Tier 1 Priority Level)**, **HYD#9 (Tier 2 Priority Level), WQIMP 01 (Hot Spot)**
Improvement Description	Replace the existing under capacity storm sewer system with pipe diameters that range from 30" to 60". Minor changes to existing pipe slopes are required to optimize the proposed diameters. The new storm sewer is typically located lower than the sanitary sewer to avoid conflicts with sewer mains and service laterals. Construct storm sewer along Lookout Rd to connect with system to east along Spine Road. Constructed wetland pond with discharge to Dry Creek.
Technical Data:	System is required to convey the 5-year storm. Pond Volume = 347,000 cu ft (8 acre feet) Pond surface area: 69,000 square feet
Land Ownership:	All construction would be within Public ROW south of Odel Road. North of Odel Road it is assumed the existing pipe is in an easement and no additional permanent easement acquisition would be required.
Implementation Issues:	Traffic control and business impacts (shipping/truck traffic) for construction in Spine Road and Lookout Road. Possible conflicts with existing sanitary sewers and 16 inch water main.
Capital Cost:	$7,195,000

8.4.2 Tier 2 Priority Improvements

This section includes fact sheets that provide details for each of the Tier 2 problem priority areas in the Recommended Plan.

SC_01: MOORHEAD AND MOORHEAD FRONTAGE	
Subbasin/Outfall:	Skunk Creek Subbasin, Outfall to Skunk Creek
Problem ID:	**HYD#42 (Tier 2 Priority Level)**
Improvement Description	Diversion to Bear Creek Ditch Construct a diversion manhole in the Moorhead/31st St. intersection to divert flow to a new storm sewer running northeast to discharge into the Bear Creek Ditch adjacent to Highway 36. Install a new storm sewer to replace the ditch. The alignment between the homes is to follow the existing storm sewers between 31st and 32nd. The existing ditch along Highway 36 could also be used instead of installing the 36" storm sewer. The ditch would need to be re-graded to flow consistently toward the north and the cross-section improved to convey the design flow.
Technical Data:	The system is required to convey the 5-yr storm
Land Ownership:	Construction through possible residential area
Implementation Issues:	Potential for relocating private utilities along Bear Creek Ditch. Construction on private property, between existing homes would require easement acquisition, approximately 160 ft. Limited space/width between the homes could also create difficulties during construction. Potential for high groundwater.
Capital Cost:	$1,250,000

MBC_04: LINCOLN	
Subbasin/Outfall:	Middle Boulder Creek Subbasin; Outfall to Anderson Ditch
Problem ID:	**HYD#41 (Tier 2 Priority Level)**
Improvement Description	Replace the existing under capacity storm sewer system between College and the Anderson Ditch and match existing grades.
Technical Data:	The system is required to convey the 2-yr storm
Land Ownership:	All construction would be within Public ROW.
Implementation Issues:	Construction in Lincoln would require traffic control. Limited cover north of College requires parallel pipes for the short connection to the Anderson Ditch. A transportation (road widening/bike lane) project is planned along 9th, west of Lincoln.
Capital Cost:	$733,000

WC_03: VAIL AND INDEPENDENCE	
Subbasin/Outfall:	Wonderland Creek Subbasin; Outfall to Boulder & Lefthand Ditch
Problem ID:	**HYD#19 (Tier 2 Priority Level)**
Improvement Description	Abandon the existing system that is routed under the existing trailers/mobile home and construct a new system in the street. The reservoir outlet needs to be confirmed prior to final design development. The reservoir was assumed to be full and therefore rainfall would spill into the outlet/storm sewer system.
Technical Data:	The system is required to convey the 2-yr storm
Land Ownership:	Construction would be within Public ROW.
Implementation Issues:	Probable water and sewer utility relocations and potential for relocating private utilities. A transportation (road widening/bike lane) project is planned adjacent to the existing storm sewer on the east side of Independence. Potential for high groundwater
Capital Cost:	$810,000

MBC_22: ARAPAHOE, COMMERCE, AND RANGE	
Subbasin/Outfall:	Middle Boulder Creek Subbasin, Outfall to a unknown tributary to Boulder Creek
Problem ID:	**HYD#24 (Tier 2 Priority Level)**
Improvement Description	Range Street System: Replace the existing under capacity storm sewer system along Range. Commerce Street System: Replace the existing under capacity storm sewer system along Commerce. As the 36" pipe crosses under the railroad embankment and is only slightly surcharge, it is recommended this pipe not be replaced.
Technical Data:	The system is required to convey the 5-yr storm
Land Ownership:	All construction would be within Public ROW.
Implementation Issues:	Potential for high groundwater
Capital Cost:	$2,298,000

MBC_20: PARKING STRUCTURE BETWEEN FOOTHILLS AND 38TH	
Subbasin/Outfall:	Middle Boulder Creek Subbasin, Outfall to Boulder Creek
Problem ID:	**HYD#29 (Tier 2 Priority Level)**
Improvement Description	Replace the existing under capacity storm sewer system and match existing grades.
Technical Data:	The system is required to convey the 5-yr storm
Land Ownership:	Private. Potential for pipe to be within a drainage easement.
Implementation Issues:	Potential for high groundwater
Capital Cost:	$88,000

DC2_02: THUNDERBIRD, OSAGE, AND FOOTHILLS	
Subbasin/Outfall:	Dry Creek Subbasin, Outfall Dry Creek No. 2 Ditch
Problem ID:	**HYD#47 (Tier 2 Priority Level)**
Improvement Description	(1) System Replacement - Along Foothills, Osage, and Qualla to Highway 36. Replace the under capacity and severely under capacity pipes. (2) System Replacement - Foothills to Thunderbird Lake. (3) System Replacement – Sioux between Iroquois & Seminole. (4) System Replacement – Across Foothills at Cherokee. Replace the existing under capacity storm sewer systems.
Technical Data:	(1) Foothills, 5-Year system. (2) Thunderbird Lake, 2-year system (3) Sioux, 2-Year system (4) Cherokee, 2 & 5-Year systems
Land Ownership:	Construction would be within Public ROW and some private/public lawn areas.
Implementation Issues:	Potential for high groundwater. Boring will be required to cross foothills. Thunderbird Lake system has shallow cover issues and may require a parallel HERCP system. Possible conflicts with existing sanitary sewers and 16 inch water main. Final design process should consider an alternative alignment evaluation to remove the upstream crossing under Foothills Parkway as this will be a bore crossing. Consider routing flow north to the Foothills crossing at Sioux.
Capital Cost:	$5,364,000

GC_08: FOOTHILLS AND VALMONT	
Subbasin/Outfall:	Goose Creek Subbasin, Outfall to Goose Creek
Problem ID:	**HYD#27 (Tier 2 Priority Level), WQIMP 11 (Hot Spot)**
Improvement Description	Replace the existing under capacity 18" diameter storm sewer in Foothills, under Valmont and 36" diameter storm sewer in Foothills and match existing grades. Install a proprietary BMP southwest of the intersection of Foothills and Valmont.
Technical Data:	The system is required to convey the 5-yr storm Q(wq) – 5.54 cfs Size of manhole: 8-foot Size of connector pipe: 24-inch
Land Ownership:	All construction would be within Public ROW.
Implementation Issues:	Construction in Valmont would require traffic control and closing of the east and westbound lanes. A transportation (multi-use path) project is planned along the west side of Foothills Highway from Valmont to the Federal facility.
Capital Cost:	$476,000

ETC_01: BROADWAY AND IRIS	
Subbasin/Outfall:	Elmers Two Mile Canyon Creek Subbasin, Outfall to Farmers Ditch
Problem ID:	**HYD#15 (Tier 2 Priority Level)**
Improvement Description	Diversion to Major Drainageway Improvement Construct a diversion manhole at the Broadway/Iris intersection to divert excess flow from the collector system south into the planned Two Mile Canyon Creek (TMCC) major drainageway improvement. The TMCC improvement consists on a 54" storm sewer the runs south of Iris in Broadway then turns east on Hawthorne and continues to eventually outfall to Goose Creek as shown in GC_04.
Technical Data:	• The system is required to convey the 5-yr storm • Increase in 5-year flow to the TMCC project is approximately 20 cfs totaling about a 10% in the original design capacity. This would require 2,640' of 24" RCP to be increased to 60" RCP.
Land Ownership:	All construction would be within Public ROW with the exception of a drainage easement identified in the TMCC major drainageway project.
Implementation Issues:	Construction in Broadway would require significant traffic control. Potential for high groundwater
Capital Cost:	$639,000

GC_09: INDUSTRIAL AREA NEAR PEARL PARKWAY AND WONDERLAND CREEK	
Subbasin/Outfall:	Goose Creek Subbasin, Outfall to Goose Creek
Problem ID:	**HYD#21 (Tier 2 Priority Level), WQIMP 07 (Hot Spot)**
Improvement Description	Construct a new system that abandons the system that is routed under the existing building. The new pipe system would be routed in the middle of the access road. Constructed wetland pond in the city Yards (to be redesigned). Flow would be diverted from the collector systems to the pond via a diversion manhole and storm sewer. Flow from the water quality pond would be discharged to Wonderland Creek via the collector system. Flows in excess of the WQ storm would not be routed through the pond.
Technical Data:	The system is required to convey the 5-yr storm Pond volume = 40,800 cubic feet (0.9 acre feet) Pond surface area: 14,000 square feet
Land Ownership:	Private property. Being the system goes under a building it is doubtful an easement exists.
Implementation Issues:	Probable water and sewer utility relocations and potential for relocating private utilities. Little to no room may be available for relocation. An easement, approximately 220 ft, for Link 1748 will be needed.
Capital Cost:	$957,000

MBC_23: ACCESS RD AND 55TH ST/PEARL AND BOULDER CREEK	
Subbasin/Outfall:	Middle Boulder Creek Subbasin & 100-year flood zone, Outfall to Boulder Creek
Problem ID:	**HYD#20 (Tier 2 Priority Level), WQIMP 17 (Boulder Creek Outfall)**
Improvement Description	Replace the existing under capacity storm sewer system and match existing grades. Install a proprietary BMP along 55h Street near the outfall.
Technical Data:	The system is required to convey the 5-yr storm Q(wq) – 2.95 cfs Size of manhole: 8-foot Size of connector pipe: 24-inch
Land Ownership:	Some construction would be within Public ROW; Other construction may be within an assumed drainage easement across private property within the industrial area.
Implementation Issues:	Potential for high groundwater
Capital Cost:	$445,000

DC2_06: ARAPAHOE/56TH STREET AND DRY CREEK	
Subbasin/Outfall:	Dry Creek No.2 Subbasin and 100-year Flood Zone, Outfall to Dry Creek
Problem ID:	**HYD#22 (Tier 2 Priority Level), WQIMP 04 (Hot Spot)**
Improvement Description	Replace the existing under capacity storm sewer system and match existing grades. Install a proprietary BMP at northeast corner of the basin. Requires two diversion structures from two systems.
Technical Data:	The system is required to convey the 5-yr storm Q(wq) – 6.5 cfs Size of manhole: 8-foot Size of connector pipe: 24-inch
Land Ownership:	All construction would be within Public ROW.
Implementation Issues:	Construction in Arapahoe would require traffic control and closing of the lane(s). A transportation (road widening/multi-use path) project is planned along Arapahoe.
Capital Cost:	$637,000

SC_02: EUCLID AND 30TH	
Subbasin/Outfall:	Skunk Creek Subbasin, Outfall to Wellman Ditch
Problem ID:	**HYD#38 (Tier 2 Priority Level)**
Improvement Description	Replace the existing under capacity storm sewer system.
Technical Data:	The system is required to convey the 5-yr storm
Land Ownership:	Assumed located within drainage easement(s) through private property. May need to increase easement width as pipe diameters at downstream end are significantly larger.
Implementation Issues:	Confined construction behind condos and impacts to existing trees and landscaping would increase project costs and public involvement issues.
Capital Cost:	$1,135,000

MBC_09: 16TH ST.	
Subbasin/Outfall:	Middle Boulder Creek Subbasin, Outfall to North Boulder Farmers Ditch
Problem ID:	**HYD#35 (Tier 2 Priority Level)**
Improvement Description	System Replacement. Replace the existing under capacity storm sewer system in Pine and 16th Street,.
Technical Data:	The system is required to convey the 5-yr storm
Land Ownership:	All construction would be within Public ROW.
Implementation Issues:	Construction in 16th St. would require traffic control
Capital Cost:	$1,224,000

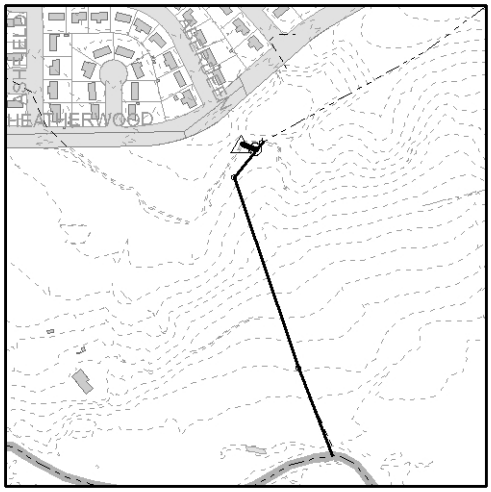
BCC_03: GILLASPIE AND SHOPPING CENTER PARKING	
Subbasin/Outfall:	Bear Canyon Creek Subbasin, Outfall to Bear Canyon Creek
Problem ID:	**HYD#49 (Tier 2 Priority Level), HYD#50 (Tier 3 Priority Level)**
Improvement Description	System Replacement/Diversion. Replace the existing under capacity storm sewer along Darley from Edinboro to Gillaspie. Construct a diversion manhole near the Darley/Gillaspie intersection to divert flow to a new storm sewer that continues northeast in Darley. This new storm sewer would connect with the existing storm sewer at the Darley/Toedtli intersection where it would eventually discharge into Viele Creek.
Technical Data:	• The system is required to convey the 2 and 5-yr storms
Land Ownership:	All construction would be within Public ROW.
Implementation Issues:	Construction in Darley and Broadway would require minor traffic control. Potential for high groundwater
Capital Cost:	$1,512,000

8.4.3 Water Quality Specific Projects

This section includes fact sheets for areas in the Recommended Plan that have only water quality improvements.

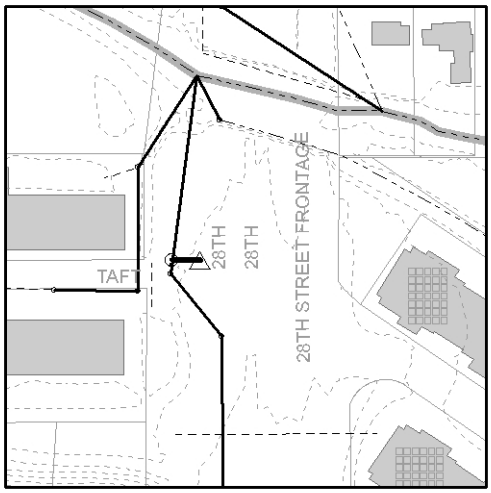
LBC_02: BOULDER CREEK 1,400' EAST OF 75TH STREET

Improvement Location:	The basin for WQIMP 02 consists of the east half of the area encompassed by Heatherwood Dr and 75th.
Improvement Description:	**WQIMP 02 (Boulder Creek Outfall)** - Install a proprietary BMP east of 75th near Aberdeen and Heatherwood
Technical Data:	• Q(wq) – 19.41 cfs • Size of manhole: 10-foot • Size of connector pipe: 30-inch
Land Ownership:	• City of Boulder
Implementation Issues:	• Maintenance access may be problematic.
Capital Cost:	$133,000



MBC_16: BOULDER CREEK & 28TH STREET

Improvement Location:	The basin for WQIMP 03 includes the area south of Boulder Creek along 28th to Colorado.
Improvement Description:	**WQIMP 03 (Boulder Creek Outfall)** - Install a proprietary BMP west of 28th near Boulder Creek
Technical Data:	• Q(wq) – 14.49 cfs • Size of manhole: 10-foot • Size of connector pipe: 30-inch
Land Ownership:	• Public ROW
Implementation Issues:	• CDOT ROW
Capital Cost:	$104,000



LBC_01: BOULDER CREEK & 75TH STREET

Improvement Location: The basin for WQIMP 05 includes the area about 450 ft wide along 75th from Boulder Creek north to Clubhouse.

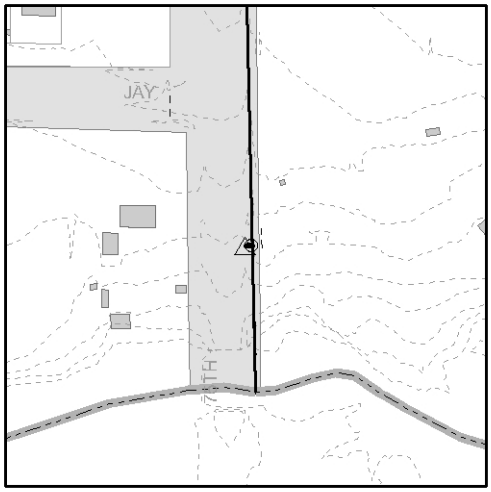
Improvement Description: **WQIMP 05 (Boulder Creek Outfall)** - Install a proprietary BMP along 75th.

Technical Data:
- Q(wq) – 11.72 cfs
- Size of manhole: 10-foot
- Size of connector pipe: 30-inch

Land Ownership:
- Construction would be within Public ROW.

Implementation Issues:
- Property acquisition

Capital Cost: $97,000



MBC_06: BOULDER CREEK & EAST BROADWAY STREET & ARAPAHOE AVENUE

Improvement Location: The basins for WQIMP 06 and WQIMP 09 include a large area south of Boulder Creek to Cascade about 1,200 ft wide on the east side of Broadway.

Improvement Description: **WQIMP 06 and WQIMP 09 (Boulder Creek Outfalls)** - Install a proprietary BMP west of Broadway near Boulder Creek and a second south of Arapahoe near Boulder Creek

Technical Data:

Broadway BMP
- Q(wq) – 22.48 cfs
- Size of manhole: 10-foot
- Size of connector pipe: 30-inch

Arapahoe BMP
- Q(wq) – 23.91 cfs
- Size of manhole: 10-foot
- Size of connector pipe: 30-inch

Land Ownership:
- City of Boulder

Implementation Issues:
- Construction in Broadway

Capital Cost: $201,000

MBC_11: BOULDER CREEK 200' WEST OF FOLSOM STREET

Improvement Location: The basin for WQIMP 08 includes the area south of Boulder Creek along Folsom to Colorado.

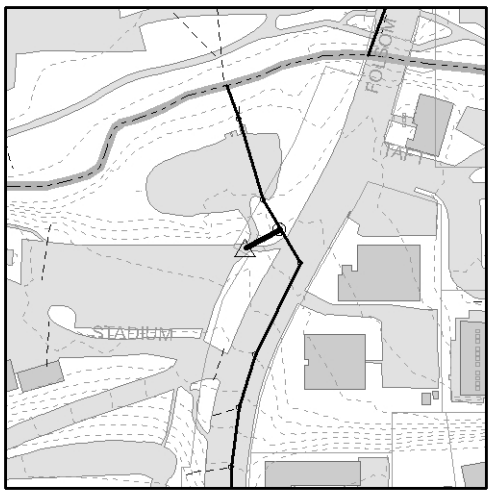
Improvement Description: **WQIMP 08 (Boulder Creek Outfall)** - Install a proprietary BMP west of Folsom south of Boulder Creek

Technical Data:
- Q(wq) – 10.13 cfs
- Size of manhole: 10-foot
- Size of connector pipe: 30-inch

Land Ownership:
- University of Colorado

Implementation Issues:
- Property acquisition

Capital Cost: $108,000



MBC_12: BOULDER CREEK & FOLSOM STREET

Improvement Location: The basin for WQIMP 12 includes the area north of Boulder Creek along Folsom to Arapahoe.

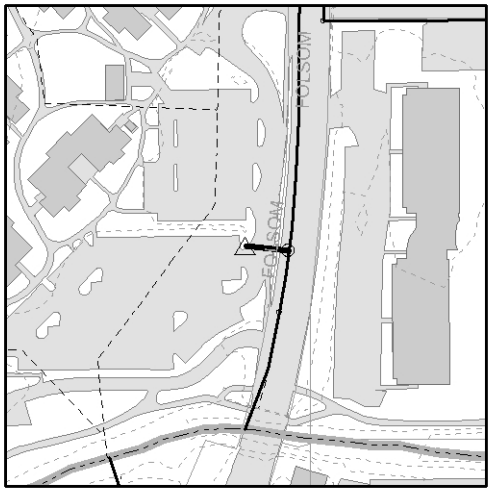
Improvement Description: **WQIMP 12 (Boulder Creek Outfall)** - Install a proprietary BMP west of Folsom north of Boulder Creek

Technical Data:
- Q(wq) – 6.32 cfs
- Size of manhole: 8-foot Size of connector pipe: 24-inch

Land Ownership:
- University of Colorado

Implementation Issues:
- Property acquisition.

Capital Cost: $100,000



MBC_03: BOULDER CREEK & 9TH STREET

Improvement Location: The basin for WQIMP 14 includes the area 200 ft wide along 9th from Boulder Creek to Walnut and east from 9th about 1,100 ft.

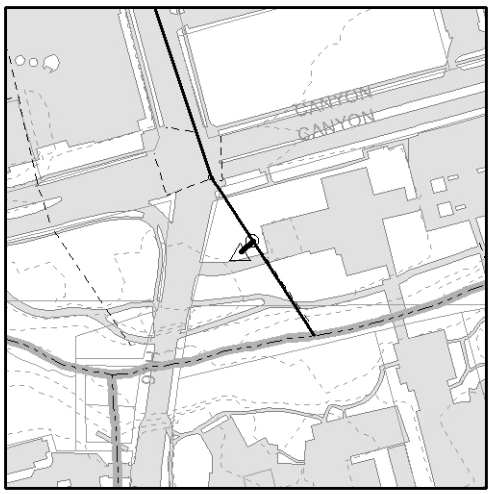
Improvement Description: **WQIMP 14 (Boulder Creek Outfall)** - Install a proprietary BMP near 9th and Canyon.

Technical Data:
- Q(wq) – 10.71 cfs
- Size of manhole: 10-foot
- Size of connector pipe: 30-inch

Land Ownership:
- City of Boulder

Implementation Issues:
- None identified

Capital Cost: $73,000



KG_01: BROADWAY & SKUNK CREEK

Improvement Location: The basin for WQIMP 15 encompasses the NIST facility west of Broadway and south of Bluebell Ave.

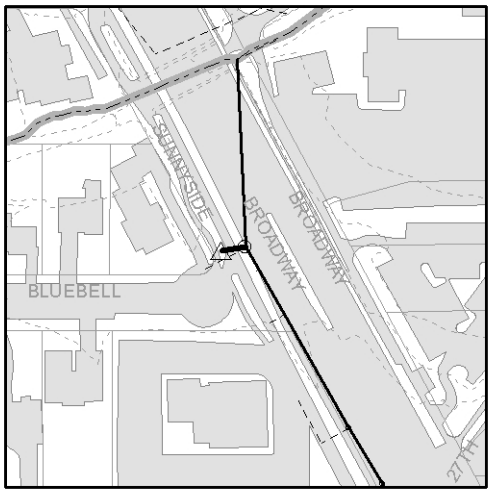
Improvement Description: **WQIMP 15 (Hot Spot)** - Install a proprietary BMP along Broadway.

Technical Data:
- Q(wq) – 5.34 cfs
- Size of manhole: 8-foot
- Size of connector pipe: 24-inch

Land Ownership:
- Construction would be within the ROW.

Implementation Issues:
- None Identified

Capital Cost: $93,000



MBC_07: BOULDER CREEK & 13TH STREET

Improvement Location: The basin for WQIMP 16 includes the area encompassed by Arapahoe, 16th, Canyon, and 13th.

Improvement Description: **WQIMP 16 (Boulder Creek Outfall)** - Install a proprietary BMP west of 13th.

Technical Data:
- Q(wq) – 7.59 cfs
- Size of manhole: 10-foot
- Size of connector pipe: 30-inch

Land Ownership:
- City of Boulder

Implementation Issues:
- None Identified

Capital Cost: $104,000

MBC_05: BOULDER CREEK & 11TH STREET

Improvement Location: The basin for WQIMP 18 encompasses an area about 750 ft wide from Boulder Creek north to Pine St.

Improvement Description: **WQIMP 18 (Boulder Creek Outfall)** - Install a proprietary BMP near 11th and Canyon.

Technical Data:
- Q(wq) – 6.40 cfs
- Size of manhole: 8-foot
- Size of connector pipe: 24-inch

Land Ownership:
- City of Boulder

Implementation Issues:
- None identified

Capital Cost: $65,000

8.5 Local System Recommended Plan Summary Tables

Summary tables were developed to provide details regarding each of the Tier I and Tier II local system improvements. These tables provide the problem ID, description of the project improvement, technical and implementation comments and planning level capital cost estimate. The problem ID can be used with the technical memorandum titled *Task 4 – Local System Analysis* to research the problem causes and severity.

8.5.1 Tier I Priority Improvements

This section includes summary tables that provide details for each of the Tier I Local System Improvements.

Project ID (Subbasin)	**Wonderland Creek – 1 (WC_LI1)**
Problem Location	Broadway Street from Rosewood Avenue to Violet Avenue
Problem Description	Due to a lack of stormwater infrastructure along the east side of Broadway Street from Fourmile Creek to Violet Ave, and poor capture of stormwater by the existing storm sewer system north of Fourmile creek, runoff continues across Violet Ave and has the potential to flood properties on the south side of the street. Runoff also continues east along Violet and spills south along 13th Avenue. The contributing area to the identified problem area is approximately 2 acres.
Improvement Description	Provide collection and conveyance infrastructure (inlets, manholes, and storm sewer) along the east side of Broadway and convey to the existing system along the west side of Broadway.
Technical Data	The conveyance system is required to convey the 5-yr storm Storm sewer diameters range from 30 to 36-inch with 2 inlets
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way.
Implementation Challenges	Based on review of the city utility GIS data, it has been determined that this project would likely require the relocation of approximately 300 feet of both and water sewer line along Broadway Street from Violet Avenue to Rosewood Avenue.
Capital Cost	$318,000

Project ID (Subbasin)	Elmer's Twomile Creek – 2 (ETC_LI2)
Problem Location	Farmer's Ditch - Iris Avenue to Linden Avenue and Broadway Street to Cloverleaf Drive
Problem Description	Entire neighborhood bounded to the north, west, and south by Cloverleaf Drive, Broadway Street, and Kalmia Ave, respectively drains easterly to the Farmer's irrigation ditch. Specifically, runoff from the area described above is discharged to the ditch via four outfalls of 12, 18, 21, and 48-inches in diameter. The ditch system can become overwhelmed during heavy rains and cause potential overflows, causing flooding of downstream properties. The total contributing area is approximately 76 acres.
Improvement Description	Remove stormwater outfalls to the ditch. Construct new collection system in the subbasins and a new storm sewer in Kalmia with outfall to Elmer's Twomile Creek.
Technical Data	The conveyance system is required to convey the 2-yr storm Storm sewer diameters range from 18 to 36-inch with 25 inlets
Land Ownership	This reach of the Farmer's Ditch is located on private property and is assumed to be contained within an easement.
Implementation Challenges	Based on review of the city utility GIS data, it has been determined that this project would likely require the relocation of approximately 2,300 feet of water and sewer lines along Linden Avenue from 16th Street to Cloverleaf Drive, along Cloverleaf Drive from Linden Avenue to Kalmia Avenue, and along Kalmia Avenue from Cloverleaf to 19th Street. Additionally, relocation of 6 water and 6 sewer laterals will likely be required along Kalmia Avenue from 19th Street to the outfall to Elmer's Twomile Creek.
Capital Cost	$3,874,000

Project ID (Subbasin)	Goose Creek – 1 (GC_LI1)
Problem Location	Intersection of 8th Street and Dellwood Avenue
Problem Description	The existing local stormwater conveyance system is undersized and reported as reaching capacity during relatively minor storm events. The inadequacy of the system has lead to frequent roadway flooding, to the point that the crown of the road is inundated several inches. This intersection is a low point, creating an exacerbated flooding condition during storm events. The total contributing area to the problem area described above is approximately 32 acres.
Improvement Description	Improve/provide a stormwater collection and conveyance system along Dellwood Avenue between 3rd to 8th Street, eventually connecting into the existing conveyance system at the intersection of 8th Street and Dellwood Avenue. Upsize existing system south of Dellwood Avenue through North Boulder Park to just south of Balsam Street.
Technical Data	The conveyance system is required to convey the 2-yr storm Storm sewer diameters consists of 18 to 36-inch with 16 inlets
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way.
Implementation Challenges	Based on review of the city utility GIS data, it has been determined that this project would likely require the relocation of approximately 330 feet of both and water sewer line along 5th Street from Dellwood Avenue to Cedar Avenue. Additionally, it is anticipated that approximately 500 feet of sewer line within the private property parcel, described above, would also require relocation.
Capital Cost	$1,585,000

Project ID (Subbasin)	Goose Creek – 2 (GC_LI2)
Problem Location	Alpine Avenue to Dellwood Ave and 3rd Street to 7th Street
Problem Description	Steep slopes and an inadequate existing storm sewer network cause high surface runoff flows, threatening pedestrians and residences at intersections where runoff is currently unmanaged. Many alleys contain low points, localized to the center of the block, and have been observed to collect runoff and spill it into adjacent residences. The total contributing area to the problem area described above is approximately 48 acres.
Improvement Description	Extend the existing stormwater collection and conveyance system along Balsam Avenue and Alpine Avenue west to 4th Street, connecting to the existing systems. Formalize the existing inadvertent detention that occurs in North Boulder Park and increase the volume to mitigate the increased runoff peaks created by improving the upstream storm sewer conveyance.
Technical Data	The conveyance system is required to convey the 2-yr storm Storm sewer diameters range from 18 to 36-inch with 29 inlets
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way. The associated detention/water quality facility would be located on Parks Department property.
Implementation Challenges	Based on review of the city utility GIS data, it has been determined that this project would likely require the relocation of approximately 1,000 feet of water lines along Alpine Avenue from 4th Street to 6th Street. Additionally, it is anticipated that approximately 900 feet of sewer line along Balsam Avenue from 4th Street to 6th Street would need to be relocated.
Capital Cost	$2,417,000

Project ID (Subbasin)	Goose Creek – 3 (GC_LI3)
Problem Location	Dewey Avenue from 4th Street to 9th Street
Problem Description	The existing stormwater infrastructure along 4th Street from Maxwell Avenue to Dewey Avenue has been identified as insufficient through observations of runoff bypassing the inlets during high rainfall storm events. Additionally, a bottleneck in the storm sewer at 6th Street and North Street where the storm sewer transitions from 30” to 12” sewer has been identified, which creates a local roadway flooding condition as a result of back-ups within the system. The area of concern is also perceived to receive a significant portion of runoff from adjacent impervious areas, exacerbating the flooding condition. The total contributing area to the problem area described above is approximately 64 acres.
Improvement Description	Remove orifice plate in manhole in 6th Street just south of North Street. Provide additional stormwater infrastructure (inlets and conveyance pipe) from 6th Street to North Street then extending east in North Street to 9th Street. Connect to existing system at intersection of 9th Street and North Street. Existing system from 6th Street to 9th Street between North Street and Dewey Avenue to remain in service.
Technical Data	The conveyance system is required to convey the 2-yr storm Storm sewer diameters consists of 30-inch with 8 inlets
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way. Detention would be located on private property requiring land acquisition.
Implementation Challenges	Based on review of the city utility GIS data, it has been determined that this project would likely require the relocation of approximately 320 feet of sewer

	line along 6th Street from Dewey Avenue to north Street. Additionally, it is anticipated that approximately 430 and 170 feet of water and sewer line, respectively, would require location along 9th Street from North Street to Dewey Avenue.
Capital Cost	$984,000

Project ID (Subbasin)	**Middle Boulder Creek – 2 (MBC_LI2)**
Problem Location	Vicinity of Pine Street from 16th Street to 21st Street.
Problem Description	2013 flooding was reported to exceed the level of service of the drainage system along local collector streets which may have been exacerbated by the potentially capacity-limited downstream conveyance system.
Improvement Description	Improve existing storm sewer in 18th Street from Pine Street to Spruce Street, in 20th Street from Spruce Street north halfway to Pine Street, and in Spruce Street from 18th Street to the manhole east of 21st Street. Introduce new storm sewer system along Pearl Street from 18th Street to 21st Street, conveying flows easterly into the Boulder White Rock Ditch.
Technical Data	The conveyance system is required to convey the 5-yr storm Storm sewer diameters range from 24 to 42-inch with 47 inlets
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way.
Implementation Challenges	Based on review of the city utility GIS data, it has been determined that this project would likely require the relocation of approximately 1,800 feet of water line along Spruce Street from 16th Street to 21st Street.
Capital Cost	$3,175,000

Project ID (Subbasin)	**Dry Creek No. 2 – 1 (DC2_LI1)**
Problem Location	Intersection of Chippewa Drive and Caddo Parkway east of Inca Parkway
Problem Description	Chippewa Drive and Caddo Parkway, east of Inca Parkway, are currently graded such that runoff is collected primarily along the north side of the roadway. During heavy rains the inlets on the north side of the roadway become overwhelmed, causing localized flooding of adjacent properties. The total contributing area to the problem area described above is approximately 15 acres.
Improvement Description	Provide a new storm sewer system in Chippewa Drive and Caddo Parkway that drain to a new system Mohawk Drive that discharges to Thunderbird Lake. Combine this improvement with the Type B problem area improvement opportunity that also increases flows to the lake and improves water quality in the lake which has had issues with insufficient replenishment and stagnation.
Technical Data	The conveyance system is required to convey the 2-yr storm Storm sewer diameters range from 18 to 36-inch with 24 inlets
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way.
Implementation Challenges	Based on review of the city utility GIS data, it has been determined that this project would likely require the relocation of approximately 840 feet of water line along Caddo Parkway from Mohawk Drive to Inca Parkway.
Capital Cost	$1,837,000

Project ID (Subbasin)	Dry Creek No. 2 – 3 (DC2_LI3)
Problem Location	Baseline and 55th Street from Foothills Hwy to Arapahoe Avenue
Problem Description	Several sections of the existing open channel system on the north side of Baseline Road and Dry Creek Ditch #2 along 55th St north of Baseline are capacity limited and can cause stormwater to back up into the upstream conveyance and detention facilities. The total contributing area to the problem area described above is approximately 314 acres. The 2007 SMP identified the existing storm sewer systems are under capacity in Manhattan, under Foothills Parkway, near Broadway, and south along Foothills Parkway.
Improvement Description	Construct new storm sewer in Baseline from Brooklawn Drive to 55th Street and within 55th Street from Baseline to approximately 300 feet north of Pennsylvania Avenue with a new outfall to Wellman Ditch.
Technical Data	The conveyance system is required to convey the 5-yr storm Storm sewer diameters range from 46 to 54-inch with 38 inlets
Land Ownership	This portion of the open channel conveyance system and Dry Creek No. 2 reach is located on both city right-of-way and private property. The portion of the problem area located on private property is assumed to be contained within an easement.
Implementation Challenges	Based on review of the city utility GIS data, it has been determined that this project would likely require the relocation of approximately 2,300 feet of water and sewer lines along Baseline from Manhattan Drive to 55th Street. Additionally, relocation of approximately 3,400 feet of existing water line and 7 water and 2 sewer laterals would be required along 55th Street from Baseline to the northern extent of the project, as described above.
Capital Cost	$6,505,000

Project ID (Subbasin)	Bear Canyon Creek – 3 (BrCC_LI3)
Problem Location	Vicinity of Kohler Drive from south of Dartmouth Avenue
Problem Description	Steep terrain drains to sump condition in Kohler Drive with stormwater discharging to Anderson Ditch. Closed conveyance is inadequate and overflow path runs to properties downhill in Dover Drive.
Improvement Description	Improve existing collection and conveyance system in sump condition of Kohler Drive. Route to Dartmouth Avenue and connect to system in Broadway Street. Improvements in Kohler will alleviate downhill flooding in Dover. Additionally, upsize portions of the existing system where throttling occurs due to reduced pipe diameters.
Technical Data	Select portions of the conveyance system are required to convey either the 2 or 5-yr storm Storm sewer diameters range from 36 to 48-inch with 12 inlets
Land Ownership	This portion of the conveyance system is located on both city right-of-way and private property. The portion of the problem area located on private property is assumed to be contained within an easement.
Implementation Challenges	Based on review of the city utility GIS data, it has been determined that this project would likely require the relocation of approximately 1,500 feet of water and sewer lines along Kohler Drive from Stanford Drive to Dartmouth Avenue and along Dartmouth Avenue from Kohler Drive to South Broadway Street.
Capital Cost	$2,265,000

Project ID (Subbasin)	Bear Canyon Creek – 5 (BrCC_LI5)
Problem Location	Vicinity of Wildwood Road
Problem Description	Runoff to Wildwood Drive sump/sag locations may exceed storm sewer capacity and major storm overflow paths.
Improvement Description	Install and/or improve discharge locations to Bear Canyon Creek.
Technical Data	The conveyance system is required to convey the 2-yr storm Storm sewer diameters consists of 18-inch with 1 inlet.
Land Ownership	This portion of the conveyance system is located on both city right-of-way and private property. The portion of the problem area located on private property is assumed to be contained within an easement.
Implementation Challenges	Based on review of the city utility GIS data, it has been determined that this project may require the relocation of approximately 420 feet of sewer line along Ithaca Drive from Wildwood Road to Holyoke Drive.
Capital Cost	$267,000

8.5.2 Tier II Priority Improvements

This section includes summary tables that provide details for each of the Tier II Local System Improvements.

Problem Name and ID	**Fourmile Canyon Creek – 1 (FCC_LI1)**
Problem Location	Vicinity of Jay Road and 26th Street.
Problem Description	Limited drainage infrastructure, combined with the potentially capacity-limited roadside ditch and culvert system, was presumed to contribute to 2013 flooding reports.
Improvement Description	Provide a stormwater collection and closed conveyance system along 26h Street from Jay Rd to approximately 300 feet south of Topaz Drive, discharging to the Fourmile Canyon Creek Drainageway.
Technical Data	The conveyance system is required to convey the 2-yr storm. Storm sewer diameters range from 30 to 36-inch with 11 inlets and 4 manholes.
Land Ownership	All work is contained within city ROW and existing easements
Implementation Challenges	None identified
Capital Cost	$ 688,000

Problem Name and ID	**Wonderland Creek – 2 (WC_LI2)**
Problem Location	Intersection of 19th Street and Sumac Avenue
Problem Description	During larger storm events, runoff from Sumac Ave flows across 19th Street and has the potential to flood properties that are below road grade on the east side of 19th Street. Currently, there is existing storm sewer on the north side of the intersection, but none provided on the south where the issue is predominantly observed. The contributing area to the identified problem area is approximately 70 acres.
Improvement Description	Provide collection and conveyance infrastructure (inlets and conveyance pipe) at the southwest corner of intersection and extending west in Sumac Ave to collect and convey into the existing system along the west side of 19th Street. Depending on the capacity of the existing system along 19th Street, the capacity of the existing system may need to be increased to discharge into Wonderland Creek.
Technical Data	The conveyance system is required to convey the 2-yr storm. Storm sewer diameters range from 18 to 30-inch with 32 inlets and 13 manholes.
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way.
Implementation Challenges	None identified
Capital Cost	$ 1,925,000

Problem Name and ID	Wonderland Creek – 7 (WC_LI7)
Problem Location	Vicinity of Oak Avenue and 21st Street.
Problem Description	Limited drainage infrastructure, combined with the potentially capacity-limited roadside ditch and culvert system, was presumed to contribute to 2013 flooding reports. Roadway flooding of Norwood Ave has also been observed by city staff during other heavy rainfalls.
Improvement Description	Provide a stormwater collection and closed conveyance system along Oak Avenue from Oak Place to 21st Street and along Norwood Avenue from 21st Street to 26th Street, eventually discharging to the Wonderland Creek Drainageway.
Technical Data	The conveyance system is required to convey the 2-yr storm. Storm sewer diameters range from 18 to 36-inch with 34 inlets and 16 manholes.
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way.
Implementation Challenges	None identified
Capital Cost	$ 2,452,000

Problem Name and ID	Twomile Canyon Creek – 1 (TCC_LI1)
Problem Location	Kalmia Avenue and Juniper Avenue west of Broadway Street
Problem Description	Kalmia Avenue and Juniper Avenue do not have curb and gutter and surface runoff collects in irrigation ditch laterals which parallel these roads. During heavy rains runoff can overwhelm the laterals if they are not operated properly to convey runoff rather than irrigation water. The approximate contributing area to the identified Kalmia Ave and Juniper Ave problem areas are 30 and 21 acres, respectively.
Improvement Description	Provide increased overall system capacity through retrofitting the existing open channel conveyance network from Twomile Creek to Broadway Street along Kalmia Ave and Juniper Ave. Introduce sewer collection and conveyance (inlets and pipes) from Twomile Creek to Broadway Street along Kalmia Ave and Juniper Ave.
Technical Data	The conveyance system is required to convey the 2-yr storm. Storm sewer diameters range from 18 to 24-inch with 36 inlets and 23 manholes.
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way.
Implementation Challenges	None identified
Capital Cost	$ 2,939,000

Problem Name and ID	Goose Creek – 4 (GC_LI4)
Problem Location	Vicinity of Forest Avenue between 3rd Street and Broadway Street
Problem Description	Limited drainage infrastructure, yielding relatively no removal of surface waters from the roadway was presumed to contribute to 2013 flooding reports.
Improvement Description	Construct a new storm sewer system in Forest Avenue from 4th Street to Broadway Street and Hawthorn Avenue, from 4th Street and connecting to the proposed system in Forest Avenue, eventually discharging to the existing system in Broadway Street.
Technical Data	The conveyance system is required to convey the 2-yr storm. Storm sewer diameters range from 18 to 36-inch with 93 inlets and 26 manholes.
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way.
Implementation Challenges	None identified
Capital Cost	$ 4,885,000

Problem Name and ID	Goose Creek – 5 (GC_LI5)
Problem Location	Vicinity of Cedar Avenue and 19th Street
Problem Description	2013 flooding reports exceeded the level of service of the drainage system along local collector streets.
Improvement Description	Per the recommendations provided in the 2007 SMP, construct a new storm sewer system in Elder Avenue from Broadway Street to 19th Street and along Floral Drive from 19th Street to approximately 300 feet south of Edgewood Drive, eventually discharging to the Goose Creek Drainageway.
Technical Data	The conveyance system is required to convey the 5-yr storm. Storm sewer diameters range from 60 to 66-inch with 28 inlets and 14 box base manholes.
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way.
Implementation Challenges	None identified
Capital Cost	$ 5,484,000

Problem Name and ID	Middle Boulder Creek – 3 (MBC_LI3)
Problem Location	Vicinity of Cascade Avenue from College Avenue to Chautauqua Reservoir Road.
Problem Description	2013 flooding reports exceeded the level of service of the drainage system along local collector streets and combined with the potentially capacity-limited downstream conveyance system.
Improvement Description	Construct new collection and conveyance system along Baseline Road from Grant Place to 13th Street and along 13th Street between Baseline Road and College Avenue, eventually discharging to the system within 13th Street identified for improvement with the 2007 SMP recommendations.
Technical Data	The conveyance system is required to convey the 2-yr storm. Storm sewer diameters range from 18 to 36-inch with 36 inlets and 12 manholes.
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way.
Implementation Challenges	None identified
Capital Cost	$ 2,826,000

Problem Name and ID	Bluebell Canyon Creek – 1 (BbCC_LI1)
Problem Location	Intersection of 20th Street and Mariposa Avenue
Problem Description	The Anderson Ditch culvert under Mariposa Avenue is too tall, causing a crown perpendicular to the slope on the east side of the intersection. This crown impedes conveyance of gutter flow and surface runoff, creating a localized flooding condition within the intersection and adjoining properties. The total contributing area to the culvert is approximately 65 acres.
Improvement Description	Construct a new storm sewer in 20th from Bluebell Ave north to Mariposa, then east in Mariposa connecting to the existing system in Broadway. Inlets would be located upstream of the Anderson Ditch intercepting flow before entering the ditch and sized such that intersection ponding would not create flooding.
Technical Data	The conveyance system is required to convey the 2-yr storm. Storm sewer diameters range from 18 to 36-inch with 14 inlets and 8 manholes.
Land Ownership	This reach of Anderson Ditch is located on both city right-of-way and private property with private property areas assumed to be contained within an easement.
Implementation Challenges	Installation requires tunneling under the existing Anderson Ditch culvert.
Capital Cost	$ 1,137,000

Problem Name and ID	Bear Canyon Creek – 1 (BrCC_LI1)
Problem Location	Bear Canyon Creek, downstream of Stony Hill Court crossing, located approximately 250 feet east of the intersection of Stony Hill Drive and Rockmont Circle.
Problem Description	The 48-inch diameter storm sewer culvert under Stony Hill Drive providing conveyance of Bear Canyon Creek was not built as specified on the original design plans. Specifically, the outlet is aligned directly at residences located along the right bank instead of down the creek main channel. During significant storms events, flow from the outlet has been observed to shoot overt the creek and flow directly into the nearest residence. In addition to the misalignment of the culvert, creek excavation was not done according to the original plans, further exacerbating the flooding condition. Potentially, six homes may flood during heavy rainfall. The total contributing area to the culvert is approximately at 104 acres.
Improvement Description	Maintain existing culvert alignment and introduce a structure at the location of the originally designed center of the downstream channel, and provide 42-inch-diameter conveyance pipe oriented with a properly determined alignment. This option would also require realignment of the downstream channel and sufficient downstream channel protection.
Technical Data	The conveyance system is required to convey the 2-yr storm. Includes open channel and 54-inch storm sewer with 1 manhole.
Land Ownership	The problem area is located on private property in an open space subdivision tract owned by the Devil's Thumb Homeowner's Association.
Implementation Challenges	None identified
Capital Cost	$ 69,000

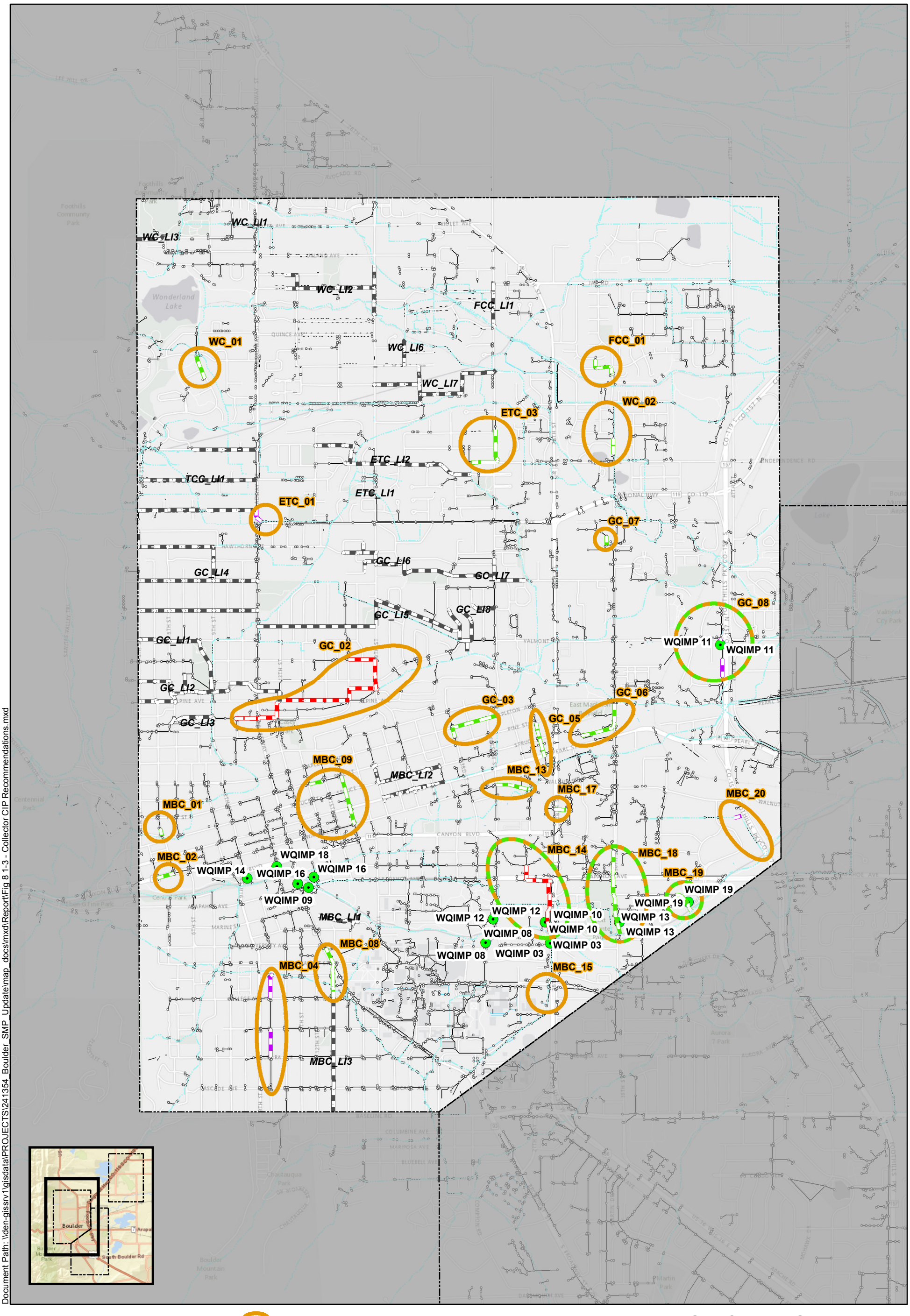
Problem Name and ID	Bear Canyon Creek – 4 (BrCC_LI4)
Problem Location	Vicinity of Yale Road and Hartford Drive
Problem Description	Potential flooding from surface run-off.
Improvement Description	Construct collection and conveyance system in Hartford Drive and Baylor Drive to reduce volume of surface flow through the neighborhood to existing collection point.
Technical Data	The conveyance system is required to convey the 2-yr storm. Storm sewer diameters range from 18 to 24-inch with 13 inlets and 8 manholes.
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way.
Implementation Challenges	None identified
Capital Cost	$ 726,000

Problem Name and ID	Viele Channel – 1 (VC_LI1)
Problem Location	Longwood Ave and Lafayette Drive from Lehigh Street to Greenbriar Boulevard
Problem Description	Runoff from the local roadway and residential parcels is currently conveyed easterly towards Greenbriar Boulevard via roadway section along Lafayaette Drive and Longwood Avenue. The roadway section contains no stormwater infrastructure and has been identified as having insufficient capacity to convey runoff through frequent observations of flooding of local sidewalks. The problem is exacerbated by the pitch and crown of the roads which causes almost all runoff to flow on the north side of Longwood Ave. The total contributing area to the system described above is approximately 21 acres.
Improvement Description	Provide a stormwater collection and conveyance system in Lafayette Drive 160 feet north of Longwood Avenue and eastward along Longwood Avenue from Lafayette Drive to Greenbriar Boulevard to alleviate local flooding through effective conveyance of runoff to the existing downstream system.
Technical Data	The conveyance system is required to convey the 2-yr storm. Storm sewer diameters range from 18 to 24-inch with 13 inlets and 7 manholes.
Land Ownership	Proposed storm sewer improvements are located within the city right-of-way with the exception of the existing storm sewer that cut across the high school parking lot. The parking lot alignment is assumed to be contained within an easement.
Implementation Challenges	None identified
Capital Cost	$ 936,000

8.5.3 Tier III Priority Improvements

This section includes a summary table for the Tier III Local System Improvements.

Problem Name		Improvement Type	Improvement Description	Cost
Dry Creek No. 2 - 2	DC2_LI2	New and Replacement Storm Sewer	New system in Pinon and Meadowbrook, connect to existing system in Baseline Rd	$ 726,000
Dry Creek No. 2 - 5	DC2_LI5	New Storm Sewer	New system in McKinley, Eisenhower, and 4th St, connect to existing system in Arapahoe Ave	$ 2,386,000
Dry Creek No. 2 - 6	DC2_LI6	New Storm Sewer	New system in Merritt Dr with collection from Arapahoe Ridge Park, connect to existing system north of Patton Dr	$ 1,689,000
Goose Creek - 6	GC_LI6	New and Replacement Storm Sewer	New system west of 20th St. Replace existing system in 20th St and Glenwood Dr west of 23rd St	$ 1,946,000
Goose Creek - 8	GC_LI8	New and Replacement Storm Sewer	New systems in 23rd and 24th St. Replace and extend existing system in Fremont St	$ 932,000
Wonderland Creek - 6	WC_LI6	New Storm Sewer	New system in 20th St north of Orchard Ave discharging into Wonderland Creek	$ 366,000
Dry Creek No. 2 - 8	DC2_LI8	New and Replacement Storm Sewer	New system in Holmes and White Place, connect to existing system in 55th St	$ 604,000
Goose Creek - 7	GC_LI7	New and Replacement Storm Sewer	A continuation of the Goose Creek – 6 system. New system in Glenwood Dr East of Folsom St. Replace system in Glenwood Dr west of Folsom and system in Folsom north of Glenwood Dr	$ 1,913,000
Elmers Twomile Creek - 1	ETC_LI1	New Storm Sewer and Open Channel	New storm sewer and open channel between residential parcels northwest of Del Rosa Ct and 19th St	$ 98,000
Middle Boulder Creek - 1	MBC_LI1	New Storm Sewer and Open Channel	New storm sewer and open channel north of Grandview Ave, discharging into Boulder Creek	$ 176,000
Dry Creek No. 2 - 4	DC2_LI4	New Storm Sewer	New system in Pawnee Dr discharging into existing Thunderbird Lake	$ 976,000
Dry Creek No. 2 - 7	DC2_LI7	Replacement Storm Sewer	Replace existing system in Lodge Lane	$ 801,000
Wonderland Creek - 3	WC_LI3	New Open Channel	New open channel in Boulder Open Space behind residential lots northwest of Utica Ave and Locust Pl	$ 24,000
Wonderland Creek - 4	WC_LI4	New Open Channel	New open channel in Boulder Open Space behind residential lots northwest of Promontory Ct	$ 20,000
TOTAL TIER III				**$12,657,000**



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Collector System Improvement Area
Local Storm Drain System Improvements

2007 SMP Collector System Improvements (Updated)

Tier I Pipes
Tier II Pipes
Tier III Pipes
Water Quality Manholes
2007 SMP Surface BMP

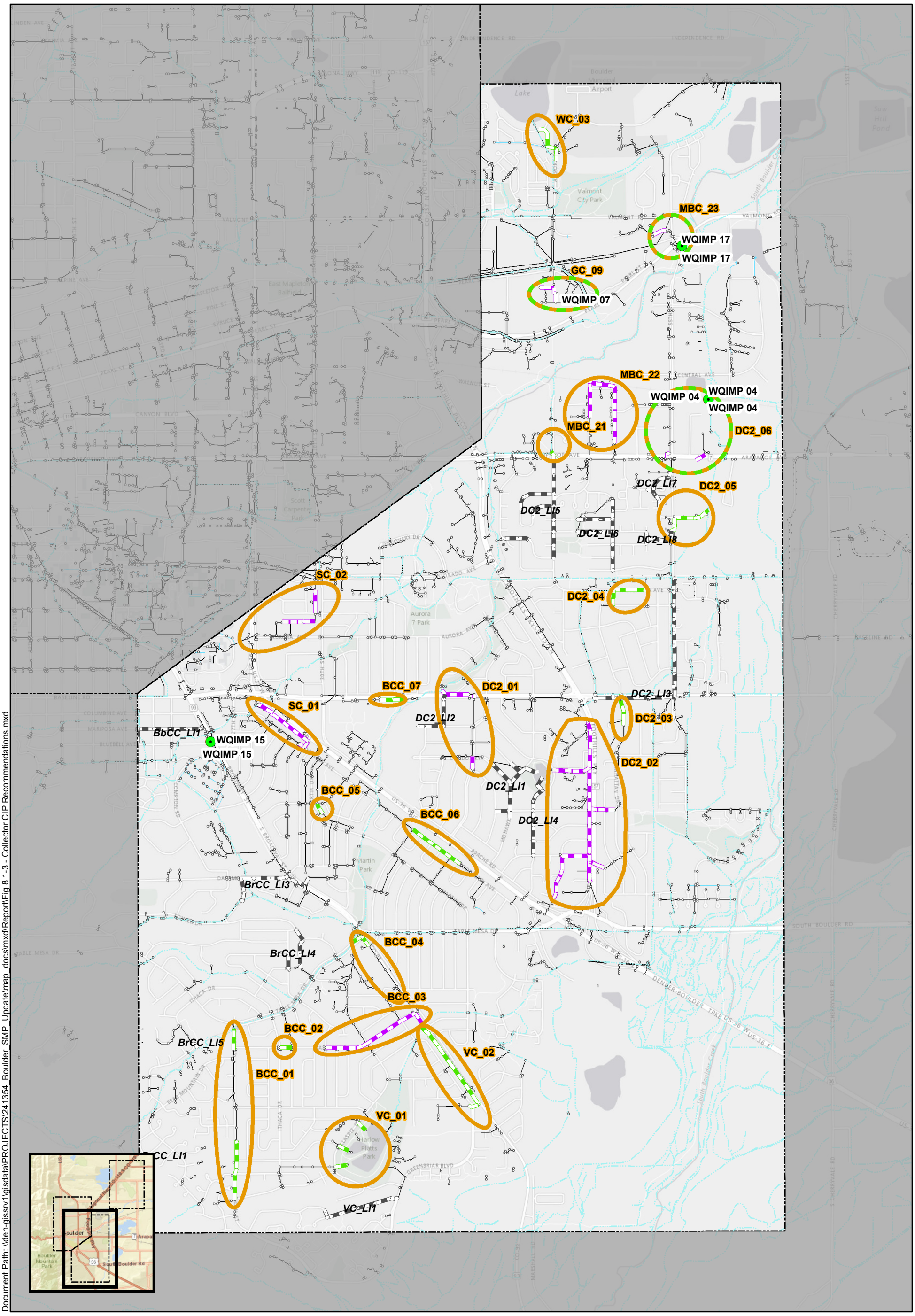
Creek/Ditch
Existing Storm Drain/Culvert
Existing Open Channel

N

0 1,200 2,400 Feet

2007 SMP Collector System Improvements (Updated) - North

Figure 8-1



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Collector System Improvement Area
Local Storm Drain System Improvements

2007 SMP Collector System Improvements (Updated)

Tier I Pipes
Tier II Pipes
Tier III Pipes
Water Quality Manholes
2007 SMP Surface BMP

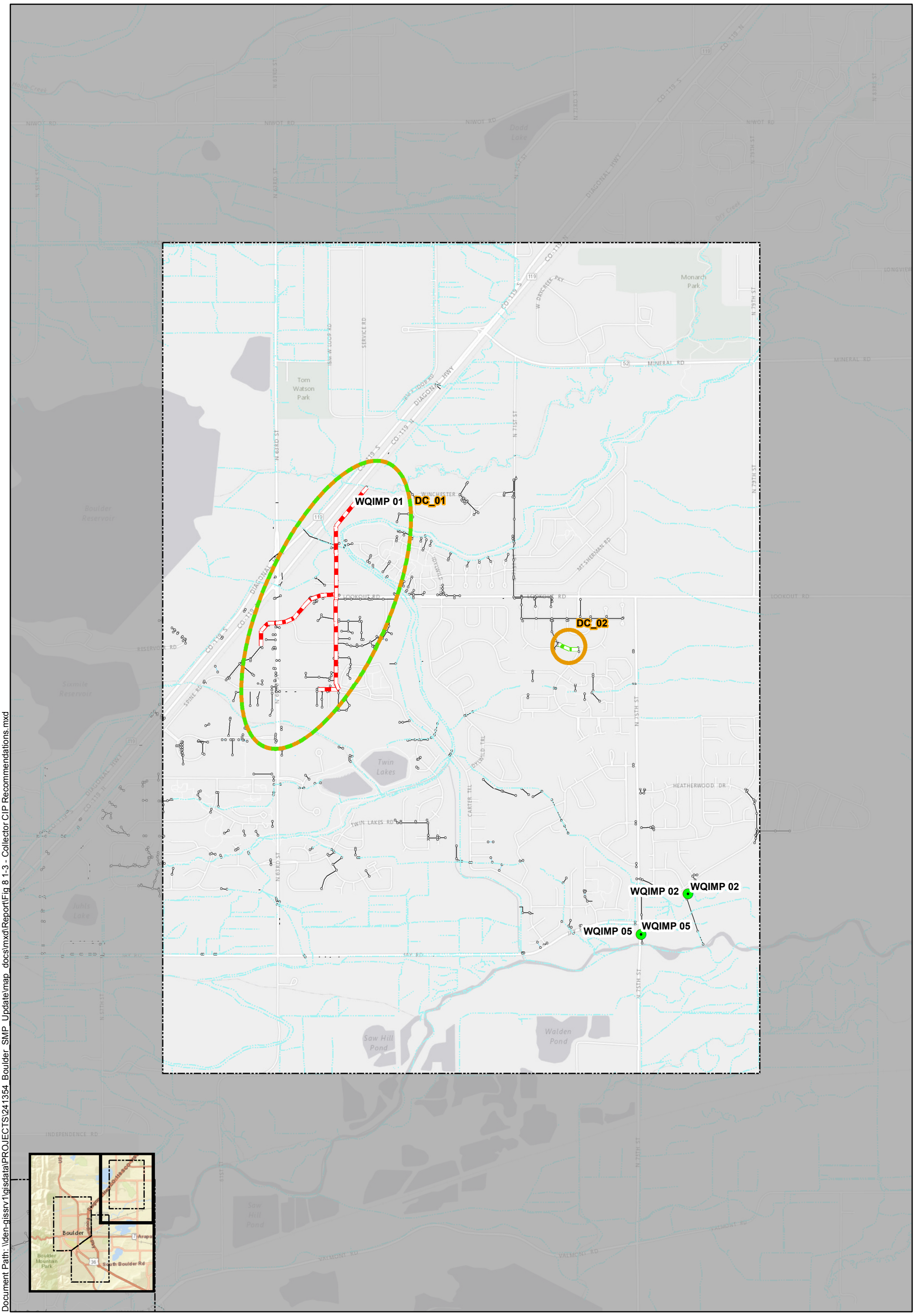
Creek/Ditch
Existing Storm Drain/Culvert
Existing Open Channel

N

0 1,200 2,400 Feet

2007 SMP Collector System Improvements (Updated) - South

Figure 8-2



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Collector System Improvement Area
Local Storm Drain System Improvements

2007 SMP Collector System Improvements (Updated)

Tier I Pipes
Tier II Pipes
Tier III Pipes
Water Quality Manholes
2007 SMP Surface BMP

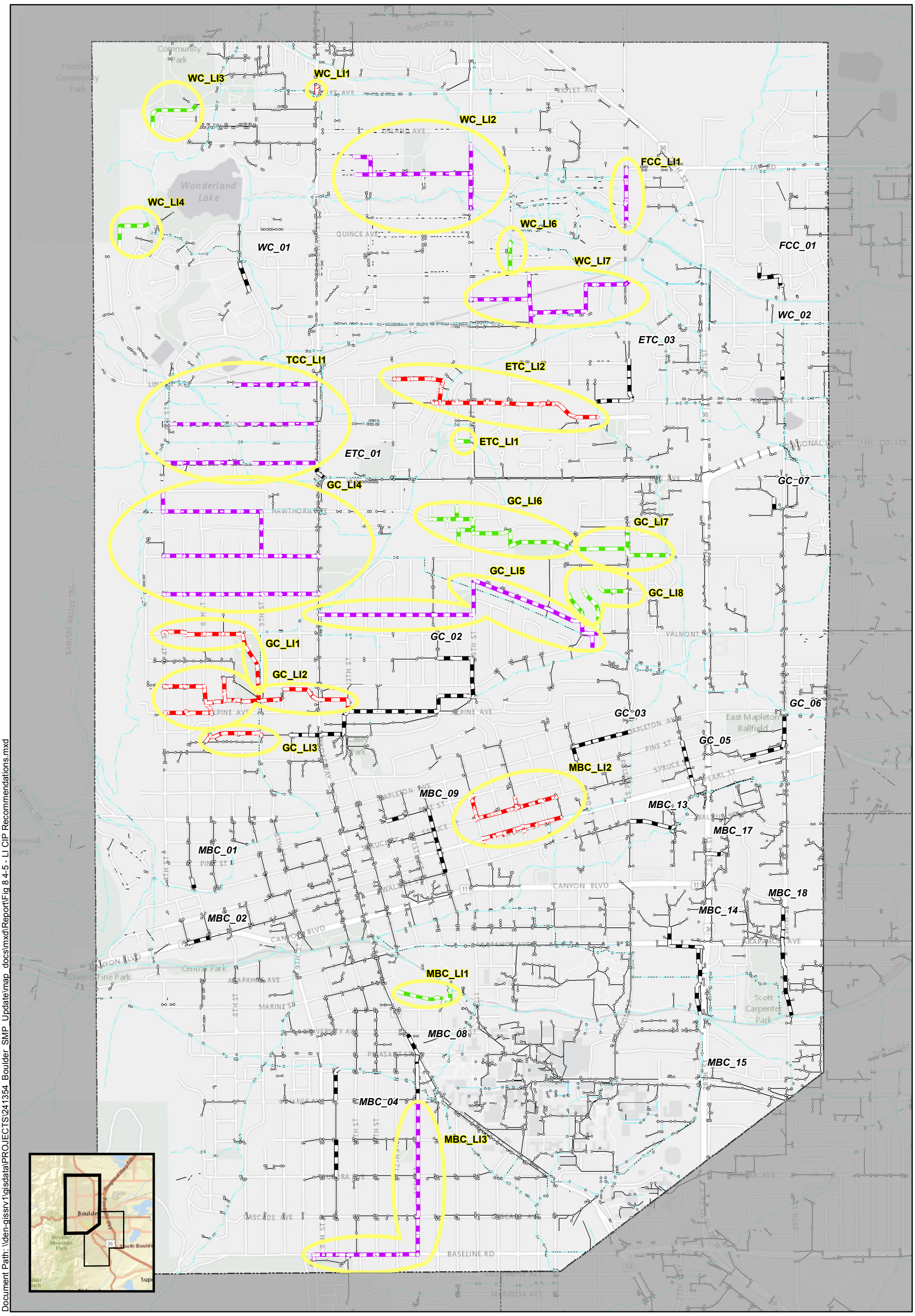
Creek/Ditch
Existing Storm Drain/Culvert
Existing Open Channel

N

0 1,200 2,400 Feet

2007 SMP Collector System Improvements (Updated) - Gunbarrel

Figure 8-3



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N

0 900 1,800 Feet

Local System Improvement Area

Collector Storm Sewer System Improvements

Local System Improvements

Tier I Pipes

Tier II Pipes

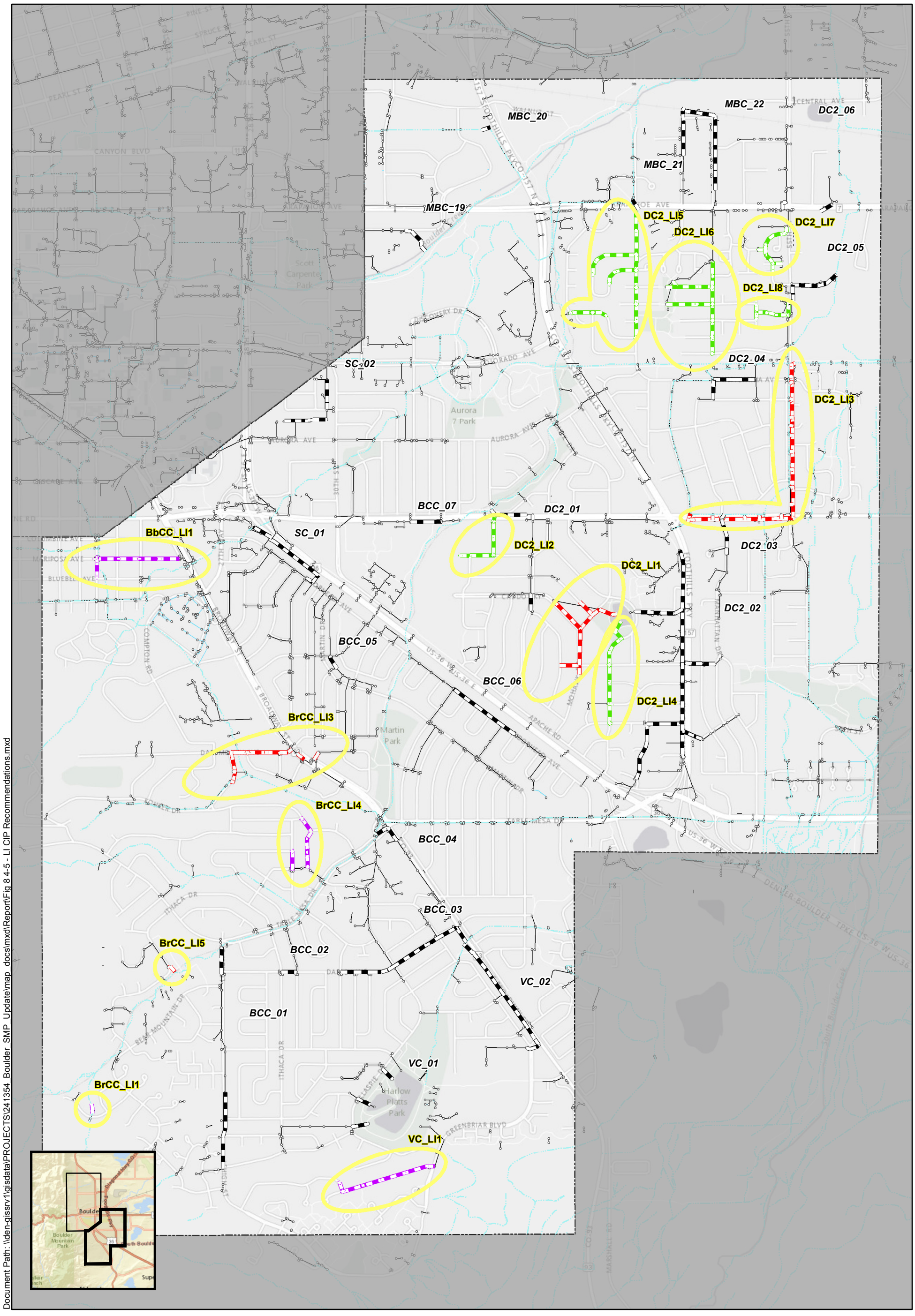
Tier III Pipes

Ditch

Existing Storm Sewer

Existing Open Channel

Local System Improvements - North
Figure 8-4



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N

0 900 1,800 Feet

Local System Improvement Area

Collector Storm Sewer System Improvements

Local System Improvements

Tier I Pipes

Tier II Pipes

Tier III Pipes

Ditch

Existing Storm Sewer

Existing Open Channel

Local System Improvements - South
Figure 8-5

9 Water Quality and Stormwater Program

This section outlines the stormwater quality regulatory requirements that will be incorporated in the City of Boulder's (city) Stormwater Master Plan (SMP) update. This memo combines Tasks 6-10 and forms the basis of the water quality regulatory compliance portion of the SMP update.

This update is partially driven by the upcoming reissuance of the state MS4 permit. The previous MS4 permit was issued in 2008 (2008 MS4 permit) and a new draft MS4 was issued in 2013 for comment and review. This 2013 draft MS4 received comments and a second draft was issued on May 5, 2015. The updated draft MS4 permit (2015 draft MS4 permit) is substantially longer and includes more stringent requirements for tracking and enforcement of stormwater quality requirements. The 2015 draft MS4 permit also contains new requirements for the city to report annually on how it is addressing the Total Maximum Daily Load (TMDL) for the *Escherichia coli* (*E. coli*) impairment on section 2b of Boulder Creek (from 13th Street to the confluence with South Boulder Creek). In addition to the MS4 permit, other changes to state water quality regulations are summarized in this document. The impacts of these upcoming regulation changes are detailed in this SMP update to help inform capital improvement program (CIP) projects.

9.1 Goals and Objectives

The primary goal of the SMP update is to identify a series of system improvements and maintenance recommendations to support the quantity and quality of stormwater runoff under current and future development. Within the context of the SMP, the strengths and weaknesses of the city's water quality and stormwater program were evaluated and a comparative analysis was conducted between the city's program and the programs of other Colorado Front Range cities. By fully integrating regulatory requirements with conveyance planning, the city can better prioritize funding for projects and staffing that simultaneously support conveyance, flood control, and stormwater quality.

The objectives of the water quality and stormwater program review are to:

- Review new water quality regulations (updated MS4 and other state regulations) and their respective impacts on the city.
- Perform an assessment of the city's operations and maintenance (O&M) program and provide recommendations.
- Review the city's current construction stormwater program and provide recommendations for standardizing the program across the city.
- Provide recommendations for implementing requirements in the 2015 draft MS4 permit.
- Provide recommendations for implementing requirements of other new water quality regulations.

9.2 Summary of Regulatory Drivers

Recent updates to the stormwater regulatory compliance requirements outlined in three main documents are a major driver for this SMP update. The requirements for each of the following regulations are discussed in more detail in subsequent sections of this TM.

- Phase II Municipal Separate Storm Sewer System (MS4) Permit.

- Boulder Creek *E. coli* Total Maximum Daily Load (TMDL) Reporting.
- Colorado Department of Public Health and Environment (CDPHE) Regulation 85.

Additional regulations and environmental issues that may have a future effect on the city's water quality and stormwater programs are summarized below. While these issues are not directly addressed within this TM, they do influence regulations developed within the Environmental Protection Agency (EPA) and the CDPHE.

- Colorado Revised Statute (CRS) §37-92-602 (8).
- Federal revisions to *E. coli* recreational water quality standard.
- Colorado Water Plan.
- State Engineers Office detention reporting requirements that could impact potential water rights, regional detention, and green infrastructure (GI).
- Ongoing impacts of dewatering remediation permitting.
- Potential for other 303(d) impaired stream listings.
- Arsenic with possible issues related to groundwater and infiltration into the storm sewer system.

9.3 MS4 Permit Requirements and Changes

This section briefly summarizes the requirements in each of the sections of the 2008 MS4 permit and outlines the changes made in the 2015 draft MS4 permit. The requirements are addressed according to the MS4 Minimum Control Measures (MCM) and then by additional permit requirements beyond the MCMs.

9.3.1 MCM 1: Public Education and Outreach

MCM 1, public education and outreach, describes activities that involve the public in developing, implementing, and reviewing MS4 management programs; and it describes ways to reduce stormwater pollution. The goal behind MCM 1 is to inform the public of common residential and commercial activities that contribute to stormwater pollution. The following sections describe the 2008 MS4 permit and the changes under the 2015 draft MS4 permit.

2008 MS4 Permit Summary

Currently, the 2008 MS4 permit requires permittees to implement a public education and outreach program to promote behavioral change by the general public and businesses to reduce water quality impacts associated with pollutants in stormwater runoff, illicit discharges, and improper disposal of waste. The program includes targeting specific pollutants and sources, active outreach efforts to inform the public of steps to take to reduce pollutants and their impacts, and informing businesses of what is prohibited and the water quality impacts associated with illegal discharges and improper disposal of wastes. Specific metrics are not required under the 2008 MS4 permit.

The 2008 MS4 permit does not have recordkeeping requirements.

Changes Under the 2015 Draft MS4 Permit

The 2015 draft MS4 permit lists targeted businesses for education and outreach. It also targets sources of nutrients and related education on how to reduce nutrients generated from these sources.

The 2015 draft MS4 permit includes an 'Education and Outreach Activities Table (Table 1 in the permit) that lists both passive and active/interactive outreach and requires the permittee to implement at least two education and outreach activities per year (either new or the same).

The 2015 draft MS4 permit includes the following recordkeeping requirements:

- The permittee must document and date public education and outreach activities.
- The permittee must set a priority level to public education and outreach activities.

9.3.2 MCM 2: Public Involvement and Participation

MCM 2, public participation and involvement, describes activities that involve the public in developing, implementing, and reviewing MS4 management programs and it names ways to reduce stormwater pollution. The goal behind MCM 2 is to involve interested citizens and groups to help spread the message of preventing stormwater pollution, to undertake group activities that highlight storm drain pollution, and to facilitate volunteer community actions to restore and protect local water resources. The following sections describe the 2008 MS4 permit and the changes under the 2015 draft MS4 permit.

2008 MS4 Permit Summary

Under the 2008 MS4 permit, the permittee must hold public hearings and allow public review and input when implementing the Colorado Department of Public Safety (CDPS) Stormwater Management Program. The permittee must define the mechanisms and processes by which the public has the opportunity to do this.

The 2008 MS4 permit does not have recordkeeping requirements.

Changes Under the 2015 Draft MS4 Permit

The 2015 draft MS4 permit requirements are similar to the 2008 MS4 permit. The only substantial addition refers to the Program Description Document (PPD), described in Section 9.4.1, and that it must be publically available on the permittee's website for review and comment.

9.3.3 MCM 3: Illicit Discharge Detection and Elimination

MCM 3, illicit discharge detection and elimination, describes activities for identifying and eliminating illicit discharges and spills to storm drain systems. Illicit discharges are generally any discharge into a storm drain system this is not composed entirely of stormwater, such as oil and grease, soaps, pressure wash water, and others. These discharges often contain pathogens, nutrients, surfactants, and various toxic pollutants. The following sections describe the 2008 MS4 permit and the changes under the 2015 draft MS4 permit.

2008 MS4 Permit Summary

Currently, MS4 permit holders must develop, implement, and enforce a program to detect and eliminate illicit discharges into the permittee's MS4. The program must:

- Develop and maintain a current storm sewer map.
- Prohibit and enforce regulations for illicit discharges.

- Develop, implement, and document a plan to detect and address non-stormwater discharges.
- Develop and implement a plan to train municipal staff to recognize and appropriately respond to illicit discharges observed during typical duties.
- Implement regulatory mechanisms to allow permittees to implement and enforce the permit requirements.

The 2008 MS4 permit also lists allowable non-stormwater discharges, such as landscape irrigation, diverted stream flows, irrigation return flow, groundwater, and several others.

The 2008 MS4 permit includes the following recordkeeping requirements:

- Develop a list of occasional incidental non-stormwater discharges and document any local controls or conditions placed on these discharges.
- Record the total number of enforcement actions performed.

Changes Under the 2015 Draft MS4 Permit

The 2015 draft MS4 permit includes the requirements under the 2008 MS4 permit and adds the following:

- Tracking and responding to illicit discharges and associated recordkeeping.
- Regulatory exemptions, waivers, or variances implemented by the permittee.
- A method of enforcement escalation if violators are not in compliance and associated recordkeeping.
- Additional non-stormwater exclusions.
- A requirement to list priority areas, or hot spots, of known or suspected illicit discharges and associated recordkeeping.
- Ability to request additional substances to be added to non-stormwater exclusions.
- A requirement that industrial polluters must be reported to the state within 90 days.
- Additional procedures and documents related to detection and elimination of illicit discharges.

The 2015 draft MS4 permit includes the following recordkeeping requirements:

- Procedures for determining illicit discharges.
- Additional recordkeeping requirements related to illicit discharge events and reports.

9.3.4 MCM 4: Construction Site Runoff Control

MCM 4, construction site runoff control, describes Best Management Practices (BMP) for MS4s and construction site operators to address stormwater runoff from active construction sites. MCM 4 requires permittees to develop a program to reduce sediment and other pollutants in stormwater runoff from construction sites disturbing one or more acres because of the impact uncontrolled runoff from construction sites can have on open water bodies. The following sections describe the 2008 MS4 permit and the changes under the 2015 draft MS4 permit.

2008 MS4 Permit Summary

Under the 2008 MS4 permit, for construction activities disturbing more than one acre of land that discharge into the MS4, the permit holder must develop, implement, and enforce a program to reduce pollutants in any stormwater runoff from construction sites that could potentially affect water quality. The permittee must develop a program to assure adequate design, implementation, and maintenance of BMPs at construction sites. This program must include an ordinance or regulatory mechanism for erosion and sediment controls, BMP requirements for handling construction wastes, compliance assessment procedures, and compliance assurance procedures. It also includes an education and training program requirement for municipalities, their representatives, and/or their construction contractors. Site plans and inspections must be performed under the 2008 MS4 permit; however, site inspection frequencies are not dictated.

The 2008 MS4 permit includes the following recordkeeping requirements:

- Total number of construction sites.
- Total number of inspections performed.
- Full level inspection assessing the adequacy of BMPs and overall site management.
- Inspections conducted to assess sites for indicators of non-compliance.
- Summary of compliance assurance activities, including the total number of enforcement actions performed.

Changes Under the 2015 Draft MS4 Permit

The 2015 draft MS4 permit clarifies the existing permit and includes definitions. The 2015 draft MS4 permit also includes the following:

- A list of exclusions such as pavement projects, large single-family lots, and underground utilities and recordkeeping associated with these exclusions.
- Regulatory mechanisms that must be implemented to the extent allowable by the law and associated recordkeeping.
- Requirements for erosion control plans and their review and associated recordkeeping of these plans and reviews.
- A requirement that site plans are updated within 72 hours of an on-site change.
- Site inspection requirements, such as a routine inspection every 45 days for active construction, a reduced frequency inspection every 90 days for post-construction/pre-stabilization, and compliance inspection within 14 days of a failure to comply (unless correction actions are observed during the initial inspection).
- Exclusions to accommodate staff vacancy or temporary leave.
- Requirements to provide information to operators of applicable construction activities.

The 2015 draft MS4 permit includes the following recordkeeping requirements:

- Training recordkeeping.
- Enforcement recordkeeping.

- Erosion control measures recordkeeping.

9.3.5 MCM 5: Post-Construction Stormwater Management

MCM 5, post-construction runoff control, describes BMPs for MS4s, developers, and property owners to address stormwater runoff after construction activities have ended. The goal behind MCM 5 is to mitigate stormwater impacts from new development due to increased impervious surfaces that increase stormwater volume and degrade water quality. The following sections describe the 2008 MS4 permit and the changes under the 2015 draft MS4 permit.

2008 MS4 Permit Summary

Under the 2008 MS4 permit, for new development and redevelopment projects disturbing more than one acre of land or less than one acre that is part of a larger common plan of development or sale that discharges into the MS4, the permit holder must ensure controls are in place to prevent or minimize water quality impacts. The permittee must develop and implement strategies to address discharges and maintain hydrologic conditions at sites. Strategies must include an ordinance and other regulatory mechanisms for post-construction runoff, proper BMP installation and maintenance, issues of non-compliance, and procedures for tracking and monitoring of both temporary and permanent BMPs.

The 2008 MS4 permit includes the following recordkeeping requirements:

- Total number of sites for which permanent BMPs were required or specific BMPs were implemented during the reporting period.
- Total number of permanent BMPs inspected throughout the jurisdiction to ensure compliance with long-term O&M requirements.
- Total number of enforcement actions.

Changes Under the 2015 Draft MS4 Permit

The 2015 draft MS4 permit includes the following:

- A number of applicability definitions.
- The types of work excluded from requiring permanent BMPs.
- Enforcement requirements for O&M.
- Control measures for applicable development projects that meet one of six base design standards:
    - Water Quality Capture Volume (WQCV) standard.
    - Pollutant removal standard.
    - Runoff reduction standard.
    - Applicable development project draining to a regional WQCV control measure.
    - Applicable development project draining to a regional WQCV facility.
    - Constrained redevelopment site standards.
- Site plans that provide documentation of O&M, including frequency of inspections.
- Documentation of easements or other legal means for access to control measures.

- Site plans review and construction inspection and final construction acceptance of control measures.
- Inspections of permanent BMPs at least once during the MS4 permit term.
- Tracking for control measures.
- Training for inspection staff.

The 2015 draft MS4 permit also includes the following recordkeeping requirements:

- Regulatory mechanisms.
- Permanent BMP requirement documents.
- Plans and construction acceptance.
- Post acceptance oversight.
- Maintenance training.
- Permanent BMP tracking.

9.3.6 MCM 6: Pollution Prevention and Good Housekeeping

MCM 6, pollution prevention and good housekeeping for municipal operations, describes BMPs for municipalities to use for preventing pollution from entering storm drain systems. Municipalities conduct such activities as winter road maintenance, minor road repairs, water and sewer rehabilitation and other infrastructure work, fleet maintenance, landscaping and park maintenance, and building maintenance that can pose a threat to water quality if practices and procedures are not in place to prevent pollutants from entering the MS4. Municipalities also conduct activities that remove pollutants from the MS4 when performed properly, such as parking lot and street sweeping and storm drain system cleaning. Finally, municipal facilities can be sources of stormwater pollutants if BMPs are not in place to contain spills, manage trash, and handle non-stormwater discharges. The following sections describe the 2008 MS4 permit and the changes under the 2015 draft MS4 permit.

2008 MS4 Permit Summary

The MS4 permit holder must develop and implement an O&M program that includes an employee training component and has the ultimate goal of preventing or reducing pollutants in runoff from municipal operations. The program must include written procedures to prevent or reduce pollutants in runoff and must specifically list the municipal operations that are impacted. There is also a requirement to list the industrial facilities owned or operated by the permittee that are subject to separate coverage under the state's general stormwater permit for stormwater discharges associated with industrial activities.

Recordkeeping is not clear or prescriptive in the 2008 MS4 permit.

Changes Under the 2015 Draft MS4 Permit

The 2015 draft MS4 permit includes the following requirements:

- Annual inspection of applicable municipal facilities.
- Written procedures for municipal operations.

- Bulk storage containment requirements.
- Training of staff with respect to pollution prevention and good housekeeping.
- Recordkeeping of pollution prevention practices at each facility.
- Inspection documentation recordkeeping.
- The 2015 draft MS4 permit also includes the following recordkeeping requirements:
- Training recordkeeping.
- Recordkeeping of control measures for operations.

9.4 Other Permit Requirements

In addition to the MCMs described above, there are several other requirements in the new MS4 permit. These requirements are described in the following sections.

9.4.1 Program Description Document

The 2008 MS4 permit required a stormwater management program description be submitted for new and renewing permittees. There is no requirement to maintain this description, and it is not required to be publically available.

The 2015 draft MS4 permit requires the development of a Program Description Document (PDD) that contains information pertaining to the city's compliance with the MS4 permit and that must be maintained to reflect current implementation. While the PDD does not need to be submitted to or approved by the Colorado Water Quality Control Division, unless specifically requested, the PDD must be publically available. The PDD must include the following:

- **Current Control Measure Implementation and Procedures:** The specific PDD content required for public involvement and participation; pollutant restrictions, prohibitions, and reduction requirements and associated recordkeeping; and the requirement applicable to the city's MS4 discharges to Boulder Creek.
- **Current Documents and Electronic Records:** A list of citations for documents and electronic records used to comply with permit requirements. It is not required that the PDD repeat the information included in the cited documents. The PDD must include the names of the most recent version of the documents, date of the document, and location where the supporting documentation is maintained.
- **Current Organizational Chart:** An organizational chart indicating responsibility over applicable departments by the legal contact.

The PDD must be available to the public at reasonable times during regular business hours and maintained in a format that can be submitted to the Division within 10 business days of a request. Information in the PDD may be revised by the permittee at any time. The permittee must modify the PDD as changes occur so that the information is up to date.

9.4.2 Boulder Creek *E. coli* TMDL

In 2011, a TMDL for *E. coli* was approved for Segment 2b of Boulder Creek from 13th Street to the confluence with South Boulder Creek. As a component of the TMDL, a Waste Load Allocation (WLA)

was calculated for the city. According to the 2008 MS4 permit, the city is required, under its CDPS Stormwater Management Program, to implement specific management practices based on requirements of the TMDL. The city is also required to evaluate whether the requirements are being met through implementation of existing program areas or if additional or modified program areas are necessary.

The 2015 draft MS4 permit specifically addresses the city's MS4 discharges to Boulder Creek from 13th Street to South Boulder Creek, which is the reach covered by the COSPBO02 *E. coli* TMDL. The 2015 draft MS4 permit states that the city should conduct monitoring, as necessary, to identify progress towards meeting the WLA in the TMDL. As under the 2008 MS4 permit, the 2015 draft MS4 permit also states that the city needs to prepare an annual report to be submitted by March 10 of each year, covering January 1 through December 31 of the previous year. Specific requirements follow:

- For the first annual report only: A description of all control measures planned by the city to reduce the discharge of *E. coli* to COSPBO02 from 13th Street to South Boulder Creek, including specific target dates for implementation.
- A description of all control measures implemented by the city to reduce the discharge of *E. coli* to COSPBO02 from 13th Street to South Boulder Creek. The first annual report needs to include information on control measures implemented prior to the effective date of the permit.
- An identification of all illicit discharges identified by the city that contribute to discharges from the MS4 in exceedance of 126 colony forming units (CFU) of bacteria per 100 milliliters (100 mL) of water (the *E. coli* water quality standard). The first annual report needs to include information on discharges identified prior to the effective date of the permit.
- An indication that the illicit discharges identified above have been eliminated. If the discharge has not been eliminated, the report must include a description of any planned control measure that the city intends to take to address the discharge.
- A description of monitoring activities conducted, or planned, to meet the monitoring requirements. The first annual report must include information on monitoring prior to the effective date of the permit to identify progress toward meeting the WLA in the COSPB02 from 13th Street to South Boulder Creek *E. coli* TMDL. Data used in the development of the TMDL are not required to be addressed in this reporting.

9.4.3 Summary

The 2015 draft MS4 permit contains several changes from the 2008 MS4 permit. These changes are summarized below:

- MS4 permittees are required to have effluent limitations that meet water quality standards to the maximum extent practicable (MEP).
- MS4 permittees are required to conduct monitoring and must specify how monitoring is performed (equipment, methods, frequency, etc.), how monitoring records are maintained, and that monitoring activities are adequately performed.

- MS4 permittees have monitoring and recordkeeping requirements that include standard operating procedures (SOP) describing how to perform operations within the stormwater program. Policies, standards, processes, and procedures must be written down, approved, and communicated to all concerned and must provide step-by-step instructions and assure consistency, accuracy, and quality.
- The 2015 draft MS4 permit incorporated guidance directly into the permit rather than outside the permit in separate documents.
- The 2015 draft MS4 permit revises the pollutants of concern.
- The 2015 draft MS4 permit allows permittees to engage other permittees, consultants, or contractors to implement the stormwater program.

9.5 Public Education, Outreach, Involvement, and Participation

The city has an extensive Public Education, Outreach, Involvement, and Participation program that fulfill the requirements of the current MS4 permit. This program constitutes significant workload to maintain and develop program initiatives. The city additionally partners with Boulder County groups, such as the Keep It Clean Partnership (KICP) and Partners for A Clean Environment (PACE), to meet permit requirements, including school programs, maintaining a website, and community engagement through advertisements and events. A key event for the city's educational program each year is the Water Festival. The festival involves hundreds of students from the city who come to learn about such topics as identifying ways to protect and conserve water, determining where the city's water supply comes from, and discovering animals that live in and around Boulder's creeks.

The 2015 draft MS4 permit requires community engagement efforts like organizing stream-team cleanups and sending utility bill inserts. The 2015 draft MS4 permit also breaks required outreach into categories of actions that must be satisfied. While the new requirements are prescriptive, they are not the focus of the permit (comprising just 1 of 60 pages).

9.6 Boulder Creek E. coli TMDL

The Boulder Creek *E. coli* TMDL is specifically addressed in the 2015 draft MS4 permit from 13th Street to South Boulder Creek. The city's MS4 discharge is therefore impacted by this addition with *E. coli* reductions prioritized for specific outfalls within the jurisdictions of the City of Boulder, the University of Colorado, and the Boulder Valley School District for land within the sub-catchment outfall basins. The Boulder Creek *E. coli* TMDL is specifically addressed because it is believed that the MS4 is a source of much of the *E. coli* loading to Boulder Creek and applies to discharges subject to TMDL WLAs. This component of the 2015 draft MS4 permit was discussed in more detail in Section 9.4.2.

According to the 2015 draft MS4 permit, the city is required to keep a yearly log of outfalls within Boulder Creek and to monitor dry weather flows to help detect illicit sanitary connections. The following sections describe several ways the city's practices are concurrent with the permit requirements and include recommendations on how the program can be improved.

9.6.1 Illicit Sanitary Connections and SSOs (MCM 3)

The Environmental Protection Agency (EPA) MS4 website main page references several documents relating to Illicit Discharge Detection and Elimination (IDDE). Of particular application to this project is: *Illicit Discharge Detection and Elimination, A Guidance Manual for Program Development and Technical Assessments* (Center for Watershed Protection et al., 2004.).

According to the report, illicit discharges are defined as a storm drain that has measurable flow during dry weather that contains pollutants and/or pathogens. These discharges are frequently caused by illicit sanitary connections, or cross-connections between the sewage disposal system and the storm drain system.

Currently, the city is not aware of any direct cross-connections but continues to identify third-party utilities crossing through its storm sewer through its CCTV inspection program. These locations are addressed by having the third-party utility relocate the utility and repair the storm sewer.

9.6.2 TMDL Implementation Planning

The city's TMDL for Boulder Creek is summarized in the report, *Boulder Creek, Colorado Segment 2b: From 13th Street to the Confluence with South Boulder Creek, Escherichia coli Total Maximum Daily Load* (Tetra Tech, 2011). An implementation plan is provided in the report, *Boulder Creek, Segment 2B TMDL Implementation Plan* (Tetra Tech, 2011) (TMDL Implementation Plan). These reports identified management activities for the purpose of assisting the city in attaining *E. coli* water quality standards within Boulder Creek. This section of the report summarizes the recommendations made and the data that is currently available regarding the city's TMDL requirements. The objective is to determine if the city's development of BMPs since the previous report has helped them reach the required water quality standards. Additional or modified BMPs may be necessary to attain the TMDL requirements outlined in the 2015 draft MS4 permit.

Published *E. coli* Reduction Studies

The Center for Watershed Protection published a document, funded by the EPA, entitled *Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments* (Center of Watershed Protection, 2004) that is intended to provide support and guidance to MS4 communities to establish IDDE programs, as well as procedures for locating non-stormwater entries into stormwater drainage systems. This document includes recommendations for reducing illicit discharges, including *E. coli*.

The EPA published a case study, *Stormwater Management for TMDLs in an Arid Climate: A Case Study Application of SUSTAIN in Albuquerque, New Mexico* (EPA, 2013). It describes a System for Urban Stormwater Treatment and Integration Analysis (SUSTAIN), a strategy to meet water quality goals while minimizing cost. The study concluded that of the structural BMPs studied, detention ponds provide the largest reduction in *E. coli* loading of the affected water body. Additionally, nonstructural BMPs, such as street sweeping and pet waste management provide significant reductions in *E. coli* levels.

The United States Department of Agriculture (USDA) National Resources Conservation Service (NRCS) published *Nutrient Management Technical Note Number 7, Reducing Risk of E. coli O157:H7 Contamination* (NRCS, 2007). While this document focuses on *E. coli* contamination of food supplies, there is discussion on reducing *E. coli* contamination with a watershed approach.

Specifically, this document discusses irrigation water management, as well as reducing pathogens, through such vegetated treatment systems as vegetated ponds, grassed waterways, filter strips, and constructed wetlands. The USDA NRCS has also published *Watershed Science Institute Technical Note 2- Waterborne Pathogens in Agricultural Watersheds* (NRCS, 2000).

The Urban Drainage and Flood Control District (UDFCD) has recommendations in Volume 3 of its Urban Storm Drainage Criteria Manual (UDFCD, 2015) for controlling illicit discharges and thereby reducing *E. coli* loads. This document discusses illicit discharge controls under the three general categories: public education to reduce illegal dumping and discharges, municipal actions to identify and remove illegal connections to the storm sewer system, and accidental spill response measures.

The *E. coli* Work Group of the Colorado published the white paper Synopsis of Recreational Water Quality Issues in Colorado: White Paper Summarizing Results of *E. coli* Work Group 2007-2009 (*E. coli* Work Group of the Colorado Water Quality Forum et al., 2009)[1]. This document discusses regulatory background; case studies of streams in Colorado identified as impaired due to elevated *E. coli*; sources of fecal indicator bacteria, monitoring and assessment of data, including modeling; BMPs to reduce fecal contamination of water bodies; and unresolved issues related to *E. coli* in Colorado.

Water Quality and Environmental Services (WQES) staff with the city has also identified raccoons as a contributor to high concentrations of *E. coli* to Boulder Creek. This led to a study with recommendations for controlling raccoon access into the storm drain system. These recommendations are summarized in the memorandum, *Raccoon Storm Drain Access Control-University Hill Subbasin Recommendations* (HDR, 2013)

Boulder Creek, Segment 2b TMDL Implementation Plan

The TMDL Implementation Plan outlines several current or recently completed implementation measures the city has taken to raise awareness, identify sources of bacteria, better characterize the MS4 system, and regulate stormwater discharges. Table 9.6-1 summarizes the implementation measures the city has completed previously or is actively applying in relation to the *E. coli* TMDL in Boulder Creek.

Table 9.6-1 Current Implementation Measures

Category	Implementation Measure	Description/Objective
Codes and Ordinances	Boulder Revised Code (B.R.C.)	Title 11.5, Stormwater and Flood Management Utility, includes regulation of non-stormwater discharge to the storm sewer system, defining allowable and prohibited connections to the stormwater utility system.
	Design and Construction Standards (DCS)	Chapter 7, Stormwater Design, provides for a comprehensive and integrated stormwater utility system to convey and manage stormwater to enhance water quality by storm runoff by mitigating erosion, sediment and pollutant transport and to control and manage increased runoff due to local development (City of Boulder, 2005a).
Stormwater Planning Efforts	Boulder Valley Comprehensive Plan	Protects the natural environment of the Boulder Valley and provides the foundation for all planning efforts within Boulder Valley.

[1] http://www.keepitcleanpartnership.org/wp-content/uploads/2011/07/E.-coli-Work-Group-White-Paper-October-2009.pdf

Table 9.6-1 Current Implementation Measures

Category	Implementation Measure	Description/Objective
	Comprehensive Flood and Stormwater Utility Master Plan	Provides a framework for evaluating, developing, and implementing various programs and activities in Utilities considering scope and available budget. Recommends stormwater program elements that may assist with TMDL implementation.
	Stormwater Master Plan	Provides the city with the necessary planning tools to address flood management and water quality within the collector portion of the stormwater drainage system.
	Water Utility Master Plan	Outlined five goals in a city-wide planning effort to address water quality policies and priorities: provide safe and high quality drinking water, manage pollutants from wastewater and other NPS, manage pollutants from stormwater and other NPS, protect, preserve, and restore natural water systems, and conserve water resources.
	Greenways Master Plan	Provides framework to implement the Greenways Program through coordinated planning, construction, maintenance, and funding sources of multiple city departments and outside agencies (City of Boulder, 2011b).
Education and Outreach	Keep it Clean Partnership (KICP)	A collaboration of communities in the Boulder and St. Vrain watersheds working together to implement a regional stormwater management program. The "Partners" include Boulder County, the cities of Boulder, Longmont, and Louisville and, towns of Superior and Erie. Ongoing efforts include public education and outreach, public participation, illegal discharge detection and elimination, construction runoff control, post-construction management, and pollution prevention and good housekeeping for municipal operations.
	Open Space and Mountain Parks (OSMP)	The city's 43,000 acres of OSMP are a community investment in natural lands and resources (City of Boulder, 2005). Efforts include pet waste stations which are a means of reducing pollutant loadings.
Greenways Program	Greenways and Riparian Efforts	Allocates resources to specific CIP projects as well as general habitat maintenance that include removal of noxious weeds, planting of natives to discourage re-establishment of weeds, and generally maintaining the stream corridor for habitat.
Stormwater Outfalls	Outfall Inventories	Documents locations, size, and material of outfalls within the Boulder Creek. Continued inventories are critical in the characterization of discharges to Boulder Creek and identification of illicit discharges.
Outfall Monitoring	Extended Monitoring	*E. coli* samples and monitoring continue to be an important component of the adaptive management strategy used to continuously refine implementation planning based on the success of completed efforts and conditions in Boulder Creek.
Special Studies	Microbial Source Tracking[a]	Identified potential human sources of bacteria, looking primarily at storm sewer outfalls with discharges releasing to Boulder Creek during dry weather.
	In-System Sampling	Focused sampling effort began in 2011 and was prioritized in two specific storm drain basins that were identified as a concern by city monitoring and TMDL development. The objective of weekly sampling was to identify potential sources of bacteria, including cross-connections and wildlife contributions.

Table 9.6-1 Current Implementation Measures

Category	Implementation Measure	Description/Objective

Source: Tetra Tech, 2011

[a] *A Multifaceted Approach to Microbial Source Tracking within Secondary Environments* (Monroe, 2009)

Raccoon Storm Drain Access Control

The city's WQES staff has identified raccoons as a contributor to high concentrations of *E. coli* to Boulder Creek. The city found that restricting raccoon access and habitat within the storm drain system results in significant reductions in *E. coli*. In 2013, HDR prepared a technical memorandum for the city entitled, *Raccoon Storm Drain Access Control- University Hill Subbasin Recommendations* (HDR, 2013). The recommendations resulting from this study included coordinated inlet replacement that prevent raccoon entry with the improvements identified in the SMP, an implementation plan consisting of initial pilot area recommendations and subbasin buildout recommendations, and cost estimates. Control strategies to prevent raccoons from entering the storm drain system include inlet replacements, curb extensions, outfall controls, and check valves.

Over the last several years, the city has implemented the integration of raccoon proof inlet protection on future CIP project work and is continually evaluating pipe inverts, pipe condition, and cross-connections through lining and CCTV. The city has found that instream *E. coli* numbers have not decreased as a result of efforts to date. The main source of loading is still ultimately wildlife and the city will need to work with the Colorado Water Quality Control Division on these standards.

Recommendations

The TMDL Implementation Plan recommended several implementation opportunities to help reduce *E. coli* loading in Boulder Creek. Table 9.6-2 is extracted from this plan and summarizes these recommendations.

Table 9.6-2 TMDL Implementation Plan Recommended Opportunities

Phase	Activity	Recommendation	Notes
Phase 1	Illicit Discharge Detection and Elimination and Preventative Maintenance	Inspection of MS4 and Sanitary lines	Evaluation and refinement of existing program.
		Cleaning Sanitary and MS4 lines	Evaluation and refinement of existing program.
	Pet Waste Education and Outreach	Review number, location and use of pet waste stations	Coordinate with OSMP to identify additional locations and effective signage.
		Publicize city code penalties	Coordinate with OSMP to identify effective signage.
		Increase pet waste education	Evaluate refinement of existing program.

Table 9.6-2 TMDL Implementation Plan Recommended Opportunities

Phase	Activity	Recommendation	Notes
		Develop recognizable "Scoop the Poop" campaign	Evaluation and refinement of existing education program. Partner with KICP and PACE.
		Enforcement Codes	Evaluate the enforcement need and effectiveness. Coordinate efforts with OSMP.
	Residential Education and Outreach	Pet waste education	Evaluation and refinement of existing program
		Reducing irrigation overspray	Evaluation and refinement of existing program; review and revised regulations as necessary to prevent overspray.
		Downspout disconnection	Evaluation and refinement of existing codes, ordinances, and education programs.
	Restaurant Education and Outreach	Education focused on proper housekeeping of trash storage areas	Evaluation and refinement of existing education program. Partner with KICP and PACE.
		Fats, oil and grease management	Evaluation and refinement of existing education program. Partner with KICP and PACE.
		Guidance on washing of areas surrounding restaurants	Evaluation and refinement of existing education program. Partner with KICP and PACE.
	Wildlife Management	Develop wildlife management plan to include raccoons	Coordinate with Urban Wildlife Conservation Coordinator to include of raccoons to the urban wildlife management plan
		Wildlife relocation	Conduct relocation as necessary and in compliance with established city codes.
		Inlet protection	Coordinate with Utilities Maintenance and Transportation staff to minimize entry points for wildlife.
		Monitoring	Coordinate monitoring with Utilities Maintenance staff to monitor the effectiveness of wildlife management.
	Recreation and Transient Population Outreach	Targeted outreach	Evaluation and refinement of existing program.
		Improved facilities	Coordinate with other city departments to evaluate needs and opportunities of facilities surrounding high use areas.
	Riparian Enhancements	Continues maintenance and enhancement of riparian zone	Collaborate with the city's Greenways program to evaluate needs and opportunities for riparian enhancements.
		Monitoring water quality associated with CIP projects	Work with other city departments to coordinate monitoring studies to measure and document improvements related to CIP projects.

Table 9.6-2 TMDL Implementation Plan Recommended Opportunities

Phase	Activity	Recommendation	Notes
	Continued Monitoring	Continued weekly monitoring	Dedicate city staff and resources to continued weekly monitoring. In addition to the four weekly sites established, begin sampling near the Foothills Parkway to evaluate/narrow the downstream impairment.
		Continued Outfall Inventories	Dedicate city staff and resources to continued outfall inventories. May require temporary staffing. In addition to the four weekly sites established, begin sampling near the Foothills Parkway to evaluate/narrow the downstream impairment.
		Land Use Assessment	Coordinate existing and future monitoring studies to evaluate land use generation and the identification of bacteria 'hot spot' locations.
		In-System Monitoring	Continue in-system sampling. Efforts should be made to establish a monitoring cycle and document conducted monitoring with analysis of results in annual report.
Phase 2	Private Retrofits	Needs and Feasibility Study	Evaluate existing programs/partnerships to determine feasibility of private retrofits.
		Continued Monitoring	Characterize baseline conditions and evaluate effectiveness of private retrofits (include and evaluation of reduction in runoff volume and pollutant loads).
	Open Space Opportunities	Needs and Feasibility Study	Coordinate with OSMP, Parks and Recreation, and Greenways to evaluate needs and opportunities for BMP implementation of Open Space and public parks.
		Conceptual Design	Work with engineers to develop conceptual designs.
		Pilot Study	Monitor pre- and post-BMP implementation to evaluate implementation effectiveness.
	Urban Retrofits	Needs and Feasibility Study	Coordinate with Transportation and other city departments to evaluate needs and opportunities for the incorporation of proprietary BMPs in city rights-of-way.
		Conceptual Design	Work with engineers to develop conceptual designs.
		Pilot Study	Monitor pre- and post-BMP implementation to evaluate implementation effectiveness.
	Proprietary BMP	Needs and Feasibility Study	Coordinate with Transportation, Utilities, and other city departments to evaluate needs and opportunities for the incorporation of proprietary BMPs in city rights-of-way and/or end-of-pipe.
		Conceptual Design	Work with engineers to develop conceptual designs.

Table 9.6-2 TMDL Implementation Plan Recommended Opportunities

Phase	Activity	Recommendation	Notes
		Pilot Study	Monitor pre- and post-BMP implementation to evaluate implementation effectiveness.
Phase 3	Low Flow Diversions	Needs and Feasibility Study	Evaluate needs and opportunities after other stormwater BMPs have been implemented to their full capacity.
	Ultraviolet Treatment	Needs and Feasibility Study	Evaluate needs and opportunities after other stormwater BMPs have been implemented to their full capacity.
	Ozone Treatment	Needs and Feasibility Study	Evaluate needs and opportunities after other stormwater BMPs have been implemented to their full capacity.

Source: Tetra Tech, 2011

Since these recommended implementation opportunities were presented to the city in 2011, only the activities associated with the Phase 1- Illicit Discharge Detection and Elimination and Preventative Maintenance have been completed or are still being actively implemented.

The city will also need to implement the Boulder Creek TMDL reporting requirements in the 2015 draft MS4 permit, as discussed in Section 9.4.2.

9.7 Construction Stormwater and Operations and Maintenance

The city's current construction stormwater and operation and maintenance activities are summarized in this section. Recommendations are made for improvements to current programs given regulatory drivers and the 2008 MS4 permit update.

The city met with the Cities of Fort Collins and Loveland in a workshop on March 23, 2014, for input regarding stormwater related construction, inspection, and maintenance procedures. In addition, the city held an interdepartmental meeting between the Water Quality, Utilities, Transportation, Planning and Development Services (P&DS), and CIP groups to discuss their handling of construction stormwater and O&M activities. The city also developed a stormwater management program survey that was sent to several other Front Range communities. They were used to help form recommendations for the city's stormwater program.

9.7.1 Inspection Tracking Activities Associated with Construction Stormwater Program

One of the key issues identified through the interdepartmental meeting with the city was a current lack of consistency with how construction stormwater is handed between the different departments and especially with how private projects are handled compared to public projects. This inconsistency transfers over to inspection tracking activities. Given new construction stormwater requirements in the 2015 draft MS4 permit for regulatory mechanisms, erosion control plans, construction stormwater inspections, training, and extensive recordkeeping, consistency across the departments would be beneficial to ensure compliance. A summary of the city's current program, as well as

recommendations for administration of the construction stormwater program, are provided in Section 9.8.

9.7.2 O&M Activities Related to Inspection and Maintenance of Permanent BMPs and the Stormwater Conveyance Systems

One of the key issues identified through the interdepartmental meeting with the city was an inadequate program for both inspecting and maintaining post-construction (permanent) BMPs and the stormwater conveyance system. Given new requirements for both MCM 5 (Post-Construction Stormwater Management) and MCM 6 (Pollution Prevention and Good Housekeeping) in the 2015 draft MS4 permit, a refined stormwater maintenance program would be of benefit to the city. For permanent BMPs, these requirements include enforcement of O&M; control measures that meet base design standards for applicable developments; site plan documentation of O&M that includes frequency of inspections, documentation of easements or other legal means for access to control measures; inspections of all permanent BMPs during each MS4 permit term, training; and extensive recordkeeping. For stormwater conveyance, these requirements focus on nutrient and pollutant reduction. A summary of the city's current program, as well as recommendations related to stormwater O&M are provided in Section 9.8.1.

Construction Stormwater Program (MCM 4)

The four departments within the city that are involved with construction stormwater are Public Works, Parks and Recreation, Facilities Asset Management (FAM), and Open Space and Mountain Parks (OSMP). The city's current erosion control standards are contained in the Design and Construction Standards (DCS) document, but the standards do not currently outline a process to document SWMP compliance.

There are three Divisions within the Public Works Department that are involved with construction stormwater: P&DS; Transportation; and Utilities. The P&DS Division handles private development projects within the city and the Transportation and Utilities Divisions handle CIP projects that construct and maintain public infrastructure related to the water, wastewater, and stormwater/flood utilities. In general, the DCS requires public/CIP projects to have the same level of construction stormwater documentation and permit compliance as private projects; however, in some instances Boulder Revised Code may make distinctions between public and private projects.

Private Construction Projects Process Summary

The city's current construction stormwater process for private construction projects includes the following:

- Review of technical documents and construction plans.
- Requirement for an erosion control permit from the city.
- Verification that the state construction stormwater permit has been obtained.
- A pre-construction meeting with the city relating to construction stormwater.

In addition, the city performs erosion control inspections for private construction projects every 14 days and/or after a precipitation event. All private construction inspections done performed by the city are tracked using the PermiTrack database.

The city currently issues a dewatering permit and has protocol for when stormwater may be discharged to sanitary sewers. In general, this permit matches the state's permit with an agreement that mirrors the state requirements, but can allow the city to be more stringent depending upon the location of discharge.

Public Construction Project Process Summary

The city does not currently have a formalized public construction process across all departments for stormwater. The Transportation and Utilities divisions within the Public Works Department, as well as other city departments, have different processes as summarized below.

Transportation: The Transportation Division typically follows Colorado Department of Transportation (CDOT) BMP standards rather than the UDFCD standards because CDOT contributes funds to many of its projects and CDOT oversight is required. The city manages all transportation construction, but ultimately the contractor completing the work is responsible for erosion control and pulls the stormwater construction permit.

Utilities: The Utilities and Greenways/Flood Work Groups within the Utilities Division generally follow the UDFCD Urban Storm Drainage Criteria Manual, Volume 3, standards as referenced in the DCS. The BMP processes for plan preparation, implementation, inspection, and closeout-checklist vary considerably between project managers. Currently, much of the BMP implementation/maintenance work done is directed verbally and not tracked. The contractor is responsible to pull the construction stormwater permit, and stormwater inspections are done either by the contractor completing the work or by a third party.

Other Departments in the City: Parks and Recreation, FAM, and OSMP are additional departments with projects that sometimes require a state stormwater permit and stormwater oversight. Again, with these departments, the contractor is responsible to pull the state construction stormwater permit, and stormwater inspections are conducted either by the contractor completing the work or by a third party.

Recommendations

Based on the information in the previous sections, recommendations are provided in Section 9.9.4 for improving the city's current private and public stormwater construction processes.

9.8.1 Operations and Maintenance Program (MCM 5 and 6)

This section describes the city's current stormwater O&M program. O&M is included in both MCM 5 and MCM 6 in the 2008 MS4 permit. The section describes standard maintenance of the stormwater system and permanent stormwater BMPs, the stormwater repair and rehabilitation program, and monitoring and sampling of the stormwater system.

Permanent BMP Inspection

Currently, the city follows a stormwater maintenance schedule for permanent BMPs in the city. Above-ground private BMPs are inspected per state requirements and the responsible party is expected to maintain them. Stormceptors™ and other proprietary BMPs are currently used in the city's storm drain system, but there is no stormwater maintenance schedule for these or any other

city-owned BMPs. Private ponds are inspected and are entered into the city's database. The city does not perform in-depth inspections of private proprietary BMPs, such as Stormceptors™.

Recently, the city implemented a GIS-based asset management tool for tracking city-owned, proprietary, and other BMPs. The city is also trying to better organize and use as-built drawings for city projects. These are good first steps to creating consistency in maintenance and inspection schedules.

CCTV Inspection Program and Condition Assessment

The city has hired a contractor to perform a routine condition assessment of the storm sewer system. By the end of 2016, the city expects to have completed a condition assessment for 20 percent of the storm sewer system (University Hill, Downtown, Upper Goose Creek basins) and plans to continue this inspection program at a rate of 10 to 20 percent of the system per year. A maintenance plan, with defined stormwater program goals, has also been developed. The basic goal is to inspect the entire system every five to ten years with follow-up assessments. A summary of the city's program goals is described below:

Stormwater Cleaning:

- 870 days or 5 years with two trucks.
- 108,000 feet annually per truck.
- 1,800 catch basins annually per truck.

Stormwater Televising/Condition Rating:

- 270,000 feet annually.
- 4 years to complete the entire system at 1,500 feet daily.

Stormwater Construction:

- 20 spot repairs every 30 days.
- 10 culvert replacements every 30 days.
- 10 new install, local improvement projects every 30 days.
- Customer relationship management (CRM), Customer Calls, Internal Requests.

Repair and Rehabilitation Program and Improvements

Currently, the city's maintenance crews are responsible for cleaning storm sewers and inlets. Production goals are significantly lower than the goals for wastewater collection, primarily due both to a heavier amount of sediment and debris found in stormwater systems as well as a bigger range in pipe diameters.

The funding from the Utilities Division is given to the Transportation Division for street sweeping. Street sweeping on set routes is being performed.

For open channel maintenance, major drainage channels are maintained by contractors with funding from UDFCD. The Transportation Division is maintaining smaller drainage channels and ponds. The Transportation maintenance group is responsible for some maintenance of the numerous ditches

that flow through the city. The Transportation maintenance crew is anticipated to combine with the Utilities maintenance group in the future.

Observations and Recommendations

The city has expressed the desire for increased communication and coordination between the WQES group and maintenance staff to foster better collaboration on requirements and needs for permanent BMP maintenance. Maintenance issues have not been given much attention mainly because there are no enforcement measures in place for BMP maintenance. Section 9.9.5 provides further recommendations for improvements to the city's stormwater O&M program.

9.8.2 Water Quality Monitoring

Instream and stormwater outfall water quality sampling is conducted under dry weather flow conditions on, or along, Boulder Creek to assess possible impacts from the city's MS4 system. Monthly monitoring has been conducted instream for a number of years and includes analyses for *E.coli*, nutrients (total nitrogen components and total phosphorus), and metals. Weekly *E.coli* monitoring at both instream and outfall locations has also been conducted for a number of years. Wet weather conditions have not been monitored to date.

Nutrients

As stated in the CDPHE Water Quality Control Commission (CWQCC) Regulation 85 – Nutrient Management Control Regulation (5 CCR 1002-85), September 30, 2012, all MS4 permit holders are required to perform a nutrient data gap analysis. Per Regulation 85, "The goal of the MS4 data collection requirements is to identify information that exists, and the need for additional monitoring to be conducted in the future, to determine the approximate nitrogen and phosphorus contribution to state waters due to discharges from the MS4." The city completed the data gap analysis and results are documented in the October 14, 2014, report titled *Regulation 85 Discharge Assessment Data Report* (HDR, 2014). Sampling locations and constituents for Boulder Creek nutrient monitoring are provided in Table 9.7-1 . All sample locations are analyzed for total phosphorus and all analytes required for calculating total nitrogen.

Table 9.7-1 City of Boulder's Water Quality Sampling Summary (2012 Monitoring Plan)

Sample Location	Type of Sample	Total Phosphorous	TKN	Nitrite	Nitrate	Fecal – *E. coli*
BC-Can (Boulder Creek at mouth of Boulder Canyon)	Instream	X	X	X	X	X
BC-CU (Boulder Creek at CU campus)	Instream	X	X[2]	X	X	X
BC-61st (Boulder Creek at 61st Street)	Instream	X	X	X	X	X
BC-aWWTP (Boulder Creek above the 75th Street WWTF)	Instream	X	X	X	X	X

E. coli

Weekly *E. coli* instream and outfall monitoring has been conducted on Boulder Creek since the mid-2000s—first, to obtain data to develop the Boulder Creek bacteria TMDL and then to determine compliance with the TMDL and the city's associated WLA. Regular sampling locations are shown in Table 9.7-2: . In addition to weekly monitoring, a monthly monitoring event captures *E. coli* levels for sites directly above and below the TMDL reach and also one location (BC-CU) located within that reach. Finally, outfall surveys have been conducted since the mid-2000s with the last survey conducted in 2015. During the 2015 survey, *E. coli* and optical brightener samples and flow measurements were taken at each flowing outfall along the stream to determine potential sources of pollutants and associated loads.

[2] TKN measurements using current methods were initiated at BC-CU in February of 2015.

Table 9.7-2: Boulder Creek Weekly and Monthly *E. coli* Sampling

Sample Location	Type of Sample	Weekly Sampling	Monthly Sampling
BC-Can (Boulder Creek at mouth of Boulder Canyon)	Instream		X
BC-Eben (Boulder Creek at Eben G Fine Park)	Instream	X	
BC-13th (Boulder Creek at 13th Street)	Instream	X	
OUT-Arap-S (Outfall near Arapahoe on south side of creek)	Outfall	X	
OUT-CU-SKI (Outfall west of CU football practice field on campus)	Outfall	X	
OUT-CU-POM (Outfall north of CU stadium on campus)	Outfall	X	
OUT-CU-FOLSOM (Outfall on CU at Folsom)	Outfall	X	
BC-CU (Boulder Creek at CU campus)	Instream	X	X
OUT-28th (Outfall at 28th Street)	Outfall	X	
OUT-Marine (Outfall at Marine Street)	Outfall	X	
BC-30th (Boulder Creek at 30th Street)	Instream	X	
BC-55th (Boulder Creek at 55th Street)	Instream	X	
BC-61st (Boulder Creek at 61st Street)	Instream		X

9.9 MS4 Permit Implementation and Water Quality Recommendations

This section includes a number of recommendations for improvements to the city's MS4 permit implementation and management. For assistance in implementing these measures, the city can review other successful programs. Information from a workshop with the City of Loveland and the City of Fort Collins is included in and provides input on successful implementation of some of these recommendations. Implementation of these measures will improve the city's current Stormwater Quality Program and ensure compliance with the updated 2015 draft MS4 permit.

9.9.1 MCM 1 – Public Education and Outreach Recommendations

This requirement is currently being met by city staff and KICP efforts. Under the current 2008 MS4 permit, the city is in 100 percent compliance and future requirements are much less prescriptive than the level of outreach the city currently achieves. New requirements can easily be met through minor changes in outreach delivery methods. It is likely possible for the city to divert some resources away from MCM 1 to achieve greater compliance in other areas while maintaining an exemplary outreach program.

9.9.2 MCM 2 – Public Involvement and Participation Recommendations

This requirement is currently being met under the 2008 MS4 permit by city staff and KICP efforts. Under the current 2008 MS4 permit, the city is in 100 percent compliance; however, under the 2015 draft MS4 permit, the city is 70 percent compliant because of the new requirement of a PPD. Therefore, the only addition is to develop a PPD and make it available to the public on the city's website.

9.9.3 MCM 3 – Illicit Discharge Detection and Elimination Recommendations

The city is improving in all areas of illicit discharge detection and elimination and is 50 percent compliant under the 2008 MS4 permit. However, based on the 2015 draft MS4 permit, the city will only be 33 percent compliant because of 31 new permit requirements. The following recommendations would fulfill the MCM 3 requirements:

- Develop an enforcement escalation process for violations of city code.
- Increase recordkeeping to comply with the requirements in the 2015 draft MS4 permit.
- Set up a program to target hot spots and business types that are known to pollute.

9.9.4 MCM 4 – Construction Site Recommendations

The city understands that there is great need for program development under this MCM, regardless of the new permit, especially on determining how stormwater construction is handled both between different city departments and between private and public construction projects. Under the current 2008 MS4 permit, the city is 61 percent compliant. However, based on the 2015 draft MS4 permit, the city will only be 41 percent compliant because of 28 new permit requirements. Based on the city's Private and Public Construction Processes described in Section 9.8 and changes with the 2015 draft MS4 permit, the following actions are recommended for improving the city's construction procedures.

City Projects

- Clarify responsibility for projects with multiple city groups as stakeholders. Define who takes responsibility for design review and maintenance of BMPs.
    - Formalize a stormwater checklist for site inspections through PermiTrack or other software. Create a critical inspection checkbox on every project to implement construction stormwater management.
- Develop methods to achieve better compliance for CIP project contractors:
    - Review and improve contract language and include new stormwater requirements and costs in bid documents.
    - Hold pre-construction meetings to layout expectations related to construction stormwater.
    - Potential oversight of inspections through PermiTrack.
- Develop written guidance to explain when city projects are required to go through the P&DS review process and receive erosion control inspections from right-of-way inspectors.

Private Projects

- Standardize the escalation enforcement process with respect to violations.
- Streamline the requirements for dewatering permits to achieve greater compliance by reducing resource intensity, contractor waiting period, and ditch company approval (where applicable).

Both City and Private Projects

- Consistently enforce erosion control permits, inspections, etc.
- Implement a single stormwater construction database (like PermiTrack) across both public and private city construction projects (FAM, Utilities, Transportation, etc.)
- Formalize documentation for the design review process, such as a stormwater checklist and standard operating procedures.
- Provide contractor education.
- Formalize training and implement a standard process to track short-term, long-term, and ongoing training.
- Add phasing to erosion control plan mapping for both city and private construction projects.
- Implement appropriate oversight of sites that do not have coverage under the state stormwater construction permit (under 1 acre) and require appropriate stormwater controls to prevent pollution.
- Formalize a checklist for transferring or closing state SWMP permits.
- Create a centralized database, such as PermiTrack, to track instances of compliance and non-compliance.

9.9.5 MCM 5 – Post-Construction Stormwater Management Recommendations

The city understands that there are areas that require improvement under this MCM, regardless of the new permit, especially on the frequency with which permanent BMPs are inspected, how public and private permanent BMPs are handled, and how permanent BMPs are transferred from the construction stormwater phase to permanent maintenance. Under the current 2008 MS4 permit, the city is 65 percent compliant. However, based on the 2015 draft MS4 permit, the city will only be 18 percent compliant because of 39 new permit requirements. Based on the city's private and public construction processes described in Section 9.8.1 and changes with the 2015 draft MS4 permit, the following actions are recommended for improving permanent BMP management:

- Implement standardized processes for requiring permanent BMPs on city projects. including:
    - Clear requirements for design and WQCV, including linear and other less traditional types of projects.
    - Process to transfer city-owned BMPs from project engineers to maintenance staff.
    - Establishment of inspection frequencies and parties responsible for routine inspections.

- Establish an understanding of maintenance requirements for underground BMPs for both public and private projects. This can be done by:
    - Training city staff for CIP project BMPs.
    - Developing a strategy to ensure compliance on private underground BMPs and other unconventional BMPs.
- Establish a schedule for the city's WQES Group to inspect private proprietary BMPs, such as Stormceptors™.
- Reinstate a true maintenance management system to provide better preventative maintenance.
- Create a consistent process to input permanent BMPs into GIS that is uniform across all departments.
- Move the inspection of private BMPs into the Stormwater Quality Program.
- As inspections and maintenance of post-construction BMPs are taken on by WQES and Utilities maintenance groups respectively, they should work with other departments to budget appropriately for maintenance costs and to ensure appropriate and easily maintained BMPs are installed in the future.
- Perform spot inspections of both construction and post-construction BMPs.

9.9.6 MCM 6 – Pollution Prevention and Good Housekeeping

The city understands that there are areas of improvement under this MCM, regardless of the new permit. Under the current 2008 MS4 permit, the city is 33 percent compliant. However, based on the 2015 draft MS4 permit, the city will only be in 19 percent compliant because of 18 new permit requirements. To fulfill the requirements of this MCM, the following recommendations are made:

- Implement site-specific permanent water quality measures for individual facilities that include BMPs specific to the activities conducted at each facility.
- Designate a point person at each facility to be stormwater lead, advised and supported by the WQES staff.
- Begin a planning and funding (budget procurement) process for new secondary containment requirements for chemical storage tanks.
- Provide and track training at city facilities through online training or similar efforts to reduce the reporting burden for any individual staff member and to create greater buy-in by management and staff.
- Better integrate the city's WQES staff into the street sweeping program.
- Equip trucks with spill kits and implement additional spill training for Municipal Service Center staff.

HDR reviewed the city's processes in 2009, as summarized in *TM 4.1b Stormwater System Operations and Maintenance Evaluation* (HDR, 2009). The following recommendations are extracted from that document.

- Maintain Up-to-Date Mapping of the Stormwater System
    - Make completion of the GIS database a priority. The current practice of correcting discrepancies by submitting a Utility Field Report to the supervisor or planner helps to maintain consistency between the existing GIS database and current conditions.

- Computerized Maintenance Management System (CMMS)
    - Update a database software program to collect maintenance findings by asset and support geographical work scheduling.
    - Update the database (e.g., CMMS database) to store condition data collected during maintenance and inspection visits. All data, such as trouble area cleaning records, need to be entered into the CMMS.
    - Create a detailed service request or work order form and provide it to crews who maintain the system assets. The work order would be specific to the type of work being performed and would collect code-based findings for each asset maintained.
    - Provide training to staff in the effective usage of GIS and Computerized Maintenance Management System (CMMS) software.
- Cleaning Program
    - Continue to move to a proactive cleaning schedule based on hydraulic connectivity, which should lead to fewer future reactive cleaning needs.
    - Develop maintenance goals to measure crew productivity annually. Establishing these goals would enable the city to benchmark current stormwater O&M activities.
    - Move to code-based collection of findings and this data in an upgraded CMMS. As the assets are visited, data could be collected and cleaning frequencies could be developed and/or optimized for individual assets.
    - Continue the proactive updates to CMMS, or other new database, and track all individual assets maintained.
- Inspection Program
    - Move to a universal industry-recognized defect coding system. This will enable the city to collect consistent records if there is turn-over on the CCTV crew and to provide a standard for contractors. Training should be provided initially and periodically to the CCTV crews and to any other personnel who might need to use the software or operate the equipment.
    - Use CCTV for quality control on maintenance and repair activities. This evaluation should be performed on 1 to 3 pipes per 100 pipes cleaned per cleaning crew.
- Rehabilitation and Replacement Program
    - Develop a standardized methodology to determine repair, rehabilitation, and replacement needs. To assure consistent decision-making in the city's repair, rehabilitation, and replacement project identification process, it is very important that the city processes future CCTV data based on a formal decision process. This can be done manually based on the decision flow diagram, or it can be built into an algorithm developed from the diagram.
    - Integrate the condition findings with the GIS.
    - When a backlog of CIP projects develops, it is a best practice to develop a formal project prioritization process so that highest risk and/or consequence assets are addressed to assure stakeholders that available resources are focused on the highest-priority projects.
- Training

- Develop a cleaning crew training program with components that focus on improving both the cleaning work process and the cleaning information process. Training should also be held for the CCTV coding system that the city chooses for its CCTV crews.

9.9.7 Other Regulatory and Water Quality Recommendations

The following are general recommendations for the city's MS4 program:

- Clearly define which group performs maintenance on various components of the stormwater system, including storm drains, ponds and other permanent above-ground BMPs, permanent below-ground BMPs, and open ditches.
- The WQES Group should facilitate water quality training as needed with other city departments that are involved with implementing the stormwater program throughout the city.

In addition to the above, the following sections include water quality recommendations for areas outside of the 2015 draft MS4 permit.

Regulation 85

CDPHE Regulation 85 promulgates control regulations on the concentration of total inorganic nitrogen and total phosphorus that can be discharged to state waters from point sources. Per Regulation 85, "The goal of the MS4 data collection requirements is to identify information that exists, and the need for additional monitoring to be conducted in the future, to determine the approximate nitrogen and phosphorus contribution to state waters due to discharges from the MS4."

To address possible future Regulation 85 requirements, the following recommendations are made:

- Update the GIS information for storm drains and outfalls.
- Update and maintain GIS land use data. The land use file should be examined to verify that the GIS-defined land uses reflect the corresponding land cover. Educational land uses, as well as industrial complexes with large amounts of green space, such as the IBM and Celestial Seasonings industrial campuses, should be segmented based their open space and building/parking lot components.
- Update and maintain the SMP and water quality tools, such as the XPSWMM model, which could include staff licensing and running the model in-house.
- Use the existing sources of Event Mean Concentration (EMC) data for the city's land use designations and use it in the XPSWMM water quality model. The city can incorporate newer EMC data as it becomes available.
- Consider studies to explore correlations with nutrient loading and areas of high irrigation and/or overlaps between areas where nutrient loading and *E. coli* loading (in the TMDL reach) are both elevated.

Monitoring and Sampling

The city is currently performing water quality sampling based on the current monitoring and sampling plan. However, recommendations are made to evaluate *E. coli* and nutrient (ortho phosphate, total

dissolved phosphorus (TDP), total phosphorus (TP), total Kjeldahl nitrogen (TKN), nitrate (NO_3) and nitrite (NO_2), and ammonia (NH_3)) concentrations and associated flows to develop storm event-based loadings from the MS4. These monitoring and sampling recommendations are partly based on better understanding EMC nutrient loadings in association with Regulation 85. These nutrient loads can then be tied back to land use for updating EMC loads in the XPSWMM water quality model. Specific recommendations include the following:

- Set up a permanent flow monitor at the Boulder Creek sampling site BC-CU to determine loads at this location.
- Set up a flow monitor at the Boulder Creek sampling site BC-28th to determine the nutrient EMC loads at this location.
- Perform storm event-based nutrient and *E. coli* sampling and flow monitoring at all current instream sampling sites in Boulder Creek.
- Perform storm event-based nutrient and *E. coli* sampling and flow monitoring at select MS4 outfall locations, with a focus on outfalls 48 inches in diameter and greater.
- Monitor dry weather flow in MS4 outfalls to Boulder Creek and consider setting up temporary flow monitors at these locations.

Colorado Revised Statute (CRS) §37-92-602 (8)

The new CRS (CRS) §37-92-602 (8) effective on August 5, 2015, protects surface water in stormwater detention and infiltration facilities from water rights, provided that they are sufficiently reported to the state. This statute requires documentation such as location, approximate surface area at design volume, design storm, drainage times, and drainage area to protect permanent detention or infiltration facilities.

It is recommended that the P&DS, WQES, and Water Resources staff coordinate on documenting and reporting all stormwater detention and infiltration facilities to the extent required by the statute and that the city may want to protect from water rights.

Green Infrastructure

The city needs to look for additional ways to incorporate green infrastructure (GI) into both city and private projects. Recommendations related to GI include:

- Use information gained from an ongoing GI study to better understand how GI can satisfy city goals across departments.
- The current GI study and additional work should inform what initiatives/projects should be pursued to address multiple goals like localized flooding and water quality such as residential rain gardens and larger, neighborhood-scale GI projects.
- Identify methods to facilitate inclusion of water quality goals/projects from the SMP into various city projects. This might include facilitating meetings with city departments to discuss future projects, funding, and the potential for incorporating GI.

Climate and Resilience

As the city continues to evaluate the impacts of climate change and works toward greater resilience, adaptation and mitigation efforts continue to be a focus of the Stormwater Quality Program. Climate scientists have noted several issues, including the likelihood of greater variability in precipitation events, larger storm events due to more carrying capacity in warmer air systems during summer, and increased spring runoff due to rain-on-snow events or dust-on-snow events. While these impacts relate to the carrying capacity of the larger MS4, the Stormwater Quality Program may also play a role in helping to identify opportunities where GI may help work alongside of grey infrastructure to mitigate storm events in addition to continuing to leverage stormwater outreach with flood messaging to help with city adaptation efforts and overall resilience.

Appendix A: Stormwater Management Policies

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Stormwater Management Principles and Policies

The approach of this section is to present the general guiding principles, narrow these to policies, and then present the more specific aspects of the implementation measures. Note this document does not attempt to repeat previous published principles, policies, and implementation measures word for word, but rather to capture the general intent and to include the most relevant specifics within the SMP.

Guiding Principles

The Comprehensive Flood and Stormwater Utility Master Plan (CFS) presents guiding principles for stormwater drainage and water quality. These principles are listed below by topic along with additional guiding principles developed during SMP planning process. *Guiding principles from the CFS are italicized.*

Stormwater Drainage

1. *Maintain and preserve existing and natural drainage systems.*
2. *Reduce and manage developed runoff.*
3. *Eliminate drainage problems and nuisances.*

Stormwater Quality

1. *Protect public health and the environment.*
2. *Manage pollution at the source.*
3. *Protect and enhance natural resources associated with the stream environment.*
4. Prevent significant erosion resulting from stormwater outfalls and their adverse effects on water quality.

Multi-Objective Stormwater Planning

1. Integrate stormwater quantity and stormwater quality solutions.
2. Provide a regional approach to stormwater management that is consistent with other community goals and plans.
3. Assure an orderly implementation of improvements to the stormwater drainage system to serve existing and future development, both new development and redevelopment.

Irrigation Ditches

1. Address irrigation ditch issues relating to the stormwater collection system, water quality, conveyance of urban stormwater runoff, and contributions to groundwater conditions.

Stormwater Management Policies

Policies and implementation measures for stormwater management were developed in the BVCP and in the CFS. Some of the policies and implementation measures adopted in the SMP are based

on those in the previous documents; others were developed by the project team to help guide the master planning process.

Stormwater Drainage Systems

Policies and implementation measures for stormwater drainage systems address the conveyance of stormwater runoff to the major drainageway system.

Policies from the Boulder Valley Comprehensive Plan

DESIGN STORM FREQUENCY (BVCP SECTION 3.D(III) - URBAN SERVICE STANDARDS)

All local collection systems shall be designed to transport the following storm frequency:

- Single family residential: 2-year storm
- All other areas: 5-year storm

Policies and Implementation Measures from the CFS

POLICY: UPDATE THE CITY'S STORMWATER DRAINAGE SYSTEM MASTER PLAN

- Update hydrology/hydraulic models from the 2007 SMP
- Prioritize projects with a focus on known problems and future development areas.
- Re-evaluate detention including the possibility of regional detention and increasing existing detention.
- Focus on smaller storms (less than 1-inch) because of the greater hydrologic impact of these storms.

SMP Policies and Implementation Measures

The following are policies and implementation measures used specifically for the development of the SMP. The policies or implementation measures that are a significant divergence from the BVCP, CFS or the Design and Construction Standards are highlighted in italics.

POLICY 1 – STORMWATER DRAINAGE SYSTEM INFRASTRUCTURE

The city will provide an adequate stormwater collection and conveyance system for existing and future development within the city.

Implementation Measures:

- Update the collection system hydrologic and hydraulic models. Use appropriate land use projections and associated imperviousness values to estimate the future stormwater runoff.
- Focus on problems areas created by smaller storms because of the greater hydrologic impact of these storms.
- Develop cost effective improvements to the existing stormwater drainage system resulting in a continuous drainage system that provides service to the upstream users.

- Size the storm sewer system to convey the runoff from 2-year storm events in residential areas and runoff from 5-year storm events in commercial areas. *At a minimum, collector and arterial roadways are to convey the 5-year storm event.*
- Prioritize CIP projects to develop a financing strategy to fund capital projects that improve the stormwater drainage system. Financing strategies will be in accordance with existing laws, rules and regulations, and may include an increase in the stormwater utility fee.

POLICY 2 – MAXIMIZE EXISTING INFRASTRUCTURE

The city will maximize the use of existing storm drainage infrastructure and optimize the size of required drainage system improvements.

Implementation Measures:

- Allow limited surcharging in the existing storm drain piped system to increase drainage system capacity. These minimum levels of surcharging will provide a sufficient safety factor as to prevent flooding under the design storm conditions by limiting the hydraulic grade line to be approximately *one foot below the ground surface*.
- Incorporate existing detention facilities in the system analysis.
- Utilize appropriate analysis and planning tools to evaluate the system capacity and identify system improvements.

POLICY 3 – OPEN CHANNEL DRAINAGE SYSTEMS

The city will strive to minimize flooding, stream bank and channel erosion within the open channel stormwater drainage system by controlling the rate and volume of stormwater runoff from development and redevelopment projects.

Implementation Measures:

- *Infiltrate storm runoff where site conditions allow as a means of reducing post development runoff volumes and associated flow rates.*
- Continue to provide detention facilities that limit post-development runoff rates to previous development rates.
- Continue to require the minimization of directly connected impervious area , as well as other development practices to reduce discharges from storm sewer systems into the receiving waters of the city, as specified in the DCS.

Stormwater Quality

Policies and implementation measures for stormwater quality address the reduction of pollutants and runoff volume inherent in urban stormwater runoff to help mitigate their negative impacts on the receiving waters.

Policies from the Boulder Valley Comprehensive Plan

2.33 ENVIRONMENTALLY SENSITIVE URBAN DESIGN

For capital improvements and private development, the city and county will strive to ensure that buildings, streets, utilities and other infrastructure are located and designed to protect natural systems, minimize energy use, urban heat island effects and air and water pollution, and support clean energy generation.

POLICY 3.24 PROTECTION OF WATER QUALITY

Water quality is a critical health, economic and aesthetic concern. The city and county will protect, maintain and improve water quality within the Boulder Creek watershed as a necessary component of existing ecosystems and as a critical resource for the human community. The city and county will seek to reduce point and non-point sources of pollutants, protect and restore natural water system, and conserve water resources. Special emphasis will be placed on regional efforts such as watershed planning and priority will be placed on pollution prevention over treatment.

Policies and Implementation Measures from the CFS

POLICY: UPDATE THE STORMWATER MANAGEMENT PLAN TO INCORPORATE A WATERSHED MANAGEMENT APPROACH

- Balance quantity and quality issues
- Prevention first, mitigation second – Prevent stormwater excessive runoff and pollution at the source using techniques tailored to each subbasin.
- Apply conservation principles. Shift the focus from stormwater disposal to prevention and conservation. Approach stormwater management as a resource to enhance natural systems and processes

SMP Policies and Implementation Measures

The following are policies and implementation measures used specifically for the development of the SMP. The policies or implementation measures that are a significant divergence from the BVCP, CFS or the Design and Construction Standards are highlighted in italics.

POLICY 4 – STORMWATER QUALITY CIP PROJECTS

The city will strive to protect the quality of water in the stormwater drainage system and receiving waters, including Boulder Creek, to maintain and enhance the environment, quality of life, and economic well-being of the City of Boulder by identifying and implementing stormwater quality CIP projects.

Implementation Measures:

- Identify and implement regional, post-construction stormwater quality facilities (best management practices or BMPs) that will reduce pollutants from existing impervious areas.
- Emphasize the use of surface oriented BMPs to manage stormwater quantity and quality in the city's CIP projects.

- Develop BMP Toolbox and user-friendly selection process, which will leverage other city capital projects (e.g., water, transportation, parks) to assist in implementing stormwater quality solutions. *Include identification of practical low impact development practices (LID) on a parcel level to mitigate impervious areas, runoff volume and associated pollutants.*

Multi-Objective Planning

Policies and implementation measures for multi-objective planning are intended to identify opportunities for including stormwater projects with other capital improvements in the city. This will improve the efficiency of implementing stormwater improvements.

Policies from the Boulder Valley Comprehensive Plan

POLICY 1.29 CHANNELING DEVELOPMENT TO AREAS WITH ADEQUATE INFRASTRUCTURE

In order to protect and use past investments in capital improvements, new development and redevelopment will be located in areas where adequate public services and facilities presently exist or are planned to be provided under the city's Capital Improvements Program.

POLICY 1.32 MULTI-PURPOSE USE OF PUBLIC LANDS

Multi-purpose use of public lands, facilities, and personnel services shall be emphasized. However, in consideration of potential use of parks and open space lands, only activities consistent with the original intent of acquisition will be considered.

POLICY 1.35 UTILITY PROVISION TO IMPLEMENT COMMUNITY GOALS

The city will consider the importance of the other objectives of the Boulder Valley Comprehensive Plan in the planning and operation of the water, wastewater and stormwater and floodplain management utilities. These other objectives include in-stream flow maintenance, enhancement of recreational opportunities, water quality management, preservation of natural ecosystems, open space and irrigated agricultural land, and implementation of desired timing and location of growth patterns.

POLICY 3.25 WATER RESOURCE PLANNING AND ACQUISITION

Water resource planning efforts will be regional in nature and incorporate the goals of water quality protection, and surface and ground water conservation. The city will continue to obtain additional municipal water supplies to insure adequate drinking water, maintain instream flows and preserve agricultural uses. The city will seek to minimize or mitigate the environmental, agricultural and economic impacts to other jurisdictions in its acquisition of additional municipal water supply to further the goals of maintaining instream flows and preventing the permanent removal of land from agricultural production elsewhere in the state.

Policies and Implementation Measures from the CFS

Update the Stormwater Management Plan by incorporating the following approaches:

- Integrate water quality and other multi-objective issues.

- Use multiple objectives approach. Develop solutions that coordinate management of peak rates and volume, water quality, and maintenance.
- Integrate BMPs into site design process. Determine appropriate application of BMPs in prioritized subbasins in order to integrate BMPs into the first stages of site planning and overall subbasin planning.

SMP Policies and Implementation Measures

The following are policies and implementation measures used specifically for the development of the SMP. The policies or implementation measures that are a significant divergence from the BVCP, CFS or the Design and Construction Standards are highlighted in italics.

POLICY 5 – STORMWATER PLANNING AND COORDINATION

The city will continue to integrate the quantity and quality aspects of stormwater in the planning, design, and construction of development and redevelopment projects, and will look for opportunities to address stormwater issues when planning and designing other capital projects in the city, including projects involving water, wastewater, transportation, and parks.

Implementation Measures:

- Emphasize the use of surface oriented BMPs to manage stormwater quantity and quality in private development projects *through revisions to city ordinances and the development code*.
- Identify and implement regional, multi-use drainage and stormwater quality facilities that combine stormwater function with public and natural resource enhancements.
- *Investigate opportunities to remove pollutants and reduce runoff volume by identifying surface oriented BMPs in conjunction with acquisition of floodplain hazard properties.*
- Identify opportunities for drainage and water quality improvements related to transportation, water, and wastewater projects.
- Investigate an achievable level for implementation of low impact development practices for new development that would reduce the size and extent of required improvements to the existing stormwater drainage system.

Irrigation Ditches

Policies and implementation measures associated with irrigation ditches address the quantity of stormwater runoff discharged to the irrigation systems within the City and problems associated with ditch over-topping.

Policies from the Boulder Valley Comprehensive Plan

STORMWATER AND FLOOD MANAGEMENT (BVCP SECTION 3(D)(V) - URBAN SERVICE STANDARDS)

Storm runoff quantity greater than the 'historical' amount will not be discharged into irrigation ditches without the approval of the flood regulatory authority or the appropriate irrigation ditch company.

Policies and Implementation Measures from the CFS

UPDATE THE CITY'S STORMWATER COLLECTION SYSTEM MASTER PLAN

- The Stormwater Management Plan should address separating stormwater drainage from the irrigation ditches.

SMP Policies and Implementation Measures

The following are policies and implementation measures used specifically for the development of the SMP. The policies or implementation measures that are a significant divergence from the BVCP, CFS or the Design and Construction Standards are highlighted in italics.

POLICY 6 – SEPARATION OF STORMWATER OUTFALLS FROM IRRIGATION DITCHES

Storm sewer outfalls (point discharges) are to be separated from irrigation ditches within the city limits.

Implementation Measures:

- Continue to allow surface runoff from undeveloped areas within the city to enter the irrigation ditches via overland flow.
- Identify near-term opportunities for removing storm sewer outfalls from irrigation ditches that alleviate known ditch over-topping problem locations.
- Identify a time schedule for separating the storm sewer system from irrigation ditches.

Groundwater

Policies and implementation measures for groundwater are associated with the identification of high groundwater areas and associated water quality issues.

Policies from the Boulder Valley Comprehensive Plan

3.28 SURFACE AND GROUND WATER

Surface and ground water resources will be managed to prevent their degradation and to protect and enhance aquatic, wetland and riparian ecosystems. Land use and development planning and public land management practices will consider the

interdependency of surface and groundwater and potential impacts to these resources from pollutant sources, changes in hydrology, and dewatering activities.

SMP Policies and Implementation Measures

The following are policies and implementation measures used specifically for the development of the SMP. (The policies or implementation measures that are a significant divergence from the BVCP, CFS or the Design and Construction Standards are highlighted in italics.)

POLICY 7 – GROUNDWATER IMPACTS RESULTING FROM DEVELOPMENT

The city will continue to address groundwater issues related to development proposals and the associated discharge locations of pump groundwater flows including water quality impacts due to potential groundwater quality issues at registered locations.

Implementation Measures:

- The Stormwater Management Plan will not include pumped groundwater discharge into the storm sewer system in the capacity analysis due to the level of complexity in determining actual pumped flow rates and discharge locations.
- Collect more accurate data on groundwater levels in potential problem areas, including seasonal fluctuations.
- Develop requirements, including groundwater quality, for disposal of pumped groundwater into the stormwater collection system from dewatering activities.
- Develop requirements for mitigation plans for problem areas such as areas where dewatering will impact wetlands and well levels.
- At relevant sites, incorporate groundwater sampling into an overall water quality monitoring plan.
- Address problems related to the interaction of irrigation ditches and groundwater, including groundwater contamination.

Appendix B: Cost Estimates

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COLLECTOR SYSTEM IMPROVEMENT COSTS

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Boulder SMP Collector System Recommended Plan Projects Tier 1 Cost

Rank	Subbasin	ID	Improvement Type	Priority	Cost
-	Goose Creek	GC_01	Hydraulic Improvement (Broadway Alternative 2)	-	
1	Goose Creek	GC_02	Hydraulic Improvement (Goose CR Alternative 2b)	Tier 1	$ 8,269,000
-	Middle Boulder Creek	MBC_10	Hydraulic Improvement	Tier 1	
3	Middle Boulder Creek	MBC_14	Combined Hydraulic/Water Quality Improvement	Tier 1	$ 2,076,000
4	Dry Creek	DC_01	Combined Hydraulic/Water Quality Improvement	Tier 1 and 2	$ 7,195,000
				Total	$ 17,540,000

Notes:

GC_01 replaced with Local System Improvement Goose Creek - 5

GC_02 modified to reflect overlap with Local System Improvement Recommendations

MBC_10 replaced with Local System Improvement Middle Creek - 2

Tier 1 Costs

Improvement ID: *GC_02 - Updated*

Description	Units	Quantity	Unit Cost (Updated)	Item Cost
General				
Insurance and Bonding (10%)				$ 452,584
Mobilization (6%)				$ 271,550
Traffic Control (5%)				$ 226,292
Misc. Utility Relocation (5%)				$ 226,292
Subtotal				$ 1,176,718
Demolition				
Sawcut	LF	8,931	$ 4.29	$ 38,269
Remove and Dispose of Asphalt	CY	862	$ 44.56	$ 38,398
Remove and Dispose of Curb and Gutter	LF	1,958	$ 8.74	$ 17,107
Remove and Dispose of Inlet	EA	84	$ 1,262	$ 106,008
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 29,024
Connect to Existing	Each	20	$ 1,200	$ 24,000
Removal and Disposal of Pipe (up to 36-inch)	LF	0	$ 30.67	$ -
Box				
4'x8' RCB - 10' Depth to Invert	LF	535	$ 680	$ 363,800
4'x12' RCB - 10' Depth to Invert	LF	1937	$ 1,130	$ 2,188,810
Pipe				
36" RCP - 10' Depth to Invert	LF	55	$ 187	$ 10,276
48" RCP - 10' Depth to Invert	LF	1381	$ 247	$ 341,104
54" RCP - 10' Depth to Invert	LF	60	$ 304	$ 18,217
60" RCP - 10' Depth to Invert	LF	347	$ 351	$ 121,649
Surface Restoration				
Type 1 (Asphalt Patch)	LF	4,112	$ 51	$ 211,273
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	2,428	$ 103	$ 250,145
Manholes				
72" and Larger	Each	12	$ 9,237	$ 110,842
Special/Box Base	Each	11	$ 13,855	$ 152,407
Curb Inlets (Type R)	Each	84	$ 7,274	$ 611,014
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041	$ 4,041
Subtotal				$ 4,525,838
Utility Relocation				
Water Line Relocation	LF	2,394		$ -
Subtotal				$ -
Subtotal Construction Costs				**$ 5,702,556**
Design Contingency (25%)				$ 1,425,639
Engineering and Administration (20%)				$ 1,140,511
Total Estimated Improvement Cost (Rounded)				**$ 8,269,000**

Improvement ID: *MBC_14*

Description	Units	Quantity	Unit Cost (Updated)	Item Cost
General				
Insurance and Bonding (10%)				$ 106,420
Mobilization (6%)				$ 63,852
Traffic Control (5%)				$ 53,210
Misc. Utility Relocation (5%)				$ 53,210
Subtotal				$ 276,691
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 18,381
Connect to Existing	Each	3	$ 1,200.00	$ 3,600
Removal and Disposal of Pipe (up to 36-inch)	LF	895	$ 30.67	$ 27,450
Pipe				
24" RCP - 6' Depth to Invert	LF	291	$ 130.14	$ 37,871
30" RCP - 6' Depth to Invert	LF	602	$ 152.28	$ 91,673
36" RCP - 8' Depth to Invert	LF	848	$ 186.84	$ 158,440
42" RCP - 8' Depth to Invert	LF	364	$ 218.78	$ 79,634
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,780	$ 51.38	$ 91,456
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	215	$ 103.02	$ 22,150
Manholes				
60" Dia and Smaller	Each	14	$ 4,618.40	$ 64,658
Curb Inlets (Type R)	Each	56	$ 7,273.98	$ 407,343
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 1,006,696
Water Quality Manholes				
10-foot Diameter (13 cfs)	Each	1	$ 45,029.40	$ 45,029
Diversion Manhole	Each	1	$ 10,391.40	$ 10,391
Diversion and Return Piping	Each	1	$ 2,078.28	$ 2,078
Subtotal				$ 57,499
Subtotal Construction Costs				**$ 1,340,886**
Design Contingency (25%)				$ 335,221
Engineering and Administration (20%)				$ 268,177
Land Acquisition	SF	10,000	$ 13.12	$ 131,240
Total Estimated Improvement Cost (Rounded)				$ 2,076,000

Tier 1 Costs

Improvement ID: *DC_01*

Description	Units	Quantity	Unit Cost (Updated)	Item Cost
General				
Insurance and Bonding (10%)				$ 397,904
Mobilization (6%)				$ 238,742
Traffic Control (5%)				$ 198,952
Misc. Utility Relocation (5%)				$ 198,952
Subtotal				$ 1,034,550
Pipe Improvements				
Connect to Existing	Each	6	$ 1,200.00	$ 7,200
Removal and Disposal of Pipe (up to 36-inch)	LF	4,740	$ 30.67	$ 145,376
Pipe				
24" RCP - 6' Depth to Invert	LF	337	$ 130.14	$ 43,857
30" RCP - 6' Depth to Invert	LF	1,962	$ 152.28	$ 298,773
36" RCP - 8' Depth to Invert	LF	775	$ 186.84	$ 144,801
42" RCP - 6' Depth to Invert	LF	401	$ 211.16	$ 84,673
48" RCP - 6' Depth to Invert	LF	800	$ 231.49	$ 185,189
54" RCP - 8' Depth to Invert	LF	108	$ 295.38	$ 31,901
60" RCP - 10' Depth to Invert	LF	1,046	$ 350.57	$ 366,698
66" RCP - 10' Depth to Invert	LF	191	$ 387.59	$ 74,030
72" RCP - 12' Depth to Invert	LF	1,894	$ 459.80	$ 870,870
Surface Restoration				
Type 1 (Asphalt Patch)	LF	4,570	$ 51.38	$ 234,805
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	490	$ 103.02	$ 50,482
Manholes				
60" Dia and Smaller	Each	14	$ 4,618.40	$ 64,658
72" and Larger	Each	3	$ 9,236.80	$ 27,710
Special/Box Base	Each	8	$ 13,855.20	$ 110,842
Curb Inlets (Type R)	Each	100	$ 7,273.98	$ 727,398
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 3,473,305
Channel Improvements				
Excavation	CY	2,519	$ 17.76	$ 44,723
Vegetation	SF	25,600	$ 0.29	$ 7,389
Subtotal				$ 52,113
Water Quality Ponds				
Excavation and shaping	CY	12,852	$ 23.09	$ 296,775
Amended topsoil and preparation	CY	1,278	$ 18.47	$ 23,605
Wetland vegetation	SF	69,000	$ 1.85	$ 127,468
Outlet structure	EA	1	$ 5,773.00	$ 5,773
Subtotal				$ 453,621
Subtotal Construction Costs				**$ 4,961,476**
Design Contingency (25%)				$ 1,240,369
Engineering and Administration (20%)				$ 992,295
Total Estimated Improvement Cost (Rounded)				$ 7,195,000

Boulder SMP Collector System Recommended Plan Projects Tier 2 Cost

Rank	Subbasin	ID	Improvement Type	Priority	Cost
21	Bear Canyon Creek	BCC_03	Hydraulic Improvement	Tier 2	$ 1,512,000
9	Dry Creek No. 2	DC2_02	Hydraulic Improvement	Tier 2	$ 5,364,000
16	Dry Creek No. 2	DC2_06	Combined Hydraulic/Water Quality Improvement	Tier 2	$ 637,000
14	Elmers Twomile Creek	ETC_01	Hydraulic Improvement	Tier 2	$ 639,000
11	Goose Creek	GC_08	Combined Hydraulic/Water Quality Improvement	Tier 2	$ 476,000
12	Goose Creek	GC_09	Combined Hydraulic/Water Quality Improvement	Tier 2	$ 957,000
6	Middle Boulder Creek	MBC_04	Hydraulic Improvement	Tier 2	$ 733,000
9	Middle Boulder Creek	MBC_20	Hydraulic Improvement	Tier 2	$ 88,000
8	Middle Boulder Creek	MBC_22	Hydraulic Improvement	Tier 2	$ 2,298,000
14	Middle Boulder Creek	MBC_23	Combined Hydraulic/Water Quality Improvement	Tier 2	$ 445,000
5	Skunk Creek	SC_01	Hydraulic Improvement	Tier 2	$ 1,250,000
18	Skunk Creek	SC_02	Hydraulic Improvement	Tier 2	$ 1,135,000
19	Middle Boulder Creek	MBC_09	Hydraulic Improvement	Tier 3	$ 1,224,000
7	Wonderland Creek	WC_03	Hydraulic Improvement	Tier 3	$ 810,000
				Total	$ 17,568,000

Notes:
GC_04 replaced with Local System Improvement Goose Creek - 7 (Tier II)

Improvement ID: *SC_01*

Description	Units	Quantity	it Cost (Updat	Item Cost
General				
Insurance and Bonding (10%)				$ 68,480
Mobilization (6%)				$ 41,088
Traffic Control (5%)				$ 34,240
Misc. Utility Relocation (5%)				$ 34,240
Subtotal				$ 178,048
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 7,245
Connect to Existing	Each	3	$ 1,200.00	$ 3,600
Removal and Disposal of Pipe (up to 36-inch)	LF	740	$ 30.67	$ 22,696
Pipe				
36" RCP - 6' Depth to Invert	LF	1,341	$ 186.84	$ 250,552
42" RCP - 8' Depth to Invert	LF	770	$ 218.78	$ 168,457
Surface Restoration				
Type 1 (Asphalt Patch)	LF	145	$ 51.38	$ 7,450
Manholes				
60" Dia and Smaller	Each	4	$ 4,618.40	$ 18,474
Special/Box Base	Each	2	$ 13,855.20	$ 27,710
Curb Inlets (Type R)	Each	24	$ 7,273.98	$ 174,576
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 684,801
Subtotal Construction Costs				**$ 862,849**
Design Contingency (30%)				$ 172,570
Engineering and Administration (20%)				$ 172,570
Land Acquisition	SF	3,200	$ 13.12	$ 41,997
Total Estimated Improvement Cost (Rounded)				$ 1,250,000

Improvement ID: *MBC_04*

Description	Units	Quantity	it Cost (Updat	Item Cost
General				
Insurance and Bonding (10%)				$ 41,500
Mobilization (6%)				$ 24,900
Traffic Control (5%)				$ 20,750
Misc. Utility Relocation (5%)				$ 20,750
Subtotal				$ 107,901
Pipe Improvements				
Connect to Existing	Each	3	$ 1,200.00	$ 3,600
Removal and Disposal of Pipe (up to 36-inch)	LF	1,284	$ 30.67	$ 39,380
Pipe				
24" RCP - 8' Depth to Invert	LF	1,133	$ 130.14	$ 147,449
30" RCP - 6' Depth to Invert	LF	151	$ 152.28	$ 22,994
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,220	$ 51.38	$ 62,683
Manholes				
60" Dia and Smaller	Each	4	$ 4,618.40	$ 18,474
Curb Inlets (Type R)	Each	16	$ 7,273.98	$ 116,384
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 415,005
Subtotal Construction Costs				**$ 522,906**
Design Contingency (30%)				$ 104,581
Engineering and Administration (20%)				$ 104,581
Total Estimated Improvement Cost (Rounded)				$ 733,000

Improvement ID: *WC_03*

Description	Units	Quantity	it Cost (Updat	Item Cost
General				
Insurance and Bonding (10%)				$ 45,869
Mobilization (6%)				$ 27,522
Traffic Control (5%)				$ 22,935
Misc. Utility Relocation (5%)				$ 22,935
Subtotal				$ 119,261
Pipe Improvements				
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	275	$ 30.67	$ 8,434
Pipe				
30" RCP - 6' Depth to Invert	LF	800	$ 152.28	$ 121,824
36" RCP - 6' Depth to Invert	LF	393	$ 186.84	$ 73,428
Surface Restoration				
Type 1 (Asphalt Patch)	LF	600	$ 51.38	$ 30,828
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	150	$ 103.02	$ 15,454
Manholes				
60" Dia and Smaller	Each	6	$ 4,618.40	$ 27,710
Curb Inlets (Type R)	Each	24	$ 7,273.98	$ 174,576
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 458,695
Subtotal Construction Costs				**$ 577,956**
Design Contingency (30%)				$ 115,591
Engineering and Administration (20%)				$ 115,591
Total Estimated Improvement Cost (Rounded)				$ 810,000

Improvement ID: *MBC_22*

Description	Units	Quantity	it Cost (Updat	Item Cost
General				
Insurance and Bonding (10%)				$ 130,272
Mobilization (6%)				$ 78,163
Traffic Control (5%)				$ 65,136
Misc. Utility Relocation (5%)				$ 65,136
Subtotal				$ 338,707
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 12,315
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	2,025	$ 30.67	$ 62,107
Pipe				
30" RCP - 6' Depth to Invert	LF	1,751	$ 152.28	$ 266,642
36" RCP - 6' Depth to Invert	LF	884	$ 186.84	$ 165,167
42" RCP - 6' Depth to Invert	LF	1,704	$ 211.16	$ 359,810
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,265	$ 51.38	$ 64,995
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	600	$ 103.02	$ 61,815
Manholes				
60" Dia and Smaller	Each	9	$ 4,618.40	$ 41,566
Curb Inlets (Type R)	Each	36	$ 7,273.98	$ 261,863
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 1,302,720
Subtotal Construction Costs				**$ 1,641,428**
Design Contingency (30%)				$ 328,286
Engineering and Administration (20%)				$ 328,286
Total Estimated Improvement Cost (Rounded)				$ 2,298,000

Improvement ID: *MBC_20*

Description	Units	Quantity	it Cost (Updat	Item Cost
General				
Insurance and Bonding (10%)				$ 4,967
Mobilization (6%)				$ 2,980
Traffic Control (5%)				$ 2,484
Misc. Utility Relocation (5%)				$ 2,484
Subtotal				$ 12,914
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 1,532
Removal and Disposal of Pipe (up to 36-inch)	LF	164	$ 30.67	$ 5,030
Pipe				
36" RCP - 6' Depth to Invert	LF	164	$ 186.84	$ 30,642
Surface Restoration				
Type 1 (Asphalt Patch)	LF	164	$ 51.38	$ 8,426
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 49,671
Subtotal Construction Costs				**$ 62,586**
Design Contingency (30%)				$ 12,517
Engineering and Administration (20%)				$ 12,517
Total Estimated Improvement Cost (Rounded)				$ 88,000

Improvement ID: *DC2_02*

Description	Units	Quantity	it Cost (Updat	Item Cost
General				
Insurance and Bonding (10%)				$ 304,071
Mobilization (6%)				$ 182,442
Traffic Control (5%)				$ 152,035
Misc. Utility Relocation (5%)				$ 152,035
Subtotal				$ 790,583
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 22,989
Connect to Existing	Each	5	$ 1,200.00	$ 6,000
Removal and Disposal of Pipe (up to 36-inch)	LF	7,015	$ 30.67	$ 215,150
Pipe				
24" RCP - 6' Depth to Invert	LF	2,343	$ 130.14	$ 304,918
30" RCP - 6' Depth to Invert	LF	1,136	$ 152.28	$ 172,990
36" RCP - 6' Depth to Invert	LF	440	$ 186.84	$ 82,210
42" RCP - 6' Depth to Invert	LF	171	$ 211.16	$ 36,108
48" RCP - 8' Depth to Invert	LF	891	$ 239.24	$ 213,165
54" RCP - 8' Depth to Invert	LF	1,022	$ 295.38	$ 301,874
60" RCP - 10' Depth to Invert	LF	1,012	$ 350.57	$ 354,779
Surface Restoration				
Type 1 (Asphalt Patch)	LF	2,470	$ 51.38	$ 126,908
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	1,750	$ 103.02	$ 180,294
Manholes				
60" Dia and Smaller	Each	22	$ 4,618.40	$ 101,605
72" and Larger	Each	5	$ 9,236.80	$ 46,184
Curb Inlets (Type R)	Each	116	$ 7,273.98	$ 843,782
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 3,040,706
Water Line Relocation	LF	1,500	$ -	$ -
Subtotal				$ -
Subtotal Construction Costs				**$ 3,831,289**
Design Contingency (30%)				$ 766,258
Engineering and Administration (20%)				$ 766,258
Total Estimated Improvement Cost (Rounded)				$ 5,364,000

Improvement ID: *GC_08*

Description	Units	Quantity	it Cost (Updat	Item Cost
General				
Insurance and Bonding (10%)				$ 26,957
Mobilization (6%)				$ 16,174
Traffic Control (5%)				$ 13,479
Misc. Utility Relocation (5%)				$ 13,479
Subtotal				$ 70,089
Pipe Improvements				
Connect to Existing	Each	4	$ 1,200.00	$ 4,800
Removal and Disposal of Pipe (up to 36-inch)	LF	458	$ 30.67	$ 14,047
Pipe				
30" RCP - 8' Depth to Invert	LF	399	$ 152.28	$ 60,760
42" RCP - 8' Depth to Invert	LF	59	$ 218.78	$ 12,908
Manholes				
60" Dia and Smaller	Each	4	$ 4,618.40	$ 18,474
Curb Inlets (Type R)	Each	16	$ 7,273.98	$ 116,384
Subtotal				$ 227,372
Water Quality Manholes				
8-foot Diameter (7.1 cfs)	Each	1	$ 29,730.95	$ 29,731
Diversion Manhole	Each	1	$ 10,391.40	$ 10,391
Diversion and Return Piping	Each	1	$ 2,078.28	$ 2,078
Subtotal				$ 42,201
Subtotal Construction Costs				**$ 339,661**
Design Contingency (30%)				$ 67,932
Engineering and Administration (20%)				$ 67,932
Total Estimated Improvement Cost (Rounded)				$ 476,000

Improvement ID: *GC_09*

Description	Units	Quantity	it Cost (Updat	Item Cost
General				
Insurance and Bonding (10%)				$ 50,931
Mobilization (6%)				$ 30,558
Traffic Control (5%)				$ 25,465
Misc. Utility Relocation (5%)				$ 25,465
Subtotal				$ 132,420
Pipe Improvements				
Connect to Existing	Each	1	$ 1,200.00	$ 1,200
Removal and Disposal of Pipe (up to 36-inch)	LF	457	$ 30.67	$ 14,016
Pipe				
24" RCP - 6' Depth to Invert	LF	442	$ 130.14	$ 57,522
30" RCP - 6' Depth to Invert	LF	235	$ 152.28	$ 35,786
Surface Restoration				
Type 1 (Asphalt Patch)	LF	677	$ 51.38	$ 34,784
Manholes				
60" Dia and Smaller	Each	7	$ 4,618.40	$ 32,329
Curb Inlets (Type R)	Each	28	$ 7,273.98	$ 203,671
Subtotal				$ 379,308
Water Quality Ponds				
Excavation and shaping	CY	1,511	$ 23.09	$ 34,895
Amended topsoil and preparation	CY	756	$ 18.47	$ 13,958
Wetland vegetation	SF	40,800	$ 1.85	$ 75,372
Outlet structure	EA	1	$ 5,773.00	$ 5,773
Subtotal				$ 129,998
Subtotal Construction Costs				**$ 641,725**
Design Contingency (30%)				$ 128,345
Engineering and Administration (20%)				$ 128,345
Land Acquisition	SF	4,400	$ 13.12	$ 57,745
Total Estimated Improvement Cost (Rounded)				$ 957,000

Improvement ID: *ETC_01*

Description	Units	Quantity	it Cost (Updat	Item Cost
General				
Insurance and Bonding (10%)				$ 36,188
Mobilization (6%)				$ 21,713
Traffic Control (5%)				$ 18,094
Misc. Utility Relocation (5%)				$ 18,094
Subtotal				$ 94,089
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 9,992
Connect to Existing	Each	1	$ 1,200.00	$ 1,200
Removal and Disposal of Pipe (up to 36-inch)	LF	220	$ 30.67	$ 6,747
Pipe				
36" RCP - 6' Depth to Invert	LF	216	$ 186.84	$ 40,357
42" RCP - 8' Depth to Invert	LF	121	$ 218.78	$ 26,472
48" RCP - 8' Depth to Invert	LF	556	$ 239.24	$ 133,019
Manholes				
60" Dia and Smaller	Each	2	$ 4,618.40	$ 9,237
Curb Inlets (Type R)	Each	16	$ 7,273.98	$ 116,384
Subtotal				$ 361,882
Subtotal Construction Costs				**$ 455,971**
Design Contingency (30%)				$ 91,194
Engineering and Administration (20%)				$ 91,194
Total Estimated Improvement Cost (Rounded)				$ 639,000

Improvement ID: *MBC_23*

Description	Units	Quantity	it Cost (Updat	Item Cost
General				
Insurance and Bonding (10%)				$ 25,204
Mobilization (6%)				$ 15,122
Traffic Control (5%)				$ 12,602
Misc. Utility Relocation (5%)				$ 12,602
Subtotal				$ 65,531
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 2,284
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	300	$ 30.67	$ 9,201
Pipe				
30" RCP - 6' Depth to Invert	LF	300	$ 152.28	$ 45,684
Surface Restoration				
Type 1 (Asphalt Patch)	LF	300	$ 51.38	$ 15,414
Manholes				
60" Dia and Smaller	Each	4	$ 4,618.40	$ 18,474
Curb Inlets (Type R)	Each	16	$ 7,273.98	$ 116,384
Subtotal				$ 209,840
Water Quality Manholes				
8-foot Diameter (7.1 cfs)	Each	1	$ 29,730.95	$ 29,731
Diversion Manhole	Each	1	$ 10,391.40	$ 10,391
Diversion and Return Piping	Each	1	$ 2,078.28	$ 2,078
Subtotal				$ 42,201
Subtotal Construction Costs				**$ 317,572**
Design Contingency (30%)				$ 63,514
Engineering and Administration (20%)				$ 63,514
Total Estimated Improvement Cost (Rounded)				$ 445,000

Improvement ID: *DC2_06*

Description	Units	Quantity	it Cost (Updat	Item Cost
General				
Insurance and Bonding (10%)				$ 36,110
Mobilization (6%)				$ 21,666
Traffic Control (5%)				$ 18,055
Misc. Utility Relocation (5%)				$ 18,055
Subtotal				$ 93,887
Pipe Improvements				
Connect to Existing	Each	3	$ 1,200.00	$ 3,600
Removal and Disposal of Pipe (up to 36-inch)	LF	403	$ 30.67	$ 12,360
Pipe				
24" RCP - 6' Depth to Invert	LF	235	$ 130.14	$ 30,583
30" RCP - 6' Depth to Invert	LF	168	$ 152.28	$ 25,583
Surface Restoration				
Type 1 (Asphalt Patch)	LF	403	$ 51.38	$ 20,706
Manholes				
60" Dia and Smaller	Each	5	$ 4,618.40	$ 23,092
Curb Inlets (Type R)	Each	20	$ 7,273.98	$ 145,480
Subtotal				$ 261,404
Water Quality Manholes				
8-foot Diameter (7.1 cfs)	Each	1	$ 29,730.95	$ 29,731
10-foot Diameter (13 cfs)	Each	1	$ 45,029.40	$ 45,029
Diversion Manhole	Each	2	$ 10,391.40	$ 20,783
Diversion and Return Piping	Each	2	$ 2,078.28	$ 4,157
Subtotal				$ 99,700
Subtotal Construction Costs				**$ 454,990**
Design Contingency (30%)				$ 90,998
Engineering and Administration (20%)				$ 90,998
Total Estimated Improvement Cost (Rounded)				$ 637,000

Improvement ID: *SC_02*

Description	Units	Quantity	it Cost (Updat	Item Cost
General				
Insurance and Bonding (10%)				$ 64,302
Mobilization (6%)				$ 38,581
Traffic Control (5%)				$ 32,151
Misc. Utility Relocation (5%)				$ 32,151
Subtotal				$ 167,185
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 12,128
Connect to Existing	Each	3	$ 1,200.00	$ 3,600
Removal and Disposal of Pipe (up to 36-inch)	LF	1,240	$ 30.67	$ 38,031
Pipe				
30" RCP - 6' Depth to Invert	LF	348	$ 152.28	$ 52,993
36" RCP - 6' Depth to Invert	LF	379	$ 186.84	$ 70,812
48" RCP - 6' Depth to Invert	LF	513	$ 231.49	$ 118,752
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,240	$ 51.38	$ 63,711
Manholes				
60" Dia and Smaller	Each	6	$ 4,618.40	$ 27,710
Curb Inlets (Type R)	Each	32	$ 7,273.98	$ 232,767
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 643,020
Subtotal Construction Costs				**$ 810,206**
Design Contingency (30%)				$ 162,041
Engineering and Administration (20%)				$ 162,041
Total Estimated Improvement Cost (Rounded)				$ 1,135,000

Improvement ID: *MBC_09*

Description	Units	Quantity	it Cost (Updat	Item Cost
General				
Insurance and Bonding (10%)				$ 69,349
Mobilization (6%)				$ 41,609
Traffic Control (5%)				$ 34,674
Misc. Utility Relocation (5%)				$ 34,674
Subtotal				$ 180,306
Pipe Improvements				
Connect to Existing	Each	4	$ 1,200.00	$ 4,800
Removal and Disposal of Pipe (up to 36-inch)	LF	1,430	$ 30.67	$ 43,858
Pipe				
24" RCP - 6' Depth to Invert	LF	306	$ 130.14	$ 39,823
30" RCP - 8' Depth to Invert	LF	381	$ 152.28	$ 58,019
48" RCP - 10' Depth to Invert	LF	743	$ 247.00	$ 183,519
Surface Restoration				
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	1,430	$ 103.02	$ 147,326
Manholes				
60" Dia and Smaller	Each	3	$ 4,618.40	$ 13,855
Curb Inlets (Type R)	Each	24	$ 7,273.98	$ 174,576
Subtotal				$ 693,486
Subtotal Construction Costs				**$ 873,792**
Design Contingency (30%)				$ 174,758
Engineering and Administration (20%)				$ 174,758
Total Estimated Improvement Cost (Rounded)				$ 1,224,000

Improvement ID: *BCC_03*

Description	Units	Quantity	it Cost (Updat	Item Cost
General				
Insurance and Bonding (10%)				$ 85,692
Mobilization (6%)				$ 51,415
Traffic Control (5%)				$ 42,846
Misc. Utility Relocation (5%)				$ 42,846
Subtotal				$ 222,800
Pipe Improvements				
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	1,586	$ 30.67	$ 48,643
Pipe				
18" RCP - 8' Depth to Invert	LF	520	$ 94.50	$ 49,140
24" RCP - 10' Depth to Invert	LF	1,310	$ 130.14	$ 170,483
30" RCP - 8' Depth to Invert	LF	401	$ 152.28	$ 61,064
36" RCP - 6' Depth to Invert	LF	255	$ 186.84	$ 47,644
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,666	$ 51.38	$ 85,599
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	820	$ 103.02	$ 84,480
Manholes				
60" Dia and Smaller	Each	9	$ 4,618.40	$ 41,566
Curb Inlets (Type R)	Each	36	$ 7,273.98	$ 261,863
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 856,924
Subtotal Construction Costs				**$ 1,079,724**
Design Contingency (30%)				$ 215,945
Engineering and Administration (20%)				$ 215,945
Total Estimated Improvement Cost (Rounded)				$ 1,512,000

Improvement ID: *MBC_18*

Description	Units	Quantity	it Cost (Updat	Item Cost
General				
Insurance and Bonding (10%)				$ 97,068
Mobilization (6%)				$ 58,241
Traffic Control (5%)				$ 48,534
Misc. Utility Relocation (5%)				$ 48,534
Subtotal				$ 252,378
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 20,722
Connect to Existing	Each	3	$ 1,200.00	$ 3,600
Removal and Disposal of Pipe (up to 36-inch)	LF	1,866	$ 30.67	$ 57,230
Pipe				
30" RCP - 6' Depth to Invert	LF	542	$ 152.28	$ 82,536
42" RCP - 8' Depth to Invert	LF	118	$ 218.78	$ 25,815
30" RCP - 8' Depth to Invert	LF	397	$ 152.28	$ 60,455
54" RCP - 10' Depth to Invert	LF	809	$ 303.62	$ 245,628
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,866	$ 51.38	$ 95,875
Manholes				
60" Dia and Smaller	Each	6	$ 4,618.40	$ 27,710
72" and Larger	Each	3	$ 9,236.80	$ 27,710
Curb Inlets (Type R)	Each	36	$ 7,273.98	$ 261,863
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 913,186
Water Quality Manholes				
10-foot Diameter (13 cfs)	Each	1	$ 45,029.40	$ 45,029
Diversion Manhole	Each	1	$ 10,391.40	$ 10,391
Diversion and Return Piping	Each	1	$ 2,078.28	$ 2,078
Subtotal				$ 57,499
Subtotal Construction Costs				**$ 1,223,063**
Design Contingency (30%)				$ 244,613
Engineering and Administration (20%)				$ 244,613
Land Acquisition	SF	800	$ 13.12	$ 10,499
Total Estimated Improvement Cost (Rounded)				$ 1,723,000

Improvement ID: *MBC_19*

Description	Units	Quantity	it Cost (Updat	Item Cost
General				
Insurance and Bonding (10%)				$ 28,003
Mobilization (6%)				$ 16,802
Traffic Control (5%)				$ 14,001
Misc. Utility Relocation (5%)				$ 14,001
Subtotal				$ 72,807
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 3,494
Connect to Existing	Each	1	$ 1,200.00	$ 1,200
Removal and Disposal of Pipe (up to 36-inch)	LF	537	$ 30.67	$ 16,470
Pipe				
24" RCP - 8' Depth to Invert	LF	537	$ 130.14	$ 69,885
Surface Restoration				
Type 1 (Asphalt Patch)	LF	350	$ 51.38	$ 17,983
Manholes				
60" Dia and Smaller	Each	4	$ 4,618.40	$ 18,474
Curb Inlets (Type R)	Each	16	$ 7,273.98	$ 116,384
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 247,931
Water Quality Manholes				
6-foot Diameter (3 cfs)	Each	1	$ 19,628.20	$ 19,628
Diversion Manhole	Each	1	$ 10,391.40	$ 10,391
Diversion and Return Piping	Each	1	$ 2,078.28	$ 2,078
Subtotal				$ 32,098
Subtotal Construction Costs				**$ 352,836**
Design Contingency (30%)				$ 70,567
Engineering and Administration (20%)				$ 70,567
Land Acquisition	SF	800	$ 13.12	$ 10,499
Total Estimated Improvement Cost (Rounded)				$ 505,000

Boulder SMP Collector System Recommended Plan Projects Tier 3 Cost

Rank	Subbasin	ID	Improvement Type	Priority	Cost
33	Bear Canyon Creek	BCC_01	Hydraulic Improvement	Tier 3	$ 1,132,000
36	Bear Canyon Creek	BCC_02	Hydraulic Improvement	Tier 3	$ 184,000
27	Bear Canyon Creek	BCC_04	Hydraulic Improvement	Tier 3	$ 540,000
36	Bear Canyon Creek	BCC_05	Hydraulic Improvement	Tier 3	$ 200,000
36	Bear Canyon Creek	BCC_06	Hydraulic Improvement	Tier 3	$ 373,000
36	Bear Canyon Creek	BCC_07	Hydraulic Improvement	Tier 3	$ 428,000
36	Dry Creek	DC_02	Hydraulic Improvement	Tier 3	$ 411,000
26	Dry Creek No. 2	DC2_01	Hydraulic Improvement	Tier 2	$ 1,226,000
50	Dry Creek No. 2	DC2_03	Hydraulic Improvement	Tier 3	$ 603,000
30	Dry Creek No. 2	DC2_04	Hydraulic Improvement	Tier 3	$ 664,000
27	Dry Creek No. 2	DC2_05	Hydraulic Improvement	Tier 3	$ 770,000
48	Elmers Twomile Creek	ETC_03	Hydraulic Improvement	Tier 3	$ 1,109,000
35	Fourmile Canyon Creek	FCC_01	Hydraulic Improvement	Tier 3	$ 863,000
30	Goose Creek	GC_03	Hydraulic Improvement	Tier 3	$ 819,000
49	Goose Creek	GC_05	Hydraulic Improvement	Tier 3	$ 810,000
29	Goose Creek	GC_06	Hydraulic Improvement	Tier 3	$ 933,000
36	Goose Creek	GC_07	Hydraulic Improvement	Tier 3	$ 184,000
53	Middle Boulder Creek	MBC_01	Hydraulic Improvement	Tier 3	$ 177,000
36	Middle Boulder Creek	MBC_02	Hydraulic Improvement	Tier 3	$ 267,000
50	Middle Boulder Creek	MBC_08	Hydraulic Improvement	Tier 3	$ 1,209,000
30	Middle Boulder Creek	MBC_13	Hydraulic Improvement	Tier 3	$ 754,000
50	Middle Boulder Creek	MBC_15	Hydraulic Improvement	Tier 3	$ 139,000
55	Middle Boulder Creek	MBC_17	Hydraulic Improvement	Tier 3	$ 480,000
36	Middle Boulder Creek	MBC_19	Combined Hydraulic/Water Quality Improvement	Tier 3	$ 408,000
54	Middle Boulder Creek	MBC_21	Hydraulic Improvement	Tier 3	$ 221,000
22	Viele Channel	VC_01	Hydraulic Improvement	Tier 3	$ 1,296,000
23	Viele Channel	VC_02	Hydraulic Improvement	Tier 3	$ 1,655,000
36	Wonderland Creek	WC_01	Hydraulic Improvement	Tier 3	$ 324,000
33	Wonderland Creek	WC_02	Hydraulic Improvement	Tier 3	$ 402,000
				Total	$ 18,581,000

Improvement ID: *VC_01*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 73,434
Mobilization (6%)				$ 44,060
Traffic Control (5%)				$ 36,717
Misc. Utility Relocation (5%)				$ 36,717
Subtotal				$ 190,928
Pipe Improvements				
Connect to Existing	Each	4	$ 1,200.00	$ 4,800
Removal and Disposal of Pipe (up to 36-inch)	LF	2,649	$ 30.67	$ 81,245
Pipe				
24" RCP - 10' Depth to Invert	LF	863	$ 130.14	$ 112,311
36" RCP - 8' Depth to Invert	LF	1,786	$ 186.84	$ 333,696
Manholes				
60" Dia and Smaller	Each	6	$ 4,618.40	$ 27,710
Curb Inlets (Type R)	Each	24	$ 7,273.98	$ 174,576
Subtotal				$ 734,338
Subtotal Construction Costs				**$ 925,266**
Design Contingency (30%)				$ 185,053
Engineering and Administration (20%)				$ 185,053
Total Estimated Improvement Cost (Rounded)				$ 1,296,000

Improvement ID: *VC_02*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 93,788
Mobilization (6%)				$ 56,273
Traffic Control (5%)				$ 46,894
Misc. Utility Relocation (5%)				$ 46,894
Subtotal				$ 243,848
Pipe Improvements				
Connect to Existing	Each	3	$ 1,200.00	$ 3,600
Removal and Disposal of Pipe (up to 36-inch)	LF	2,403	$ 30.67	$ 73,700
Pipe				
18" RCP - 6' Depth to Invert	LF	221	$ 94.50	$ 20,885
30" RCP - 6' Depth to Invert	LF	1,920	$ 152.28	$ 292,378
36" RCP - 6' Depth to Invert	LF	262	$ 186.84	$ 48,952
Surface Restoration				
Type 1 (Asphalt Patch)	LF	2,403	$ 51.38	$ 123,465
Manholes				
60" Dia and Smaller	Each	11	$ 4,618.40	$ 50,802
Curb Inlets (Type R)	Each	44	$ 7,273.98	$ 320,055
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 937,878
Subtotal Construction Costs				**$ 1,181,727**
Design Contingency (30%)				$ 236,345
Engineering and Administration (20%)				$ 236,345
Total Estimated Improvement Cost (Rounded)				$ 1,655,000

Improvement ID: *DC2_01*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 69,467
Mobilization (6%)				$ 41,680
Traffic Control (5%)				$ 34,734
Misc. Utility Relocation (5%)				$ 34,734
Subtotal				$ 180,615
Pipe Improvements				
Connect to Existing	Each	5	$ 1,200.00	$ 6,000
Removal and Disposal of Pipe (up to 36-inch)	LF	1,641	$ 30.67	$ 50,329
Pipe				
24" RCP - 10' Depth to Invert	LF	284	$ 130.14	$ 36,960
42" RCP - 8' Depth to Invert	LF	1,248	$ 218.78	$ 273,031
54" RCP - 10' Depth to Invert	LF	109	$ 303.62	$ 33,094
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,641	$ 51.38	$ 84,314
Manholes				
60" Dia and Smaller	Each	5	$ 4,618.40	$ 23,092
72" and Larger	Each	1	$ 9,236.80	$ 9,237
Curb Inlets (Type R)	Each	24	$ 7,273.98	$ 174,576
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 694,674
Subtotal Construction Costs				**$ 875,290**
Design Contingency (30%)				$ 175,058
Engineering and Administration (20%)				$ 175,058
Total Estimated Improvement Cost (Rounded)				$ 1,226,000

Improvement ID: *BCC_04*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 30,600
Mobilization (6%)				$ 18,360
Traffic Control (5%)				$ 15,300
Misc. Utility Relocation (5%)				$ 15,300
Subtotal				$ 79,560
Pipe Improvements				
Connect to Existing	Each	1	$ 1,200.00	$ 1,200
Removal and Disposal of Pipe (up to 36-inch)	LF	1,017	$ 30.67	$ 31,191
Pipe				
18" RCP - 6' Depth to Invert	LF	454	$ 94.50	$ 42,903
24" RCP - 6' Depth to Invert	LF	563	$ 130.14	$ 73,269
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,017	$ 51.38	$ 52,253
Manholes				
60" Dia and Smaller	Each	3	$ 4,618.40	$ 13,855
Curb Inlets (Type R)	Each	12	$ 7,273.98	$ 87,288
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 306,000
Subtotal Construction Costs				**$ 385,561**
Design Contingency (30%)				$ 77,112
Engineering and Administration (20%)				$ 77,112
Total Estimated Improvement Cost (Rounded)				$ 540,000

Improvement ID: *DC2_05*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 43,615
Mobilization (6%)				$ 26,169
Traffic Control (5%)				$ 21,807
Misc. Utility Relocation (5%)				$ 21,807
Subtotal				$ 113,398
Pipe Improvements				
Connect to Existing	Each	1	$ 1,200.00	$ 1,200
Removal and Disposal of Pipe (up to 36-inch)	LF	1,191	$ 30.67	$ 36,528
Pipe				
30" RCP - 6' Depth to Invert	LF	955	$ 152.28	$ 145,427
36" RCP - 6' Depth to Invert	LF	236	$ 186.84	$ 44,094
Surface Restoration				
Type 1 (Asphalt Patch)	LF	50	$ 51.38	$ 2,569
Manholes				
60" Dia and Smaller	Each	6	$ 4,618.40	$ 27,710
Curb Inlets (Type R)	Each	24	$ 7,273.98	$ 174,576
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 436,146
Subtotal Construction Costs				**$ 549,543**
Design Contingency (30%)				$ 109,909
Engineering and Administration (20%)				$ 109,909
Total Estimated Improvement Cost (Rounded)				$ 770,000

Improvement ID: *GC_06*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 52,857
Mobilization (6%)				$ 31,714
Traffic Control (5%)				$ 26,428
Misc. Utility Relocation (5%)				$ 26,428
Subtotal				$ 137,428
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 353
Connect to Existing	Each	3	$ 1,200.00	$ 3,600
Removal and Disposal of Pipe (up to 36-inch)	LF	1,247	$ 30.67	$ 38,245
Pipe				
24" RCP - 6' Depth to Invert	LF	41	$ 130.14	$ 5,336
30" RCP - 6' Depth to Invert	LF	679	$ 152.28	$ 103,398
42" RCP - 6' Depth to Invert	LF	527	$ 211.16	$ 111,279
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,247	$ 51.38	$ 64,070
Manholes				
60" Dia and Smaller	Each	6	$ 4,618.40	$ 27,710
Curb Inlets (Type R)	Each	24	$ 7,273.98	$ 174,576
Subtotal				$ 528,568
Subtotal Construction Costs				**$ 665,995**
Design Contingency (30%)				$ 133,199
Engineering and Administration (20%)				$ 133,199
Total Estimated Improvement Cost (Rounded)				$ 933,000

Improvement ID: *DC2_04*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 37,632
Mobilization (6%)				$ 22,579
Traffic Control (5%)				$ 18,816
Misc. Utility Relocation (5%)				$ 18,816
Subtotal				$ 97,844
Pipe Improvements				
Connect to Existing	Each	1	$ 1,200.00	$ 1,200
Removal and Disposal of Pipe (up to 36-inch)	LF	1,056	$ 30.67	$ 32,388
Pipe				
24" RCP - 8' Depth to Invert	LF	1,056	$ 130.14	$ 137,428
Surface Restoration				
Type 1 (Asphalt Patch)	LF	715	$ 51.38	$ 36,736
Manholes				
60" Dia and Smaller	Each	5	$ 4,618.40	$ 23,092
Curb Inlets (Type R)	Each	20	$ 7,273.98	$ 145,480
Subtotal				$ 376,323
Subtotal Construction Costs				**$ 474,168**
Design Contingency (30%)				$ 94,834
Engineering and Administration (20%)				$ 94,834
Total Estimated Improvement Cost (Rounded)				$ 664,000

Improvement ID: *MBC_13*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 42,724
Mobilization (6%)				$ 25,634
Traffic Control (5%)				$ 21,362
Misc. Utility Relocation (5%)				$ 21,362
Subtotal				$ 111,081
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 2,029
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	774	$ 30.67	$ 23,739
Pipe				
36" RCP - 6' Depth to Invert	LF	264	$ 186.84	$ 49,326
42" RCP - 6' Depth to Invert	LF	510	$ 211.16	$ 107,689
Surface Restoration				
Type 1 (Asphalt Patch)	LF	774	$ 51.38	$ 39,768
Manholes				
60" Dia and Smaller	Each	6	$ 4,618.40	$ 27,710
Curb Inlets (Type R)	Each	24	$ 7,273.98	$ 174,576
Subtotal				$ 427,236
Subtotal Construction Costs				**$ 538,318**
Design Contingency (30%)				$ 107,664
Engineering and Administration (20%)				$ 107,664
Total Estimated Improvement Cost (Rounded)				$ 754,000

Improvement ID: *GC_03*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 46,417
Mobilization (6%)				$ 27,850
Traffic Control (5%)				$ 23,209
Misc. Utility Relocation (5%)				$ 23,209
Subtotal				$ 120,685
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 148
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	1,255	$ 30.67	$ 38,491
Pipe				
24" RCP - 10' Depth to Invert	LF	229	$ 130.14	$ 29,802
30" RCP - 8' Depth to Invert	LF	1,026	$ 152.28	$ 156,239
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,255	$ 51.38	$ 64,482
Manholes				
60" Dia and Smaller	Each	5	$ 4,618.40	$ 23,092
Curb Inlets (Type R)	Each	20	$ 7,273.98	$ 145,480
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 464,175
Subtotal Construction Costs				**$ 584,860**
Design Contingency (30%)				$ 116,972
Engineering and Administration (20%)				$ 116,972
Total Estimated Improvement Cost (Rounded)				$ 819,000

Improvement ID: *WC_02*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 22,758
Mobilization (6%)				$ 13,655
Traffic Control (5%)				$ 11,379
Misc. Utility Relocation (5%)				$ 11,379
Subtotal				$ 59,170
Pipe Improvements				
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	352	$ 30.67	$ 10,796
Pipe				
24" RCP - 6' Depth to Invert	LF	352	$ 130.14	$ 45,809
Manholes				
60" Dia and Smaller	Each	5	$ 4,618.40	$ 23,092
Curb Inlets (Type R)	Each	20	$ 7,273.98	$ 145,480
Subtotal				$ 227,577
Subtotal Construction Costs				**$ 286,747**
Design Contingency (30%)				$ 57,349
Engineering and Administration (20%)				$ 57,349
Total Estimated Improvement Cost (Rounded)				$ 402,000

Improvement ID: *BCC_01*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 64,168
Mobilization (6%)				$ 38,501
Traffic Control (5%)				$ 32,084
Misc. Utility Relocation (5%)				$ 32,084
Subtotal				$ 166,837
Pipe Improvements				
Connect to Existing	Each	3	$ 1,200.00	$ 3,600
Removal and Disposal of Pipe (up to 36-inch)	LF	1,785	$ 30.67	$ 54,746
Pipe				
24" RCP - 6' Depth to Invert	LF	546	$ 130.14	$ 71,056
30" RCP - 6' Depth to Invert	LF	776	$ 152.28	$ 118,169
42" RCP - 6' Depth to Invert	LF	463	$ 211.16	$ 97,765
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,165	$ 51.38	$ 59,857
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	620	$ 103.02	$ 63,875
Manholes				
60" Dia and Smaller	Each	5	$ 4,618.40	$ 23,092
Curb Inlets (Type R)	Each	20	$ 7,273.98	$ 145,480
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 641,682
Subtotal Construction Costs				**$ 808,520**
Design Contingency (30%)				$ 161,704
Engineering and Administration (20%)				$ 161,704
Total Estimated Improvement Cost (Rounded)				$ 1,132,000

Improvement ID: *FCC_01*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 48,884
Mobilization (6%)				$ 29,330
Traffic Control (5%)				$ 24,442
Misc. Utility Relocation (5%)				$ 24,442
Subtotal				$ 127,098
Pipe Improvements				
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	781	$ 30.67	$ 23,953
Pipe				
30" RCP - 6' Depth to Invert	LF	781	$ 152.28	$ 118,931
Surface Restoration				
Type 1 (Asphalt Patch)	LF	781	$ 51.38	$ 40,128
Manholes				
60" Dia and Smaller	Each	9	$ 4,618.40	$ 41,566
Curb Inlets (Type R)	Each	36	$ 7,273.98	$ 261,863
Subtotal				$ 488,840
Subtotal Construction Costs				**$ 615,939**
Design Contingency (30%)				$ 123,188
Engineering and Administration (20%)				$ 123,188
Total Estimated Improvement Cost (Rounded)				$ 863,000

Improvement ID: *DC_02*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 23,295
Mobilization (6%)				$ 13,977
Traffic Control (5%)				$ 11,648
Misc. Utility Relocation (5%)				$ 11,648
Subtotal				$ 60,568
Pipe Improvements				
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	451	$ 30.67	$ 13,832
Pipe				
24" RCP - 8' Depth to Invert	LF	451	$ 130.14	$ 58,693
Surface Restoration				
Type 1 (Asphalt Patch)	LF	451	$ 51.38	$ 23,172
Manholes				
60" Dia and Smaller	Each	4	$ 4,618.40	$ 18,474
Curb Inlets (Type R)	Each	16	$ 7,273.98	$ 116,384
Subtotal				$ 232,955
Subtotal Construction Costs				**$ 293,523**
Design Contingency (30%)				$ 58,705
Engineering and Administration (20%)				$ 58,705
Total Estimated Improvement Cost (Rounded)				$ 411,000

Improvement ID: *GC_07*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 10,426
Mobilization (6%)				$ 6,255
Traffic Control (5%)				$ 5,213
Misc. Utility Relocation (5%)				$ 5,213
Subtotal				$ 27,107
Pipe Improvements				
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	195	$ 30.67	$ 5,981
Pipe				
18" RCP - 6' Depth to Invert	LF	195	$ 94.50	$ 18,428
Surface Restoration				
Type 1 (Asphalt Patch)	LF	195	$ 51.38	$ 10,019
Manholes				
60" Dia and Smaller	Each	2	$ 4,618.40	$ 9,237
Curb Inlets (Type R)	Each	8	$ 7,273.98	$ 58,192
Subtotal				$ 104,256
Subtotal Construction Costs				**$ 131,362**
Design Contingency (30%)				$ 26,272
Engineering and Administration (20%)				$ 26,272
Total Estimated Improvement Cost (Rounded)				$ 184,000

Improvement ID: *WC_01*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 18,314
Mobilization (6%)				$ 10,988
Traffic Control (5%)				$ 9,157
Misc. Utility Relocation (5%)				$ 9,157
Subtotal				$ 47,616
Pipe Improvements				
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	534	$ 30.67	$ 16,378
Pipe				
24" RCP - 6' Depth to Invert	LF	534	$ 130.14	$ 69,495
Surface Restoration				
Type 1 (Asphalt Patch)	LF	534	$ 51.38	$ 27,437
Manholes				
60" Dia and Smaller	Each	2	$ 4,618.40	$ 9,237
Curb Inlets (Type R)	Each	8	$ 7,273.98	$ 58,192
Subtotal				$ 183,138
Subtotal Construction Costs				**$ 230,754**
Design Contingency (30%)				$ 46,151
Engineering and Administration (20%)				$ 46,151
Total Estimated Improvement Cost (Rounded)				$ 324,000

Improvement ID: *MBC_02*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 15,110
Mobilization (6%)				$ 9,066
Traffic Control (5%)				$ 7,555
Misc. Utility Relocation (5%)				$ 7,555
Subtotal				$ 39,285
Pipe Improvements				
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	383	$ 30.67	$ 11,747
Pipe				
24" RCP - 6' Depth to Invert	LF	383	$ 130.14	$ 49,844
Surface Restoration				
Type 1 (Asphalt Patch)	LF	383	$ 51.38	$ 19,678
Manholes				
60" Dia and Smaller	Each	2	$ 4,618.40	$ 9,237
Curb Inlets (Type R)	Each	8	$ 7,273.98	$ 58,192
Subtotal				$ 151,097
Subtotal Construction Costs				**$ 190,383**
Design Contingency (30%)				$ 38,077
Engineering and Administration (20%)				$ 38,077
Total Estimated Improvement Cost (Rounded)				$ 267,000

Improvement ID: *BCC_07*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 24,258
Mobilization (6%)				$ 14,555
Traffic Control (5%)				$ 12,129
Misc. Utility Relocation (5%)				$ 12,129
Subtotal				$ 63,072
Pipe Improvements				
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	527	$ 30.67	$ 16,163
Pipe				
24" RCP - 6' Depth to Invert	LF	527	$ 130.14	$ 68,584
Surface Restoration				
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	527	$ 103.02	$ 54,294
Manholes				
60" Dia and Smaller	Each	3	$ 4,618.40	$ 13,855
Curb Inlets (Type R)	Each	12	$ 7,273.98	$ 87,288
Subtotal				$ 242,584
Subtotal Construction Costs				**$ 305,656**
Design Contingency (30%)				$ 61,131
Engineering and Administration (20%)				$ 61,131
Total Estimated Improvement Cost (Rounded)				$ 428,000

Improvement ID: *BCC_02*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 10,378
Mobilization (6%)				$ 6,227
Traffic Control (5%)				$ 5,189
Misc. Utility Relocation (5%)				$ 5,189
Subtotal				$ 26,983
Pipe Improvements				
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	160	$ 30.67	$ 4,907
Pipe				
24" RCP - 8' Depth to Invert	LF	160	$ 130.14	$ 20,822
Surface Restoration				
Type 1 (Asphalt Patch)	LF	160	$ 51.38	$ 8,221
Manholes				
60" Dia and Smaller	Each	2	$ 4,618.40	$ 9,237
Curb Inlets (Type R)	Each	8	$ 7,273.98	$ 58,192
Subtotal				$ 103,779
Subtotal Construction Costs				**$ 130,762**
Design Contingency (30%)				$ 26,152
Engineering and Administration (20%)				$ 26,152
Total Estimated Improvement Cost (Rounded)				$ 184,000

Improvement ID: *BCC_06*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 21,100
Mobilization (6%)				$ 12,660
Traffic Control (5%)				$ 10,550
Misc. Utility Relocation (5%)				$ 10,550
Subtotal				$ 54,859
Pipe Improvements				
Connect to Existing	Each	3	$ 1,200.00	$ 3,600
Removal and Disposal of Pipe (up to 36-inch)	LF	1,295	$ 30.67	$ 39,718
Pipe				
24" RCP - 20' Depth to Invert	LF	256	$ -	$ -
36" RCP - 20' Depth to Invert	LF	1,039	$ -	$ -
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,295	$ 51.38	$ 66,537
Manholes				
60" Dia and Smaller	Each	3	$ 4,618.40	$ 13,855
Curb Inlets (Type R)	Each	12	$ 7,273.98	$ 87,288
Subtotal				$ 210,997
Subtotal Construction Costs				**$ 265,857**
Design Contingency (30%)				$ 53,171
Engineering and Administration (20%)				$ 53,171
Total Estimated Improvement Cost (Rounded)				$ 373,000

Improvement ID: *BCC_05*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 11,309
Mobilization (6%)				$ 6,785
Traffic Control (5%)				$ 5,654
Misc. Utility Relocation (5%)				$ 5,654
Subtotal				$ 29,403
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 1,594
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	245	$ 30.67	$ 7,514
Pipe				
24" RCP - 6' Depth to Invert	LF	245	$ 130.14	$ 31,884
Surface Restoration				
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	22	$ 103.02	$ 2,267
Manholes				
60" Dia and Smaller	Each	2	$ 4,618.40	$ 9,237
Curb Inlets (Type R)	Each	8	$ 7,273.98	$ 58,192
Subtotal				$ 113,088
Subtotal Construction Costs				**$ 142,491**
Design Contingency (30%)				$ 28,498
Engineering and Administration (20%)				$ 28,498
Total Estimated Improvement Cost (Rounded)				$ 200,000

Improvement ID: *ETC_03*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 62,816
Mobilization (6%)				$ 37,689
Traffic Control (5%)				$ 31,408
Misc. Utility Relocation (5%)				$ 31,408
Subtotal				$ 163,321
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 2,896
Connect to Existing	Each	1	$ 1,200.00	$ 1,200
Removal and Disposal of Pipe (up to 36-inch)	LF	1,317	$ 30.67	$ 40,392
Pipe				
24" RCP - 6' Depth to Invert	LF	700	$ 130.14	$ 91,098
30" RCP - 6' Depth to Invert	LF	454	$ 152.28	$ 69,135
36" RCP - 6' Depth to Invert	LF	163	$ 186.84	$ 30,455
Surface Restoration				
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	830	$ 103.02	$ 85,511
Manholes				
60" Dia and Smaller	Each	9	$ 4,618.40	$ 41,566
Curb Inlets (Type R)	Each	36	$ 7,273.98	$ 261,863
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 628,157
Subtotal Construction Costs				**$ 791,478**
Design Contingency (30%)				$ 158,296
Engineering and Administration (20%)				$ 158,296
Total Estimated Improvement Cost (Rounded)				$ 1,109,000

Improvement ID: *GC_05*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 45,917
Mobilization (6%)				$ 27,550
Traffic Control (5%)				$ 22,958
Misc. Utility Relocation (5%)				$ 22,958
Subtotal				$ 119,384
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 749
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	949	$ 30.67	$ 29,106
Pipe				
24" RCP - 6' Depth to Invert	LF	361	$ 130.14	$ 46,981
30" RCP - 6' Depth to Invert	LF	425	$ 152.28	$ 64,719
36" RCP - 6' Depth to Invert	LF	163	$ 186.84	$ 30,455
Surface Restoration				
Type 1 (Asphalt Patch)	LF	949	$ 51.38	$ 48,759
Manholes				
60" Dia and Smaller	Each	7	$ 4,618.40	$ 32,329
Curb Inlets (Type R)	Each	28	$ 7,273.98	$ 203,671
Subtotal				$ 459,169
Subtotal Construction Costs				**$ 578,553**
Design Contingency (30%)				$ 115,711
Engineering and Administration (20%)				$ 115,711
Total Estimated Improvement Cost (Rounded)				$ 810,000

Improvement ID: *MBC_15*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 7,848
Mobilization (6%)				$ 4,709
Traffic Control (5%)				$ 3,924
Misc. Utility Relocation (5%)				$ 3,924
Subtotal				$ 20,405
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 208
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	32	$ 30.67	$ 981
Pipe				
24" RCP - 6' Depth to Invert	LF	32	$ 130.14	$ 4,164
Surface Restoration				
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	32	$ 103.02	$ 3,297
Manholes				
60" Dia and Smaller	Each	2	$ 4,618.40	$ 9,237
Curb Inlets (Type R)	Each	8	$ 7,273.98	$ 58,192
Subtotal				$ 78,480
Subtotal Construction Costs				**$ 98,884**
Design Contingency (30%)				$ 19,777
Engineering and Administration (20%)				$ 19,777
Total Estimated Improvement Cost (Rounded)				$ 139,000

Improvement ID: *MBC_08*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 68,486
Mobilization (6%)				$ 41,092
Traffic Control (5%)				$ 34,243
Misc. Utility Relocation (5%)				$ 34,243
Subtotal				$ 178,063
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ -
Connect to Existing	Each	3	$ 1,200.00	$ 3,600
Removal and Disposal of Pipe (up to 36-inch)	LF	1,152	$ 30.67	$ 35,332
Pipe				
36" RCP - 6' Depth to Invert	LF	185	$ 186.84	$ 34,565
42" RCP - 6' Depth to Invert	LF	581	$ 211.16	$ 122,682
48" RCP - 8' Depth to Invert	LF	386	$ 239.24	$ 92,347
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,152	$ 51.38	$ 59,189
Manholes				
60" Dia and Smaller	Each	10	$ 4,618.40	$ 46,184
Curb Inlets (Type R)	Each	40	$ 7,273.98	$ 290,959
Pipe Outfall (Incl. permanent erosion protection)	Each	-	$ 4,041.10	$ -
Subtotal				$ 684,859
Subtotal Construction Costs				**$ 862,922**
Design Contingency (30%)				$ 172,584
Engineering and Administration (20%)				$ 172,584
Total Estimated Improvement Cost (Rounded)				$ 1,209,000

Improvement ID: *DC2_03*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 34,163
Mobilization (6%)				$ 20,498
Traffic Control (5%)				$ 17,082
Misc. Utility Relocation (5%)				$ 17,082
Subtotal				$ 88,824
Pipe Improvements				
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	722	$ 30.67	$ 22,144
Pipe				
24" RCP - 6' Depth to Invert	LF	116	$ 130.14	$ 15,096
30" RCP - 6' Depth to Invert	LF	606	$ 152.28	$ 92,282
Surface Restoration				
Type 1 (Asphalt Patch)	LF	722	$ 51.38	$ 37,096
Manholes				
60" Dia and Smaller	Each	5	$ 4,618.40	$ 23,092
Curb Inlets (Type R)	Each	20	$ 7,273.98	$ 145,480
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 341,631
Subtotal Construction Costs				**$ 430,454**
Design Contingency (30%)				$ 86,091
Engineering and Administration (20%)				$ 86,091
Total Estimated Improvement Cost (Rounded)				$ 603,000

Improvement ID: *MBC_01*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 9,984
Mobilization (6%)				$ 5,991
Traffic Control (5%)				$ 4,992
Misc. Utility Relocation (5%)				$ 4,992
Subtotal				$ 25,959
Pipe Improvements				
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	170	$ 30.67	$ 5,214
Pipe				
18" RCP - 6' Depth to Invert	LF	170	$ 94.50	$ 16,065
Surface Restoration				
Type 1 (Asphalt Patch)	LF	170	$ 51.38	$ 8,735
Manholes				
60" Dia and Smaller	Each	2	$ 4,618.40	$ 9,237
Curb Inlets (Type R)	Each	8	$ 7,273.98	$ 58,192
Subtotal				$ 99,842
Subtotal Construction Costs				**$ 125,801**
Design Contingency (30%)				$ 25,160
Engineering and Administration (20%)				$ 25,160
Total Estimated Improvement Cost (Rounded)				$ 177,000

Improvement ID: *MBC_21*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 12,497
Mobilization (6%)				$ 7,498
Traffic Control (5%)				$ 6,248
Misc. Utility Relocation (5%)				$ 6,248
Subtotal				$ 32,491
Pipe Improvements				
Connect to Existing	Each	1	$ 1,200.00	$ 1,200
Removal and Disposal of Pipe (up to 36-inch)	LF	197	$ 30.67	$ 6,042
Pipe				
30" RCP - 6' Depth to Invert	LF	197	$ 152.28	$ 29,999
Surface Restoration				
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	197	$ 103.02	$ 20,296
Manholes				
60" Dia and Smaller	Each	2	$ 4,618.40	$ 9,237
Curb Inlets (Type R)	Each	8	$ 7,273.98	$ 58,192
Subtotal				$ 124,966
Subtotal Construction Costs				**$ 157,457**
Design Contingency (30%)				$ 31,491
Engineering and Administration (20%)				$ 31,491
Total Estimated Improvement Cost (Rounded)				$ 221,000

Improvement ID: *MBC_17*

Description	Units	Quantity	Unit Cost (Updated)	2007 SMP Unit Costs
General				
Insurance and Bonding (10%)				$ 27,154
Mobilization (6%)				$ 16,293
Traffic Control (5%)				$ 13,577
Misc. Utility Relocation (5%)				$ 13,577
Subtotal				$ 70,601
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 1,874
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	288	$ 30.67	$ 8,833
Pipe				
24" RCP - 6' Depth to Invert	LF	288	$ 130.14	$ 37,480
Surface Restoration				
Type 1 (Asphalt Patch)	LF	213	$ 51.38	$ 10,944
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	75	$ 103.02	$ 7,727
Manholes				
60" Dia and Smaller	Each	6	$ 4,618.40	$ 27,710
Curb Inlets (Type R)	Each	24	$ 7,273.98	$ 174,576
Subtotal				$ 271,544
Subtotal Construction Costs				**$ 342,145**
Design Contingency (30%)				$ 68,429
Engineering and Administration (20%)				$ 68,429
Total Estimated Improvement Cost (Rounded)				$ 480,000

LOCAL SYSTEM IMPROVEMENT COSTS

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Boulder SMP Local System Recommended Plan Projects Tier I Cost

Order	Problem Name	ID	Improvement Type	Priority	Cost
1	Wonderland Creek - 1	WC_LI1	New and Replacement	Tier I	$ 318,000
2	Elmer's Twomile Creek - 2	ETC_LI2	New and Replacement	Tier I	$ 3,874,000
3	Goose Creek - 1	GC_LI1	New and Replacement	Tier I	$ 1,585,000
4	Goose Creek - 2	GC_LI2	New and Replacement	Tier I	$ 2,417,000
5	Goose Creek - 3	GC_LI3	New and Replacement	Tier I	$ 984,000
6	Middle Boulder Creek - 2	MBC_LI2	New and Replacement	Tier I	$ 3,175,000
7	Dry Creek No. 2 - 1	DC2_LI1	New and Replacement	Tier I	$ 1,837,000
8	Dry Creek No. 2 - 3	DC2_LI3	New and Replacement	Tier I	$ 6,505,000
9	Bear Canyon Creek - 3	BrCC_LI3	Hydraulic Improvement	Tier I	$ 2,265,000
10	Bear Canyon Creek - 5	BrCC_LI5	Hydraulic Improvement	Tier I	$ 267,000
				Total	**$ 23,227,000**

Improvement ID: *Wonderland Creek - 1*

Description	Units	Quantity	2016 Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 16,790
Mobilization (6%)				$ 10,074
Traffic Control (5%)				$ 8,395
Misc. Utility Relocation (5%)				$ 8,395
Subtotal				$ 43,655
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 95
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	131	$ 30.67	$ 4,018
Pipe				
18" RCP - 6' Depth to Invert	LF	206	$ 94.50	$ 19,467
Surface Restoration				
Type 1 (Asphalt Patch)	LF	206	$ 51.38	$ 10,584
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	27	$ 103.02	$ 2,782
Manholes				
60" Dia and Smaller	Each	2	$ 4,618.40	$ 9,237
Curb Inlets (Type R)	Each	3	$ 7,273.98	$ 21,822
Utility Relocation				
Water Line Relocation	LF	300	$ 125.00	$ 37,500
Sanitary Sewer Relocation	LF	300	$ 200.00	$ 60,000
Subtotal				$ 97,500
Subtotal Construction Costs				**$ 211,559**
Design Contingency (30%)				$ 63,468
Engineering and Administration (20%)				$ 42,312
Total Estimated Improvement Cost (Rounded)				**$ 318,000**

Improvement ID: *Elmer's Twomile Creek - 2*

Description	Units	Quantity	2016 Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 204,965
Mobilization (6%)				$ 122,979
Traffic Control (5%)				$ 102,482
Misc. Utility Relocation (5%)				$ 102,482
Subtotal				$ 532,909
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 3,655.40
Connect to Existing	Each	5	$ 1,200.00	$ 6,000
Removal and Disposal of Pipe (up to 36-inch)	LF	325	$ 30.67	$ 9,968
Pipe				
18" RCP - 6' Depth to Invert	LF	617	$ 94.50	$ 58,307
24" RCP - 6' Depth to Invert	LF	597	$ 130.14	$ 77,694
30" RCP - 6' Depth to Invert	LF	652	$ 152.28	$ 99,287
36" RCP - 6' Depth to Invert	LF	2,784	$ 186.84	$ 520,163
Surface Restoration				
Type 1 (Asphalt Patch)	LF	4,650	$ 51.38	$ 238,916
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	225	$ 103.02	$ 23,181
Manholes				
60" Dia and Smaller	Each	18	$ 4,618.40	$ 83,131
Curb Inlets (Type R)	Each	25	$ 7,273.98	$ 181,850
Utility Relocation				
Water Line Relocation	LF	2,300	$ 125.00	$ 287,500
Sanitary Sewer Relocation	LF	2,300	$ 200.00	$ 460,000
Subtotal				$ 747,500
Subtotal Construction Costs				**$ 2,582,558**
Design Contingency (30%)				$ 774,767
Engineering and Administration (20%)				$ 516,512
Total Estimated Improvement Cost (Rounded)				**$ 3,874,000**

Improvement ID: *Goose Creek - 1*

Description	Units	Quantity	2016 Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 83,852
Mobilization (6%)				$ 50,311
Traffic Control (5%)				$ 41,926
Misc. Utility Relocation (5%)				$ 41,926
Subtotal				$ 218,016
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 1,791.03
Connect to Existing	Each	4	$ 1,200.00	$ 4,800
Removal and Disposal of Pipe (up to 36-inch)	LF	1,563	$ 30.67	$ 47,937
Pipe				
18" RCP - 6' Depth to Invert	LF	1,053	$ 94.50	$ 99,509
24" RCP - 6' Depth to Invert	LF	301	$ 130.14	$ 39,172
30" RCP - 6' Depth to Invert	LF	906	$ 152.28	$ 137,966
36" RCP - 6' Depth to Invert	LF	428	$ 186.84	$ 79,968
Surface Restoration				
Type 1 (Asphalt Patch)	LF	2,688	$ 51.38	$ 138,109
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	144	$ 103.02	$ 14,836
Manholes				
60" Dia and Smaller	Each	11	$ 4,618.40	$ 50,802
Curb Inlets (Type R)	Each	16	$ 7,273.98	$ 116,384
Utility Relocation				
Water Line Relocation	LF	330	$ 125.00	$ 41,250
Sanitary Sewer Relocation	LF	330	$ 200.00	$ 66,000
Subtotal				$ 107,250
Subtotal Construction Costs				**$ 1,056,538**
Design Contingency (30%)				$ 316,961
Engineering and Administration (20%)				$ 211,308
Total Estimated Improvement Cost (Rounded)				**$ 1,585,000**

Improvement ID: *Goose Creek - 2*

Description	Units	Quantity	2016 Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 128,598
Mobilization (6%)				$ 77,159
Traffic Control (5%)				$ 64,299
Misc. Utility Relocation (5%)				$ 64,299
Subtotal				$ 334,355
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 1,857.38
Connect to Existing	Each	5	$ 1,200.00	$ 6,000
Removal and Disposal of Pipe (up to 36-inch)	LF	1,318	$ 30.67	$ 40,423
Pipe				
18" RCP - 6' Depth to Invert	LF	2,709	$ 94.50	$ 256,001
24" RCP - 6' Depth to Invert	LF	614	$ 130.14	$ 79,906
30" RCP - 6' Depth to Invert	LF	285	$ 152.28	$ 43,400
36" RCP - 6' Depth to Invert	LF	45	$ 186.84	$ 8,408
Surface Restoration				
Type 1 (Asphalt Patch)	LF	3,653	$ 51.38	$ 187,690
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	261	$ 103.02	$ 26,890
Manholes				
60" Dia and Smaller	Each	18	$ 4,618.40	$ 83,131
Curb Inlets (Type R)	Each	29	$ 7,273.98	$ 210,945
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 948,692
Channel Improvements				
Excavation	CY	410	$ 17.76	$ 7,281
Vegetation	SF	6,642	$ 0.29	$ 1,917
Subtotal				$ 9,198
Water Quality Ponds				
Excavation and shaping	CY	1,000	$ 23.09	$ 23,092
Subtotal				$ 23,092
Utility Relocation				
Water Line Relocation	LF	1,000	$ 125.00	$ 125,000
Sanitary Sewer Relocation	LF	900	$ 200.00	$ 180,000
Subtotal				$ 305,000
Subtotal Construction Costs				**$ 1,611,139**
Design Contingency (30%)				$ 483,342
Engineering and Administration (20%)				$ 322,228
Total Estimated Improvement Cost (Rounded)				**$ 2,417,000**

Improvement ID: *Goose Creek - 3*

Description	Units	Quantity	2016 Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 52,050
Mobilization (6%)				$ 31,230
Traffic Control (5%)				$ 26,025
Misc. Utility Relocation (5%)				$ 26,025
Subtotal				$ 135,330
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 2,148.56
Connect to Existing	Each	4	$ 1,200.00	$ 4,800
Removal and Disposal of Pipe (up to 36-inch)	LF	130	$ 30.67	$ 3,987
Pipe				
18" RCP - 6' Depth to Invert	LF	195	$ 94.50	$ 18,428
30" RCP - 6' Depth to Invert	LF	1,051	$ 152.28	$ 160,046
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,246	$ 51.38	$ 64,019
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	72	$ 103.02	$ 7,418
Manholes				
60" Dia and Smaller	Each	6	$ 4,618.40	$ 27,710
Curb Inlets (Type R)	Each	8	$ 7,273.98	$ 58,192
Subtotal				$ 346,749
Utility Relocation				
Water Line Relocation	LF	430	$ 125.00	$ 53,750
Sanitary Sewer Relocation	LF	600	$ 200.00	$ 120,000
Subtotal				$ 173,750
Subtotal Construction Costs				**$ 655,828**
Design Contingency (30%)				$ 196,748
Engineering and Administration (20%)				$ 131,166
Total Estimated Improvement Cost (Rounded)				**$ 984,000**

Improvement ID: *Middle Boulder Creek - 2*

Description	Units	Quantity	2016 Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 167,957
Mobilization (6%)				$ 100,774
Traffic Control (5%)				$ 83,978
Misc. Utility Relocation (5%)				$ 83,978
Subtotal				$ 436,688
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 3,451.21
Connect to Existing	Each	5	$ 1,200.00	$ 6,000
Removal and Disposal of Pipe (up to 36-inch)	LF	2,064	$ 30.67	$ 63,303
Pipe				
18" RCP - 6' Depth to Invert	LF	940	$ 94.50	$ 88,830
24" RCP - 6' Depth to Invert	LF	562	$ 130.14	$ 73,139
30" RCP - 6' Depth to Invert	LF	1,074	$ 152.28	$ 163,549
36" RCP - 6' Depth to Invert	LF	1,003	$ 186.84	$ 187,401
42" RCP - 8' Depth to Invert	LF	784	$ 218.78	$ 171,520
Surface Restoration				
Type 1 (Asphalt Patch)	LF	4,363	$ 51.38	$ 224,170
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	423	$ 103.02	$ 43,580
Manholes				
60" Dia and Smaller	Each	19	$ 4,618.40	$ 87,750
Curb Inlets (Type R)	Each	47	$ 7,273.98	$ 341,877
Subtotal				$ 1,454,568
Utility Relocation				
Water Line Relocation	LF	1,800	$ 125.00	$ 225,000
Subtotal				$ 225,000
Subtotal Construction Costs				**$ 2,116,255**
Design Contingency (30%)				$ 634,877
Engineering and Administration (20%)				$ 423,251
Total Estimated Improvement Cost (Rounded)				**$ 3,175,000**

Improvement ID: *Dry Creek No. 2 - 1*

Description	Units	Quantity	2016 Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 97,171
Mobilization (6%)				$ 58,303
Traffic Control (5%)				$ 48,586
Misc. Utility Relocation (5%)				$ 48,586
Subtotal				$ 252,646
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 1,936.46
Removal and Disposal of Pipe (up to 36-inch)	LF	2,150	$ 30.67	$ 65,941
Pipe				
18" RCP - 6' Depth to Invert	LF	1,958	$ 94.50	$ 185,031
24" RCP - 6' Depth to Invert	LF	625	$ 130.14	$ 81,338
30" RCP - 6' Depth to Invert	LF	317	$ 152.28	$ 48,273
36" RCP - 6' Depth to Invert	LF	370	$ 186.84	$ 69,131
Surface Restoration				
Type 1 (Asphalt Patch)	LF	3,270	$ 51.38	$ 168,012
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	216	$ 103.02	$ 22,253
Manholes				
60" Dia and Smaller	Each	10	$ 4,618.40	$ 46,184
Curb Inlets (Type R)	Each	24	$ 7,273.98	$ 174,576
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 866,715
Utility Relocation				
Water Line Relocation	LF	840	$ 125.00	$ 105,000
Subtotal				$ 105,000
Subtotal Construction Costs				**$ 1,224,360**
Design Contingency (30%)				$ 367,308
Engineering and Administration (20%)				$ 244,872
Total Estimated Improvement Cost (Rounded)				**$ 1,837,000**

Improvement ID: *Dry Creek No. 2 - 3*

Description	Units	Quantity	2016 Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 344,172
Mobilization (6%)				$ 206,503
Traffic Control (5%)				$ 172,086
Misc. Utility Relocation (5%)				$ 172,086
Subtotal				$ 894,846
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 7,032.11
Connect to Existing	Each	7	$ 1,200.00	$ 8,400
Removal and Disposal of Pipe (up to 36-inch)	LF	1,000	$ 30.67	$ 30,670
Pipe				
18" RCP - 6' Depth to Invert	LF	760	$ 94.50	$ 71,820
48" RCP - 8' Depth to Invert	LF	3,908	$ 239.24	$ 934,958
54" RCP - 10' Depth to Invert	LF	1,263	$ 303.62	$ 383,471
Surface Restoration				
Type 1 (Asphalt Patch)	LF	5,931	$ 51.38	$ 304,733
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	342	$ 103.02	$ 35,235
Manholes				
72" and Larger	Each	23	$ 9,236.80	$ 212,446
Curb Inlets (Type R)	Each	38	$ 7,273.98	$ 276,411
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 2,269,217
Utility Relocation				
Water Line Relocation	LF	5,700	$ 125.00	$ 712,500
Sanitary Sewer Relocation	LF	2,300	$ 200.00	$ 460,000
Subtotal				$ 1,172,500
Subtotal Construction Costs				**$ 4,336,564**
Design Contingency (30%)				$ 1,300,969
Engineering and Administration (20%)				$ 867,313
Total Estimated Improvement Cost (Rounded)				**$ 6,505,000**

Improvement ID: *Bear Canyon Creek - 3*

Description	Units	Quantity	2016 Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 119,821
Mobilization (6%)				$ 71,893
Traffic Control (5%)				$ 59,911
Misc. Utility Relocation (5%)				$ 59,911
Subtotal				$ 311,535
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 1,979.25
Connect to Existing	Each	6	$ 1,200.00	$ 7,200
Removal and Disposal of Pipe (up to 36-inch)	LF	723	$ 30.67	$ 22,174
Pipe				
18" RCP - 6' Depth to Invert	LF	240	$ 94.50	$ 22,680
36" RCP - 6' Depth to Invert	LF	1,110	$ 186.84	$ 207,392
42" RCP - 8' Depth to Invert	LF	558	$ 218.78	$ 122,076
48" RCP - 8' Depth to Invert	LF	148	$ 239.24	$ 35,408
Surface Restoration				
Type 1 (Asphalt Patch)	LF	2,056	$ 51.38	$ 105,637
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	108	$ 103.02	$ 11,127
Manholes				
60" Dia and Smaller	Each	13	$ 4,618.40	$ 60,039
72" and Larger	Each	3	$ 9,236.80	$ 27,710
Curb Inlets (Type R)	Each	12	$ 7,273.98	$ 87,288
Subtotal				$ 710,711
Utility Relocation				
Water Line Relocation	LF	1,500	$ 125.00	$ 187,500
Sanitary Sewer Relocation	LF	1,500	$ 200.00	$ 300,000
Subtotal				$ 487,500
Subtotal Construction Costs				**$ 1,509,746**
Design Contingency (30%)				$ 452,924
Engineering and Administration (20%)				$ 301,949
Total Estimated Improvement Cost (Rounded)				**$ 2,265,000**

Improvement ID: *Bear Canyon Creek - 5*

Description	Units	Quantity	2016 Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 14,075
Mobilization (6%)				$ 8,445
Traffic Control (5%)				$ 7,038
Misc. Utility Relocation (5%)				$ 7,038
Subtotal				$ 36,595
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 774.90
Connect to Existing	Each	1	$ 1,200.00	$ 1,200
Removal and Disposal of Pipe (up to 36-inch)	LF	155	$ 30.67	$ 4,754
Pipe				
18" RCP - 6' Depth to Invert	LF	164	$ 94.50	$ 15,498
Surface Restoration				
Type 1 (Asphalt Patch)	LF	164	$ 51.38	$ 8,426
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	9	$ 103.02	$ 927
Manholes				
60" Dia and Smaller	Each	3	$ 4,618.40	$ 13,855
Curb Inlets (Type R)	Each	1	$ 7,273.98	$ 7,274
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 56,751
Utility Relocation				
Sanitary Sewer Relocation	LF	420	$ 200.00	$ 84,000
Subtotal				$ 84,000
Subtotal Construction Costs				**$ 177,346**
Design Contingency (30%)				$ 53,204
Engineering and Administration (20%)				$ 35,469
Total Estimated Improvement Cost (Rounded)				**$ 267,000**

Boulder SMP Local System Recommended Plan Projects Tier II and Tier III Cost

Weighted Total	ObjId	Problem Name	ID	Improvement Type	Priority	Cost
29	11	Goose Creek - 5	GC_LI5	Hydraulic Improvement	Tier II	$ 5,484,000
28	12	Wonderland Creek - 7	WC_LI7	Hydraulic Improvement	Tier II	$ 2,452,000
27	13	Twomile Canyon Creek - 1	TCC_LI1	Hydraulic Improvement	Tier II	$ 2,939,000
27	14	Viele Channel - 1	VC_LI1	Hydraulic Improvement	Tier II	$ 936,000
27	15	Wonderland Creek - 2	WC_LI2	Hydraulic Improvement	Tier II	$ 1,925,000
26	16	Bear Canyon Creek - 4	BrCC_LI4	Hydraulic Improvement	Tier II	$ 726,000
26	17	Goose Creek - 4	GC_LI4	Hydraulic Improvement	Tier II	$ 4,885,000
25	18	Middle Boulder Creek - 3	MBC_LI3	Hydraulic Improvement	Tier II	$ 2,826,000
24	19	Fourmile Canyon Creek - 1	FCC_LI1	Hydraulic Improvement	Tier II	$ 688,000
23	20	Bear Canyon Creek - 1	BrCC_LI1	Hydraulic Improvement	Tier II	$ 69,000
23	21	Bluebell Canyon Creek - 1	BbCC_LI1	Hydraulic Improvement	Tier II	$ 1,137,000
17	22	Dry Creek No. 2 - 2	DC2_LI2	Hydraulic Improvement	Tier III	$ 726,000
16	23	Dry Creek No. 2 - 5	DC2_LI5	Hydraulic Improvement	Tier III	$ 2,386,000
16	24	Dry Creek No. 2 - 6	DC2_LI6	Hydraulic Improvement	Tier III	$ 1,689,000
16	25	Goose Creek - 6	GC_LI6	Hydraulic Improvement	Tier III	$ 1,946,000
16	26	Goose Creek - 8	GC_LI8	Hydraulic Improvement	Tier III	$ 932,000
16	27	Wonderland Creek - 6	WC_LI6	Hydraulic Improvement	Tier III	$ 366,000
15	28	Dry Creek No. 2 - 8	DC2_LI8	Hydraulic Improvement	Tier III	$ 604,000
15	29	Goose Creek - 7	GC_LI7	Hydraulic Improvement	Tier III	$ 1,913,000
13	30	Elmers Twomile Creek - 1	ETC_LI1	Hydraulic Improvement	Tier III	$ 98,000
13	31	Middle Boulder Creek - 1	MBC_LI1	Hydraulic Improvement	Tier III	$ 176,000
12	32	Dry Creek No. 2 - 4	DC2_LI4	Hydraulic Improvement	Tier III	$ 976,000
12	33	Dry Creek No. 2 - 7	DC2_LI7	Hydraulic Improvement	Tier III	$ 801,000
12	34	Wonderland Creek - 3	WC_LI3	Hydraulic Improvement	Tier III	$ 24,000
12	35	Wonderland Creek - 4	WC_LI4	Hydraulic Improvement	Tier III	$ 20,000
					Total	**$ 36,724,000**

Improvement ID: *Bluebell Canyon Creek - 1*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 60,109
Mobilization (6%)				$ 36,066
Traffic Control (5%)				$ 30,055
Misc. Utility Relocation (5%)				$ 30,055
Subtotal				$ 156,284
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 1,264.46
Connect to Existing	Each	1	$ 1,200.00	$ 1,200
Removal and Disposal of Pipe (up to 36-inch)	LF	75	$ 30.67	$ 2,300
Pipe				
18" RCP - 6' Depth to Invert	LF	280	$ 94.50	$ 26,460
30" RCP - 8' Depth to Invert	LF	350	$ 152.28	$ 53,298
36" RCP - 8' Depth to Invert	LF	1,450	$ 186.84	$ 270,918
Surface Restoration				
Type 1 (Asphalt Patch)	LF	2,080	$ 51.38	$ 106,870
Manholes				
60" Dia and Smaller	Each	8	$ 4,618.40	$ 36,947
Curb Inlets (Type R)	Each	14	$ 7,273.98	$ 101,836
Subtotal				$ 601,093
Subtotal Construction Costs				**$ 757,378**
Design Contingency (25%)				$ 227,213
Engineering and Administration (20%)				$ 151,476
Total Estimated Improvement Cost (Rounded)				**$ 1,137,000**

Improvement ID: *Bear Canyon Creek - 1*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 4,092
Mobilization (6%)				$ 2,455
Traffic Control (5%)				$ 2,046
Misc. Utility Relocation (5%)				$ 2,046
Subtotal				$ 10,638
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 986.76
Connect to Existing	Each	1	$ 1,200.00	$ 1,200
Pipe				
54" RCP - 10' Depth to Invert	LF	65	$ 303.62	$ 19,735
Manholes				
72" and Larger	Each	1	$ 9,236.80	$ 9,237
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 35,200
Channel Improvements				
Excavation	CY	267	$ 17.76	$ 4,735
Vegetation	SF	3,400	$ 0.29	$ 981
Subtotal				$ 5,717
Subtotal Construction Costs				**$ 45,838**
Design Contingency (25%)				$ 13,751
Engineering and Administration (20%)				$ 9,168
Total Estimated Improvement Cost (Rounded)				**$ 69,000**

Improvement ID: *Bear Canyon Creek - 4*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 38,367
Mobilization (6%)				$ 23,020
Traffic Control (5%)				$ 19,183
Misc. Utility Relocation (5%)				$ 19,183
Subtotal				$ 99,754
Pipe Improvements				
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Pipe				
18" RCP - 6' Depth to Invert	LF	530	$ 94.50	$ 50,085
24" RCP - 6' Depth to Invert	LF	950	$ 130.14	$ 123,633
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,480	$ 51.38	$ 76,042
Manholes				
60" Dia and Smaller	Each	8	$ 4,618.40	$ 36,947
Curb Inlets (Type R)	Each	13	$ 7,273.98	$ 94,562
Subtotal				$ 383,669
Subtotal Construction Costs				**$ 483,423**
Design Contingency (25%)				$ 145,027
Engineering and Administration (20%)				$ 96,685
Total Estimated Improvement Cost (Rounded)				**$ 726,000**

Improvement ID: *Dry Creek No. 2 - 2*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 38,394
Mobilization (6%)				$ 23,036
Traffic Control (5%)				$ 19,197
Misc. Utility Relocation (5%)				$ 19,197
Subtotal				$ 99,825
Pipe Improvements				
Connect to Existing	Each	1	$ 1,200.00	$ 1,200
Removal and Disposal of Pipe (up to 36-inch)	LF	172	$ 30.67	$ 5,275
Pipe				
18" RCP - 6' Depth to Invert	LF	430	$ 94.50	$ 40,635
24" RCP - 6' Depth to Invert	LF	1,115	$ 130.14	$ 145,106
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,545	$ 51.38	$ 79,382
Manholes				
60" Dia and Smaller	Each	7	$ 4,618.40	$ 32,329
Curb Inlets (Type R)	Each	11	$ 7,273.98	$ 80,014
Subtotal				$ 383,941
Subtotal Construction Costs				**$ 483,765**
Design Contingency (25%)				$ 145,130
Engineering and Administration (20%)				$ 96,753
Total Estimated Improvement Cost (Rounded)				**$ 726,000**

Improvement ID: *Dry Creek No. 2 - 4*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 51,726
Mobilization (6%)				$ 31,036
Traffic Control (5%)				$ 25,863
Misc. Utility Relocation (5%)				$ 25,863
Subtotal				$ 134,489
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 1,071.72
Pipe				
18" RCP - 6' Depth to Invert	LF	1,450	$ 94.50	$ 137,025
24" RCP - 6' Depth to Invert	LF	800	$ 130.14	$ 104,112
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,985	$ 51.38	$ 101,989
Manholes				
60" Dia and Smaller	Each	8	$ 4,618.40	$ 36,947
Curb Inlets (Type R)	Each	18	$ 7,273.98	$ 130,932
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 516,117
Channel Improvements				
Vegetation	SF	3,975	$ 0.29	$ 1,147
Subtotal				$ 1,147
Subtotal Construction Costs				**$ 650,606**
Design Contingency (25%)				$ 195,182
Engineering and Administration (20%)				$ 130,121
Total Estimated Improvement Cost (Rounded)				**$ 976,000**

Improvement ID: *Dry Creek No. 2 - 5*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 126,241
Mobilization (6%)				$ 75,745
Traffic Control (5%)				$ 63,121
Misc. Utility Relocation (5%)				$ 63,121
Subtotal				$ 328,228
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 1,177.59
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Pipe				
18" RCP - 6' Depth to Invert	LF	3,155	$ 94.50	$ 298,148
24" RCP - 6' Depth to Invert	LF	1,240	$ 130.14	$ 161,374
36" RCP - 6' Depth to Invert	LF	840	$ 186.84	$ 156,946
Surface Restoration				
Type 1 (Asphalt Patch)	LF	5,235	$ 51.38	$ 268,973
Manholes				
60" Dia and Smaller	Each	21	$ 4,618.40	$ 96,986
Curb Inlets (Type R)	Each	38	$ 7,273.98	$ 276,411
Subtotal				$ 1,262,415
Subtotal Construction Costs				**$ 1,590,642**
Design Contingency (25%)				$ 477,193
Engineering and Administration (20%)				$ 318,128
Total Estimated Improvement Cost (Rounded)				**$ 2,386,000**

Improvement ID: *Dry Creek No. 2 - 6*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 89,524
Mobilization (6%)				$ 53,714
Traffic Control (5%)				$ 44,762
Misc. Utility Relocation (5%)				$ 44,762
Subtotal				$ 232,763
Pipe Improvements				
Connect to Existing	Each	1	$ 1,200.00	$ 1,200
Removal and Disposal of Pipe (up to 36-inch)	LF	100	$ 30.67	$ 3,067
Pipe				
18" RCP - 6' Depth to Invert	LF	2,030	$ 94.50	$ 191,835
24" RCP - 6' Depth to Invert	LF	285	$ 130.14	$ 37,090
30" RCP - 6' Depth to Invert	LF	1,080	$ 152.28	$ 164,462
36" RCP - 6' Depth to Invert	LF	435	$ 186.84	$ 81,275
Surface Restoration				
Type 1 (Asphalt Patch)	LF	3,340	$ 51.38	$ 171,608
Manholes				
60" Dia and Smaller	Each	10	$ 4,618.40	$ 46,184
Curb Inlets (Type R)	Each	27	$ 7,273.98	$ 196,397
Subtotal				$ 893,119
Subtotal Construction Costs				**$ 1,125,882**
Design Contingency (25%)				$ 337,765
Engineering and Administration (20%)				$ 225,176
Total Estimated Improvement Cost (Rounded)				**$ 1,689,000**

Improvement ID: *Dry Creek No. 2 - 7*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 42,374
Mobilization (6%)				$ 25,425
Traffic Control (5%)				$ 21,187
Misc. Utility Relocation (5%)				$ 21,187
Subtotal				$ 110,173
Pipe Improvements				
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	900	$ 30.67	$ 27,603
Pipe				
18" RCP - 6' Depth to Invert	LF	1,605	$ 94.50	$ 151,673
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,515	$ 51.38	$ 77,840
Manholes				
60" Dia and Smaller	Each	15	$ 4,618.40	$ 69,276
Curb Inlets (Type R)	Each	13	$ 7,273.98	$ 94,562
Subtotal				$ 423,353
Channel Improvements				
Vegetation	SF	1,350	$ 0.29	$ 390
Subtotal				$ 390
Subtotal Construction Costs				**$ 533,527**
Design Contingency (25%)				$ 160,058
Engineering and Administration (20%)				$ 106,705
Total Estimated Improvement Cost (Rounded)				**$ 801,000**

Improvement ID: *Dry Creek No. 2 - 8*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 31,933
Mobilization (6%)				$ 19,160
Traffic Control (5%)				$ 15,967
Misc. Utility Relocation (5%)				$ 15,967
Subtotal				$ 83,026
Pipe Improvements				
Connect to Existing	Each	1	$ 1,200.00	$ 1,200
Pipe				
18" RCP - 6' Depth to Invert	LF	465	$ 94.50	$ 43,943
24" RCP - 6' Depth to Invert	LF	760	$ 130.14	$ 98,906
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,225	$ 51.38	$ 62,940
Manholes				
60" Dia and Smaller	Each	7	$ 4,618.40	$ 32,329
Curb Inlets (Type R)	Each	11	$ 7,273.98	$ 80,014
Subtotal				$ 319,332
Subtotal Construction Costs				**$ 402,358**
Design Contingency (25%)				$ 120,707
Engineering and Administration (20%)				$ 80,472
Total Estimated Improvement Cost (Rounded)				**$ 604,000**

Improvement ID: *Elmers Twomile Creek - 1*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 1,930
Mobilization (6%)				$ 1,158
Traffic Control (5%)				$ 965
Misc. Utility Relocation (5%)				$ 965
Subtotal				$ 5,019
Pipe Improvements				
Pipe				
18" RCP - 6' Depth to Invert	LF	35	$ 94.50	$ 3,308
Surface Restoration				
Type 1 (Asphalt Patch)	LF	10	$ 51.38	$ 514
Manholes				
Curb Inlets (Type R)	Each	1	$ 7,273.98	$ 7,274
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 15,136
Channel Improvements				
Excavation	CY	163	$ 17.76	$ 2,894
Vegetation	SF	4,410	$ 0.29	$ 1,273
Subtotal				$ 4,167
Subtotal Construction Costs				**$ 20,155**
Design Contingency (25%)				$ 6,047
Engineering and Administration (20%)				$ 4,031
Land Acquisition	SF	5,100	$ 13.12	$ 66,932
Total Estimated Improvement Cost (Rounded)				**$ 98,000**

Improvement ID: *Fourmile Canyon Creek - 1*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 36,398
Mobilization (6%)				$ 21,839
Traffic Control (5%)				$ 18,199
Misc. Utility Relocation (5%)				$ 18,199
Subtotal				$ 94,635
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 2,326.41
Pipe				
18" RCP - 6' Depth to Invert	LF	220	$ 94.50	$ 20,790
30" RCP - 6' Depth to Invert	LF	565	$ 152.28	$ 86,038
36" RCP - 6' Depth to Invert	LF	470	$ 186.84	$ 87,815
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,255	$ 51.38	$ 64,482
Manholes				
60" Dia and Smaller	Each	4	$ 4,618.40	$ 18,474
Curb Inlets (Type R)	Each	11	$ 7,273.98	$ 80,014
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 363,979
Subtotal Construction Costs				**$ 458,614**
Design Contingency (25%)				$ 137,584
Engineering and Administration (20%)				$ 91,723
Total Estimated Improvement Cost (Rounded)				**$ 688,000**

Improvement ID: *Goose Creek - 4*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 258,419
Mobilization (6%)				$ 155,051
Traffic Control (5%)				$ 129,209
Misc. Utility Relocation (5%)				$ 129,209
Subtotal				$ 671,889
Pipe Improvements				
Connect to Existing	Each	3	$ 1,200.00	$ 3,600
Pipe				
18" RCP - 6' Depth to Invert	LF	2,845	$ 94.50	$ 268,853
24" RCP - 6' Depth to Invert	LF	5,130	$ 130.14	$ 667,618
30" RCP - 6' Depth to Invert	LF	980	$ 152.28	$ 149,234
36" RCP - 6' Depth to Invert	LF	1,000	$ 186.84	$ 186,840
Surface Restoration				
Type 1 (Asphalt Patch)	LF	9,955	$ 51.38	$ 511,485
Manholes				
60" Dia and Smaller	Each	26	$ 4,618.40	$ 120,078
Curb Inlets (Type R)	Each	93	$ 7,273.98	$ 676,480
Subtotal				$ 2,584,189
Subtotal Construction Costs				**$ 3,256,078**
Design Contingency (25%)				$ 976,823
Engineering and Administration (20%)				$ 651,216
Total Estimated Improvement Cost (Rounded)				**$ 4,885,000**

Improvement ID: *Goose Creek - 5*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 290,147
Mobilization (6%)				$ 174,088
Traffic Control (5%)				$ 145,073
Misc. Utility Relocation (5%)				$ 145,073
Subtotal				$ 754,382
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 11,875
Connect to Existing	Each	2	$ 1,200	$ 2,400
Pipe and Asphalt Demo/Disposal	LF	5,960	$ 31	$ 182,793
Pipe				
24" RCP - 6' Depth to Invert	LF	320	$ 130	$ 41,645
60" RCP - 10' Depth to Invert	LF	2,640	$ 351	$ 925,510
66" RCP - 10' Depth to Invert	LF	3,320	$ 388	$ 1,286,801
Surface Restoration				
Type 1 (Asphalt Patch)	LF	949	$ 51	$ 48,759
Manholes				
Special/Box Base	Each	14	$ 13,855	$ 193,973
Curb Inlets (Type R)	Each	28	$ 7,274	$ 203,671
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041	$ 4,041
Subtotal				$ 2,901,470
Subtotal Construction Costs				**$ 3,655,852**
Design Contingency (25%)				$ 1,096,756
Engineering and Administration (20%)				$ 731,170
Total Estimated Improvement Cost (Rounded)				**$ 5,484,000**

Estimated quantities derived from GC_01 Twomile Creek Alt 2 costs from 2007 SMP

Improvement ID: *Goose Creek - 6*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 100,185
Mobilization (6%)				$ 60,111
Traffic Control (5%)				$ 50,093
Misc. Utility Relocation (5%)				$ 50,093
Subtotal				$ 260,481
Pipe Improvements				
Connect to Existing	Each	4	$ 1,200.00	$ 4,800
Removal and Disposal of Pipe (up to 36-inch)	LF	1,240	$ 30.67	$ 38,031
Pipe				
18" RCP - 6' Depth to Invert	LF	950	$ 94.50	$ 89,775
24" RCP - 6' Depth to Invert	LF	3,130	$ 130.14	$ 407,338
Surface Restoration				
Type 1 (Asphalt Patch)	LF	3,810	$ 51.38	$ 195,757
Manholes				
60" Dia and Smaller	Each	18	$ 4,618.40	$ 83,131
Curb Inlets (Type R)	Each	25	$ 7,273.98	$ 181,850
Subtotal				$ 1,000,681
Channel Improvements				
Vegetation	SF	4,050	$ 0.29	$ 1,169
Subtotal				$ 1,169
Subtotal Construction Costs				**$ 1,261,162**
Design Contingency (25%)				$ 378,349
Engineering and Administration (20%)				$ 252,232
Land Acquisition	SF	4,125	$ 13.12	$ 54,136
Total Estimated Improvement Cost (Rounded)				**$ 1,946,000**

Improvement ID: *Goose Creek - 7*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 101,203
Mobilization (6%)				$ 60,722
Traffic Control (5%)				$ 50,602
Misc. Utility Relocation (5%)				$ 50,602
Subtotal				$ 263,128
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 6,624.22
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Removal and Disposal of Pipe (up to 36-inch)	LF	760	$ 30.67	$ 23,309
Pipe				
18" RCP - 6' Depth to Invert	LF	880	$ 94.50	$ 83,160
24" RCP - 6' Depth to Invert	LF	1,454	$ 130.14	$ 189,224
30" RCP - 6' Depth to Invert	LF	847	$ 152.28	$ 128,981
Surface Restoration				
Type 1 (Asphalt Patch)	LF	1,541	$ 51.38	$ 79,176
Type 2 (Asphalt Patch/Curb-Gutter Replacement)	LF	760	$ 103.02	$ 78,299
Manholes				
60" Dia and Smaller	Each	11	$ 4,618.40	$ 50,802
Curb Inlets (Type R)	Each	44	$ 7,273.98	$ 320,055
Pipe Outfall (Incl. permanent erosion protection)	Each	-	$ 4,041.10	$ -
Subtotal				$ 962,031
Utility Relocation				
Sanitary Sewer Relocation	LF	250	$ 200.00	$ 50,000
Subtotal				$ 50,000
Subtotal Construction Costs				**$ 1,275,159**
Design Contingency (25%)				$ 382,548
Engineering and Administration (20%)				$ 255,032
Land Acquisition	SF	-	$ 13.12	$ -
Total Estimated Improvement Cost (Rounded)				**$ 1,913,000**

Improvement ID: *Goose Creek - 8*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 49,269
Mobilization (6%)				$ 29,562
Traffic Control (5%)				$ 24,635
Misc. Utility Relocation (5%)				$ 24,635
Subtotal				$ 128,100
Pipe Improvements				
Connect to Existing	Each	3	$ 1,200.00	$ 3,600
Removal and Disposal of Pipe (up to 36-inch)	LF	300	$ 30.67	$ 9,201
Pipe				
18" RCP - 6' Depth to Invert	LF	2,180	$ 94.50	$ 206,010
Surface Restoration				
Type 1 (Asphalt Patch)	LF	2,180	$ 51.38	$ 112,008
Manholes				
60" Dia and Smaller	Each	13	$ 4,618.40	$ 60,039
Curb Inlets (Type R)	Each	14	$ 7,273.98	$ 101,836
Subtotal				$ 492,694
Subtotal Construction Costs				**$ 620,794**
Design Contingency (25%)				$ 186,238
Engineering and Administration (20%)				$ 124,159
Total Estimated Improvement Cost (Rounded)				**$ 932,000**

Improvement ID: *Middle Boulder Creek - 1*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 10,623
Mobilization (6%)				$ 6,374
Traffic Control (5%)				$ 5,312
Misc. Utility Relocation (5%)				$ 5,312
Subtotal				$ 27,621
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 637.50
Connect to Existing	Each	2	$ 1,200.00	$ 2,400
Pipe				
18" RCP - 6' Depth to Invert	LF	30	$ 94.50	$ 2,835
24" RCP - 6' Depth to Invert	LF	375	$ 130.14	$ 48,803
Manholes				
60" Dia and Smaller	Each	5	$ 4,618.40	$ 23,092
Curb Inlets (Type R)	Each	1	$ 7,273.98	$ 7,274
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 89,082
Channel Improvements				
Excavation	CY	607	$ 17.76	$ 10,786
Vegetation	SF	22,050	$ 0.29	$ 6,365
Subtotal				$ 17,151
Subtotal Construction Costs				**$ 116,703**
Design Contingency (25%)				$ 35,011
Engineering and Administration (20%)				$ 23,341
Total Estimated Improvement Cost (Rounded)				**$ 176,000**

Improvement ID: *Middle Boulder Creek - 3*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 149,501
Mobilization (6%)				$ 89,701
Traffic Control (5%)				$ 74,751
Misc. Utility Relocation (5%)				$ 74,751
Subtotal				$ 388,703
Pipe Improvements				
Connect to Existing	Each	3	$ 1,200.00	$ 3,600
Removal and Disposal of Pipe (up to 36-inch)	LF	2,240	$ 30.67	$ 68,701
Pipe				
18" RCP - 6' Depth to Invert	LF	795	$ 94.50	$ 75,128
24" RCP - 6' Depth to Invert	LF	715	$ 130.14	$ 93,050
30" RCP - 6' Depth to Invert	LF	1,870	$ 152.28	$ 284,764
36" RCP - 6' Depth to Invert	LF	2,010	$ 186.84	$ 375,548
Surface Restoration				
Type 1 (Asphalt Patch)	LF	5,390	$ 51.38	$ 276,937
Manholes				
60" Dia and Smaller	Each	12	$ 4,618.40	$ 55,421
Curb Inlets (Type R)	Each	36	$ 7,273.98	$ 261,863
Subtotal				$ 1,495,011
Subtotal Construction Costs				**$ 1,883,714**
Design Contingency (25%)				$ 565,114
Engineering and Administration (20%)				$ 376,743
Total Estimated Improvement Cost (Rounded)				**$ 2,826,000**

Improvement ID: *Twomile Canyon Creek - 1*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 155,488
Mobilization (6%)				$ 93,293
Traffic Control (5%)				$ 77,744
Misc. Utility Relocation (5%)				$ 77,744
Subtotal				$ 404,270
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 3,648.09
Connect to Existing	Each	5	$ 1,200.00	$ 6,000
Pipe				
18" RCP - 6' Depth to Invert	LF	1,630	$ 94.50	$ 154,035
24" RCP - 6' Depth to Invert	LF	5,175	$ 130.14	$ 673,475
Surface Restoration				
Type 1 (Asphalt Patch)	LF	6,805	$ 51.38	$ 349,639
Manholes				
60" Dia and Smaller	Each	23	$ 4,618.40	$ 106,223
Curb Inlets (Type R)	Each	36	$ 7,273.98	$ 261,863
Subtotal				$ 1,554,883
Subtotal Construction Costs				**$ 1,959,152**
Design Contingency (25%)				$ 587,746
Engineering and Administration (20%)				$ 391,830
Total Estimated Improvement Cost (Rounded)				**$ 2,939,000**

Improvement ID: *Viele Channel - 1*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 49,520
Mobilization (6%)				$ 29,712
Traffic Control (5%)				$ 24,760
Misc. Utility Relocation (5%)				$ 24,760
Subtotal				$ 128,752
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 628.32
Connect to Existing	Each	1	$ 1,200.00	$ 1,200
Pipe				
18" RCP - 6' Depth to Invert	LF	260	$ 94.50	$ 24,570
24" RCP - 6' Depth to Invert	LF	1,810	$ 130.14	$ 235,553
Surface Restoration				
Type 1 (Asphalt Patch)	LF	2,070	$ 51.38	$ 106,356
Manholes				
60" Dia and Smaller	Each	7	$ 4,618.40	$ 32,329
Curb Inlets (Type R)	Each	13	$ 7,273.98	$ 94,562
Subtotal				$ 495,198
Subtotal Construction Costs				**$ 623,950**
Design Contingency (25%)				$ 187,185
Engineering and Administration (20%)				$ 124,790
Total Estimated Improvement Cost (Rounded)				**$ 936,000**

Improvement ID: *Wonderland Creek - 2*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 101,846
Mobilization (6%)				$ 61,107
Traffic Control (5%)				$ 50,923
Misc. Utility Relocation (5%)				$ 50,923
Subtotal				$ 264,799
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 1,758.06
Pipe				
18" RCP - 6' Depth to Invert	LF	1,935	$ 94.50	$ 182,858
24" RCP - 6' Depth to Invert	LF	1,715	$ 130.14	$ 223,190
30" RCP - 6' Depth to Invert	LF	620	$ 152.28	$ 94,414
Surface Restoration				
Type 1 (Asphalt Patch)	LF	4,270	$ 51.38	$ 219,391
Manholes				
60" Dia and Smaller	Each	13	$ 4,618.40	$ 60,039
Curb Inlets (Type R)	Each	32	$ 7,273.98	$ 232,767
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 1,018,458
Subtotal Construction Costs				**$ 1,283,257**
Design Contingency (25%)				$ 384,977
Engineering and Administration (20%)				$ 256,651
Total Estimated Improvement Cost (Rounded)				**$ 1,925,000**

Improvement ID: *Wonderland Creek - 3*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 6,031
Mobilization (6%)				$ 3,619
Traffic Control (5%)				$ 3,016
Misc. Utility Relocation (5%)				$ 3,016
Subtotal				$ 15,681
Channel Improvements				
Excavation	CY	2,813	$ 17.76	$ 49,958
Vegetation	SF	35,870	$ 0.29	$ 10,354
Subtotal				$ 60,312
Subtotal Construction Costs				**$ 15,681**
Design Contingency (25%)				$ 4,704
Engineering and Administration (20%)				$ 3,136
Total Estimated Improvement Cost (Rounded)				**$ 24,000**

Improvement ID: *Wonderland Creek - 4*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 4,945
Mobilization (6%)				$ 2,967
Traffic Control (5%)				$ 2,473
Misc. Utility Relocation (5%)				$ 2,473
Subtotal				$ 12,857
Channel Improvements				
Excavation	CY	2,307	$ 17.76	$ 40,961
Vegetation	SF	29,410	$ 0.29	$ 8,489
Subtotal				$ 49,450
Subtotal Construction Costs				**$ 12,857**
Design Contingency (25%)				$ 3,857
Engineering and Administration (20%)				$ 2,571
Total Estimated Improvement Cost (Rounded)				**$ 20,000**

Improvement ID: *Wonderland Creek - 6*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 19,418
Mobilization (6%)				$ 11,651
Traffic Control (5%)				$ 9,709
Misc. Utility Relocation (5%)				$ 9,709
Subtotal				$ 50,487
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 1,235.75
Pipe				
18" RCP - 6' Depth to Invert	LF	140	$ 94.50	$ 13,230
24" RCP - 6' Depth to Invert	LF	620	$ 130.14	$ 80,687
Surface Restoration				
Type 1 (Asphalt Patch)	LF	560	$ 51.38	$ 28,773
Manholes				
60" Dia and Smaller	Each	4	$ 4,618.40	$ 18,474
Curb Inlets (Type R)	Each	7	$ 7,273.98	$ 50,918
Subtotal				$ 193,317
Channel Improvements				
Vegetation	SF	3,000	$ 0.29	$ 866
Subtotal				$ 866
Subtotal Construction Costs				**$ 243,804**
Design Contingency (25%)				$ 73,141
Engineering and Administration (20%)				$ 48,761
Total Estimated Improvement Cost (Rounded)				**$ 366,000**

Improvement ID: *Wonderland Creek - 7*

Description	Units	Quantity	Unit Cost	Item Cost
General				
Insurance and Bonding (10%)				$ 129,730
Mobilization (6%)				$ 77,838
Traffic Control (5%)				$ 64,865
Misc. Utility Relocation (5%)				$ 64,865
Subtotal				$ 337,298
Pipe Improvements				
Dewatering (5% of Pipe Cost)				$ 2,268.78
Connect to Existing	Each	1	$ 1,200.00	$ 1,200
Pipe				
18" RCP - 6' Depth to Invert	LF	1,380	$ 94.50	$ 130,410
30" RCP - 6' Depth to Invert	LF	1,235	$ 152.28	$ 188,066
36" RCP - 6' Depth to Invert	LF	2,165	$ 186.84	$ 404,509
Surface Restoration				
Type 1 (Asphalt Patch)	LF	4,780	$ 51.38	$ 245,595
Manholes				
60" Dia and Smaller	Each	16	$ 4,618.40	$ 73,894
Curb Inlets (Type R)	Each	34	$ 7,273.98	$ 247,315
Pipe Outfall (Incl. permanent erosion protection)	Each	1	$ 4,041.10	$ 4,041
Subtotal				$ 1,297,299
Subtotal Construction Costs				**$ 1,634,597**
Design Contingency (25%)				$ 490,379
Engineering and Administration (20%)				$ 326,919
Total Estimated Improvement Cost (Rounded)				**$ 2,452,000**

ATTACHMENT B

New language for adding the Stormwater Master Plan Summary

Stormwater Master Plan (2016)

The Stormwater Master Plan (SMP) was updated in 2016 based on new data from the 2013 flood event. The primary goal of the SMP is to provide the City of Boulder with a guide to proactively address existing and future stormwater drainage and stormwater quality through a series of recommended improvements to the city's stormwater collection system. The 2016 SMP builds on previous planning efforts through additional analysis of where under-served or non-existent drainage systems create potential stormwater collection problems and develops improvements and associated estimates of capital costs needed to increase the level of service in these local drainage system areas.

City of Boulder
City Council

Mayor Suzanne Jones Mayor Pro Tem Mary Young

Council Members: Matt Appelbaum, Aaron Brockett, Jan Burton, Liza Morzel, Andrew Shoemaker, Sam Weaver, Bob Yates

October 21, 2016

Dear Boulder Board & Commission Members:

At the end of each year, the Boulder City Council asks members of the city's boards and commissions to provide input on the next year's goals and objectives in order to help Council and the city staff prepare the annual work plan at the January city council retreat. In the past, some board and commission members have found the questions too narrowly focused. Because you are leaders in our community, and you are certainly aware of a spectrum of issues, this year we decided to broaden the questions, seeking input in any area where you have views.

Please see this year's questions below. You need not limit your responses to the area of expertise of your board/commission. Your entire board/commission may provide a single set of responses or, if you prefer, each member can provide his or her own responses (if the latter, please submit all of the member responses in a single packet). So that Council may have the benefit of your views before its pre-retreat Study Session on January 10, please deliver your responses to your board secretary no later than the close of business on Friday, December 16.

Thank you for your service to our community.

Sincerely,

Lisa Morzel
Bob Yates
Council Retreat Committee

1. How do you think the City can improve its public engagement process? How would you recommend that Council engage with the community?
2. What do you think the City's top three priorities should be in 2017?
3. What do you think will be the City's three biggest challenges over the next five years, and how should we address them?

CITY OF BOULDER
Planning Board

email boulderplaningboard@bouldercolorado.gov
web www.bouldercolorado.gov

December 28, 2012
Mayor Appelbaum
Members of the Boulder City Council
P.O. Box 791
Boulder, CO 80306

Dear Mayor Appelbaum and Members of Boulder City Council,

The Planning Board appreciates the opportunity to offer ideas to Council for its consideration for inclusion into the next year's work plan.

These past years' numerous and costly extreme weather events[1] have generated much vigorous discussion among the Board about Planning Board's role in combating climate change and the urgent need for greater measures toward reducing GHG emissions and increasing the sustainability of development. Consequently, our recommendations for work plan priorities are focused, with just five recommendations. Four of the five recommendations directly impact GHG emissions and climate change. One of these, **Recommendation D** (Area Plan Lite), has appeared in several prior years' letters to Council and has increasing relevance in light of its sustainability implications.

Planning Board's recommendations for inclusion in the work plan are as follows:

1 According to Munich RE, one of the world's major re-insurers, weather-related insurance losses in North America have nearly quintupled since 1980, due in part to global warming. http://www.youtube.com/watch?feature=player_embedded&v=zpbsdVvEa8M

Boulder Building Energy Codes, Energy and Water in Site Plan Review, and Density Bonuses

"The biggest source of greenhouse gas emissions and energy consumption in this nation and around the world is the buildings in which we live and work (almost 50% of all GHGs in the US) – not gas guzzling SUVs and other widely recognized energy consumers that we hear so much about," Edward Mazria told attendees at the 2006 Southeast regional meeting of the American Institute of Architects. "The architecture and design profession is the only profession that can slow this down." In Boulder, due to the coal intensity of the electrical energy supply, the amount of emissions attributable to buildings is over 70% according to the 2011 Climate Action Plan Progress Report. It seems clear that that Planning Board, as the primary arbiter of City planning policies, has an instrumental responsibility to reduce GHG emissions from the building sector. This is equally important as reducing emissions from the supply side.

Recommendation A: Building Codes

The periodic consideration of the adoption and/or augmentation of the International Energy Code into the Boulder building code is on the docket this year for the Planning Board and City Council. In order to reach many of the six Energy Future Goals adopted by Council, *it is imperative to push the envelope on building performance in the arenas of electricity consumption, heating and cooling, and transportation*. The Planning Board encourages Council take the energy performance code issue very seriously, and to set very ambitious goals for reduced energy consumption in new buildings in Boulder in order to advance the Energy Future goals. These codes will apply to all new buildings in Boulder,

whether receiving Site/Use review or not, and are a critical tool to reducing energy consumption and pollution in the community in the coming years.

Recommendation B: Clarification of current site review criteria for energy use

There is a significant difference between what the Site Review criteria appear to require in evaluating energy use in Site Review and what recent Planning Board practice has been as regards energy consumption, water consumption and quality, construction waste, heat islands, and renewable energy. BRC Section 9-2-14.h states: "Criteria for Review: No site review application shall be approved unless the approving agency finds that: (2) Site Design: Projects should [meet multiple goals]. In determining whether this subsection is met, the approving agency will consider the following factors:… (F) Building Design, Livability and Relationship to the Existing or Proposed Surrounding Area:… **(xi) Buildings minimize or mitigate energy use; support on-site renewable energy generation and/or energy management systems; construction wastes are minimized; the project mitigates urban heat island effects; and the project reasonably mitigates or minimizes water use and impacts on water quality."**

Until now, Planning Board and planning staff practice has been to presume that the application of the existing building codes (to both by-right and site reviewed projects) satisfies the consideration of determining the fitness of the project with the site review criteria regarding energy, water, waste, and renewables. However, some of us have reservations about the current practice because this practice does not seem to reflect the written policy on this subject for the following reasons. Two key terms are used several times in the preceding code passage: 'minimize' and 'mitigate'. To minimize energy or water use would be to drive it to zero (or even negative). To mitigate energy and water use requires that a use of energy/water[2] would be less than some reference level. One cannot mitigate unless there is a reference that forms the baseline below which there is a reduction. This portion of code inconveniently does not provide that reference level for either energy or water, so in order to evaluate a project against this criteria, Planning Board has to infer against which target levels there must be a reduction.

Planning Board requests that Council clarify this section of the BRC. As one example of a potential clarification, some of us have suggested that the baseline from which to mitigate water and energy use and maximize renewable energy be the absolute energy, water, heat island, and renewables performance of a by-right building built to code on the candidate site. As it stands, there is some disagreement and unclarity on how to interpret the evaluation of this factor in the criteria for Site Review. If the Council does not wish to strengthen or clarify this section of Code, the Planning Board will continue to use its best judgment on how to apply this important evaluation factor to projects in the Site Review process.

2 Water is used in most electric power production, so minimizing electricity use generally helps with minimizing water use.

Recommendation C: Use impacts on overall site emissions and inclusionary housing goals

Different building uses have different impacts on energy consumption and emissions. In particular, entirely commercial uses often impose increased impacts, including transportation and building energy and water consumption, relative to similarly sized residential or mixed uses. Often, increased site intensity can reduce the overall impacts per building user, but there can still be a significant difference in impacts on energy and water consumption between types of uses, even in the presence of increased allowable intensity on a site. In addition, the (relatively) recent intensity bonuses available to commercial projects seem to be providing an incentive to build projects that are completely commercial in the downtown core, rather than mixed-use or residential. This has the side effect of reducing both the construction of residential or mixed use projects, as well as reducing the funding for (or construction of) affordable housing units associated with downtown projects. The linkage fees from commercial projects are not nearly as great as the Cash-in-Lieu affordable housing payments (or the value of constructed affordable housing) would be from a similarly sized residential or mixed-use project. For both energy/emissions and affordable housing reasons, Planning Board requests that Council review the

current intensity bonus rules in light of the impacts of different uses on the City energy future and inclusionary housing goals.

Recommendation D: Layered, incremental approach to area planning (Area Plan Lite)
It is critical that the planning department have tools at their disposal to address needed changes in the Land Use code on an ongoing basis and in a time sensitive manner. Rather than viewing changes to an area as an effort with a clear beginning and a clear and comprehensive end, it is important that we view areas of the City, and therefore the Land Use code, as evolving entities.

To this end, we would like to revisit the concept of layered, incremental area planning or "area plan lite", the idea that it is possible to update or adjust an area's zoning without a multi-year effort. It is necessary to create a process with a shorter product development cycle, so that we can respond to changing needs more quickly. Without this, we will continue to see the Land Use Code fall further and further behind our current community vision, and see our zoning fall more and more out of step with what we understand to be the best planning practices that we should be implementing. There is simply not enough time to use a full area plan process on every part of the city that needs updating and keep up with the needed changes.

There are some planning changes that are quite drastic and need a good deal of community involvement. The layered, incremental approach can address changes that are not as far reaching and that the Planning Staff and Planning Board should be able to implement on a "quick-fix" basis with a basic level of public outreach. There might be intermediate steps as well that require a bit more vetting with the public, and these different processes can form the layered implementation.

Sustainable Streets and Centers is a good example of this need for a "lite" process. As currently conceived, it will take literally years of study, outreach, and process to even begin to make changes. If, however, we had a policy of a layered, incremental implementation, then we could attack the low hanging fruit immediately, such as the currently allowed large parking lots in front of new buildings. By creating a multi-tiered process and a willingness to enact base level changes without a time-consuming process, we will be nimbler, more responsive, and have a Land Use Code that is on the leading edge of our vision rather than constantly lagging behind.

Planning Board requests that Council include in the Planning Department's work plan, development of an initial framework(s) that can be applied to some key areas of concern. Currently, the areas we see as experiencing significant development or redevelopment activity are the 28th St., 30th St and Arapahoe (East) corridors and the Broadway and Mapleton hospital areas. With the expectation of imminent increased development activity after a four plus year lull, we believe this issue has only become more urgently in need of concerted planning attention. As the corridors such as 28th St. redevelop, the die will be cast for development patterns for the next several generations and all the attendant GHG emission and sustainability consequences. In the absence of a framework that reflects current City planning goals, development will (as 28th St redevelopment currently is) perpetuate the historic auto-centric pattern, delaying a more sustainable future; something we can ill-afford.

Recommendation E: North Boulder Sub-community Plan
We understand that staff is proposing work on the **North Boulder Sub-community Plan** in 2013. We support a revision to that plan in order to address the changed location of a potential grocery store, the Library's long term expansion plans, and the mix of affordable and market rate housing.

In conclusion, Boulder has displayed foresight and leadership in planning and sustainability but there is much more to do and the acceleration of extreme weather events in number, intensity and cost make planning an existential issue worthy of our greatest effort, not just for the effect on our city but as an example of what is possible. We look forward to working with Council on these matters in 2013.

Cordially,

Bill Holicky, Chairperson
Mary Young, Vice-chairperson
Bryan Bowen
Aaron Brockett
Leonard May
Danica Powell
Sam Weaver

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January 3, 2014
Mayor Appelbaum
Members of the Boulder City Council
P.O. Box 791
Boulder, CO 80306

Re: Planning Board Recommendations for 2014 Priorities and Initiatives

Dear Mayor Appelbaum and Members of Boulder City Council,

The Planning Board appreciates the opportunity to submit this letter to Council regarding our recommendations for City priorities and initiatives in the upcoming year. With a Boulder Valley Comprehensive Plan update beginning in a year, we ask the Council to begin thinking in advance, and allocate resources for staff to begin thinking in advance, about a more integrated planning process that both establishes a clearer long term vision for Boulder and a clearer path for achieving that vision.

1. Addressing the Vision Gap between the Comprehensive Plan and Zoning

Planning Board believes there is a gap that needs to be filled as part of the Comprehensive Plan update process between the current broad conceptual, yet vague, goals of the Comprehensive Plan and the detailed implementation tools such as Area Plans and zoning. When a development project is evaluated, we do not always understand its long term impact on key Comprehensive Plan goals such as: "protect[ing] the natural environment of the Boulder Valley while fostering a livable, vibrant and sustainable community" or "The unique community identity and sense of place". The lack of intermediate plans and vision often means that the following types of important questions are not fully considered during development review:

- How does a project impact these and other goals at the neighborhood, area and citywide levels?
- How does a project or the aggregation of all new projects affect the jobs-housing balance, GHG emissions and sense of place?
- How will the city look 20 or 50 years into the future? Will the view shed be what we want?
- Will we still have a small town feel and is that even a long term goal?
- Will jobs and housing reach a more desirable balance and help achieve GHG emission reductions?
- Do we want to be more proactive about affecting the rate of population and employment growth relative to each other or just react to trends as they develop?

Our current development review process is usually more about making buildings rather than making places. A more integrated approach as discussed above is one part of enabling a shift to placemaking. ***Placemaking should involve a meaningful dialogue with stakeholders and neighbors (business and***

residential) if we are to be successful. But Boulder also needs to have a community conversation about visual preference for the city form and consider changes to zoning so it has a greater form basis. We also need better data to understand our employee characteristics – ages, family profiles (single, married, with or without children), income, desired housing type or context (urban vs. suburban), reasons for living or not living in Boulder, to better guide land-use policies that directly impact housing and employment growth.

2014 is the right time to focus on these issues.

2. Currently Planned Initiatives

Boulder has made good progress addressing related issues affecting the questions identified above during 2013 and is already prepared to address critical issues in 2014. The Planning Board offers its support and some thoughts on the following efforts.

a. Comprehensive Housing Strategy

We encourage City Council to continue its work on the Comprehensive Housing Strategy in 2014. The City should pursue measures that allow us to create more types of housing as well as add more affordable housing. To that end, we recommend changing the Boulder Revised Code to remove some of the impediments to ADUs, OAUs (and betterment capture in zones where they are not now allowed) , cooperative housing and micro-units.

b. North Boulder Subcommunity Plan Revision

The North Boulder Subcommunity Plan revision has gotten off to a successful start in 2013. The City should continue the process in 2014. But, the Plan needs to be informed by data from the September floods. We need to strike a balance between waiting to know exactly how the flood maps will change and moving forward with the plan in a timely manner. Perhaps the Plan revisions can be based on preliminary flood data so that the process is not unduly delayed.

c. Resilience Planning

The Planning Board applauds the City's efforts to focus on resilience in planning and operations in 2014, including its selection as one of the first 33 resilient cities. As the City undertakes this effort, we want to stress the importance of not overemphasizing the last disaster – flooding. While flood risks are critical and need to be part of the process, the City should also consider and prioritize a wide array of possible impacts that could challenge our resilience as a community, including wildfire, electric grid vulnerability, epidemics, cyberthreats, energy shocks, and other issues. In the immediate term, we believe it is important to continue efforts to address fire resiliency for existing homes and properties along the Wildland Urban Interface, a portion of the Wildland Fire Code that was not adopted in 2013.

d. Sustainable Streets and Centers; East Arapahoe Plan

In previous years' Planning Board letters to Council, the Board has expressed a desire for "Area Plan Lite" to be part of the Work Plan to establish a general framework for certain high priority corridors and centers. The general idea was to develop a set of tools that have a much faster and cheaper product development cycle that the traditional Area Plan. This is an example of the needed planning in the gap between the Comprehensive Plan and the zoning code. Because of the time and resources involved with Area Planning (as we do it in Boulder), development is occurring and will occur in certain high-priority areas before the planning can be put in place. But planning is about being out in front of development, so this concept continues to be of critical importance if we want development and redevelopment of these areas over the next 50 years to be consistent with our goals. The areas we have previously expressed this concern about include (1) East Arapahoe; (2) East Pearl; (3) 30th St and 28th Street between Arapahoe

and Iris; (4) Boulder Community Hospital Broadway environs; and (5) Boulder Community Hospital Mapleton environs.

Fortunately, the Sustainable Streets and Centers initiative is evolving in a way that it will achieve the intent of "Area Plan Lite". Continued development of the initiative and expansion of its application beyond the Pearl/30th Street pilot as soon as possible will allow these areas to redevelop in a manner consistent with general city goals and consistent with the integrated planning process we are promoting herein.

3. New Recommended Initiatives

In addition to the integrated planning thinking and continuation of existing initiatives discussed above, we recommend two new initiatives which deserve attention.

a. Site Use Impacts and Intensity Bonuses

In last year's letter to Council, PB proposed that Council address site-use impacts on overall site emissions and inclusionary housing goals (Recommendation C in the 2013 letter to Council). This continues to be an issue that would benefit from some conceptual refinement.
Specifically, after previous Councils created intensity bonuses (FAR and height increases) to promote more and higher density housing units in the downtown core, followed by extending those same bonuses to non-residential uses, a confused incentive program has resulted. The subsequent bonus extension to non-residential uses has had the effect of promoting exclusively non-residential developments over projects that include residential. That then reduces funding available for affordable housing as the linkage fees from commercial projects are substantially smaller than cash-in-lieu payments for similarly sized residential projects. Additionally, non-residential uses tend to have greater GHG emissions per site than residential uses.
The current circumstance with the incentives raises the question: "what is the vision"? How much housing and how much commercial space are sought in the core and what do we want to the core to be like when built out to capacity according by current regulations? Related to this is betterment capture – is the City obtaining a benefit commensurate with the value it creates by granting increased development intensity or is that value disproportionately accruing to the benefit of property owners? If there are bonuses at all, should they be tied to attainment of specific and clearly defined City goal?
For energy/emissions, affordable housing and betterment capture reasons, Planning Board requests that Council re-examine the current development intensity bonus rules in light of the impacts of different uses on City goals.

b. Energy Districts, Microgrids, Solar Gardens

As part of the City's Energy Future, resiliency and upcoming Comprehensive Plan update, we recommend that Council direct City Staff to consider the potential for integrating innovative energy concepts like energy districts (like Fort Zed in Fort Collins), microgrids, solar gardens, or combined heat and power into the City's planning efforts. Current site review criteria for industrial subdivisions, mixed-use projects or residential subdivisions do not consider or encourage the potential for some of these innovations, which could help the City meet energy, resiliency and economic goals.

We look forward to working with you in 2014 to continue making Boulder a resilient and sustainable City.

For the Planning Board,

Aaron Brockett, Chair

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January 2, 2015
Mayor Appelbaum
Members of the Boulder City Council
P.O. Box 791
Boulder, CO 80306

Re: Planning Board Recommendations for 2015 Priorities and Initiatives

Dear Mayor Appelbaum and Members of Boulder City Council,

The Planning Board thanks you for the opportunity to share our priorities and concerns with you through our annual letter. While the Planning Board broadly supports the projects included in the 2015 Work Plan, we want to draw special focus to several areas of interest that we hope you will consider as you refine Council's priorities for the coming year. In this letter, we have arranged our remarks into the following areas: Community Engagement, Community Benefit, Site Review Criteria, Use, Housing, Growth, Design Excellence and Short Term Issues.

Community Engagement

The Planning Board believes that the city's noticing procedures for land use and project development decisions should be improved and enhanced in some combination of the following ways:

1. All residents within the notification areas, including renters and tenants, should receive formal notices. This would be in addition to the present practice of notifying only property owners.
2. The size of the areas in which formal notice is required should be increased.
3. There should be enhanced and improved use of electronic media to provide project information to interested parties.
4. More detailed information on specific agenda items should be included in the newspaper public notices to improve public awareness and potential participation in Planning Board meetings.
5. The city should improve timely notification of property owners and residents materially affected by various city actions, such as proposed changes in floodplain mapping and area classifications.
6. There should be improved descriptions and information on project signage, with images if possible, and information on where to find a proposed site plan or other relevant information on the city website.

Additional effort should be devoted to providing information to neighborhoods, promoting neighborhood engagement and soliciting coherent and representative response and comment from project-affected neighborhoods, perhaps in coordination with the new city neighborhood liaison staff position. The Planning Board hopes to have regular and frequent contact with the new city neighborhood liaison.

At the pre-application stage, key city populations should be identified to the applicant to ensure their involvement.

Project and proposal-related neighborhood meetings should have a higher level of staff involvement to ensure the provision of objective information, background, and staff and Planning Board roles.

Planning Board recommends that neighborhoods be engaged in meaningful ways as part of the BVCP update. The Board supports including a neighborhood section in the updated document that identifies

neighborhoods, describes their current character, strengths and vulnerabilities (from a resilience standpoint), and expected large scale changes, if any.

Community Benefit

Perhaps the greatest source of debate among Planning Board members is whether height and area increases should require specified public benefits in order to be approved.

Three members believe increased height and area help achieve wider city goals such walkable neighborhoods, improved urban form, effective transit, greenhouse gas emissions reduction, etc., and therefore no additional specific public benefits should be required for approvals for projects pursuing these desirable increases. For these members, the critical question is whether the site review criteria are sufficiently clear to meet city objectives.

Four members, however, assert that the hoped-for benefits of height and area increases (affordability, walkability, furthering our efforts to mitigate climate change, etc.) are not being achieved and therefore need to be clearly articulated in the site review criteria. Examples of public benefits and how they could be included in the criteria are illustrated in **Appendix A**.

Site Review Criteria

The Planning Board believes that the site review criteria need updating to provide better results and more clarity and predictability, particularly with respect to height and FAR modifications. Any site review criteria changes should mirror the resolution and direction of the community benefit discussion above. Should Council decide not to modify the site review criteria to require specific public benefits, then clear pathways to increases need to be established, and clarification of how the by-right height and modifications up to 55 feet are to be applied and to what extent will be necessary.

Other recommended site review improvements include:

1. When serving specific city goals, Uses should become part of site review criteria to ensure that appealing offerings made by applicants are retained in projects and that Uses that activate streets are provided to the degree proposed.
2. Clarify "Minimize and Mitigate" energy use site review criteria (9.2.h.2.F.xi specifically *but also other similar terminology elsewhere in site review criteria*).
3. Explicitly require quality design rather than it being indirectly referred to in the BVCP and guidelines.
4. Enable Planning Board call-up for minor modifications.
5. Consider revising the site review thresholds—reduce property size threshold and tighten other triggers to get more projects into site review if it is generally agreed that site review results in better outcomes. Or, if by-right developments can accomplish city goals more effectively by tuning/clarifying the land use code then it's possible that fewer projects need to be brought through the discretionary review processes. The underlying question is whether discretionary reviews like site review, use review, and BDAB review are yielding better results on balance than by-right projects are achieving.

Use Tables

The Use tables should be comprehensively reviewed to make sure that they reflect city goals. They may need tightening in some areas—for example, we may want to change what uses are allowed in the BC zones to make sure they support the intent of the zoning district. In other areas they may need loosening—for example, we may want to allow more uses in the MU-1 and MU-2 zones so that they can support more neighborhood services.

We should also consider requiring certain uses in certain zones. For example, we may want to require retail uses on the ground floor in critical locations in the MU, BMS and DT zones. If they are developed as 100% residential, we lose the ability to have local services that support 15-minute neighborhoods. This is part of the reason why the Hill moratorium was necessary and has been a problem along Broadway north of Violet.

Housing

The Board also recommends that the Council ensure that Housing Boulder remain a high priority during 2015. The issues related to housing affordability remain critical for the city and will require considerable staff time and resources, along with engagement from the community, Council and the Board. As the Council has seen during the year, the issues are complex and often contentious, requiring both a city-wide view and recognition that many of the opportunities and constraints are unique from neighborhood to neighborhood. As this process unfolds, the Board hopes that particular attention is paid to the recommendations by the Landmarks Board to align housing and preservation goals through incentives for the preservation of smaller, historic housing units and structures. Similarly, the Board encourages special focus on the goal of inclusion of affordable housing on site as part of community benefit for developments.

Growth Questions

As regularly happens, growth is becoming a hot topic in some portions of the public eye right now, largely spurred by the recent completion of new developments in high visibility areas. Resolving growth questions is integral to issues like affordable housing, transportation, urban form, sustainability, and economics. As such, Planning Board recognizes growth as a BVCP-level issue that should be reviewed through that upcoming process with appropriate public engagement. Our key suggestions include:

1. Use visioning as a tool to help the public, the city, and the applicants for various review processes understand what sort of character we ought to expect to see in different distinct areas of town under a variety of development assumptions. These tools should focus on the character of the public realm and incorporate both streetscapes and buildings, as the ones being proposed for the East Arapahoe effort. It would also help inform the land use code and the relevant design standards.
2. Revisit residential growth management rules to understand if they are achieving what we want.
3. Compile good numbers on commercial growth so we can see if we're going in the right direction. This can be informed by efforts in item 1.
4. Update the Impact Fee Study to make sure that the current fees are appropriate.

Design Excellence

Planning Board supports the design excellence initiative and encourages City Council to commit time and resources to it. We are hopeful that the outcome of the initiative will be tangible guidance, whether it is city-wide design guidelines or standards, a pattern book, form-based code, or revisions to the site review criteria, which drive us toward projects that achieve city goals while still being authentic to Boulder and embraced by the community. As part of this initiative, it would also be helpful to adopt a feedback loop that looks at successes and failures of recently completed projects, both by-right and discretionary. We also appreciate the input that BDAB has provided on projects and would like to clarify and improve the process of working on design with them.

Important Short Term Issues

East Arapahoe Medical Offices

The recent move of more functions to the Foothills Boulder Community Hospital has highlighted use table issues and other planning problems in the vicinity of the new location. Currently, there is inadequate close-by office space for doctors and other medical offices and that is creating difficulties for both medical professionals and patients, as well as undermining the city’s objectives of reducing unnecessary car trips and enhancing the mobility of the elderly and other sensitive populations. While there is long-term potential, the hospital environs do not provide the walkable mix of jobs, services, retail and housing available at the original Broadway site. The Board recommends that the city consider, as soon as possible, short term use table and other changes to address the current imbalance between demand for, and supply of, space within walking distance of the hospital in which medical uses are allowed. In the medium and long-term, as part of the East Arapahoe planning process, the Board recommends that the city work to recreate and improve on the walkable and vibrant neighborhood that existed in the vicinity of the old Broadway medical campus.

Mapleton and Broadway Hospital Areas

The Board supports planning efforts to get ahead of redevelopment applications at the two former hospital sites and their environs as more medical practices and functions move to the east Arapahoe location.

Linkage Fees

Planning Board encourages City Council to pursue city-wide implementation of non-residential linkage fees for affordable housing.

MU-1 Zoning Changes

The MU-1 zone was created and adopted as part of the North Boulder Sub-Community Plan specifically for the Holiday Neighborhood area. The zone has not been evaluated since it was created and several changes have been suggested that would make for a better urban design to benefit the community.

1. Allowed uses: Add (small, 2000 to 2500 sf) retail to the allowed by-right uses. Current by-right uses are overly restrictive and in fact would not allow artists to sell from their studios. Add small offices by right. Add outdoor entertainment use in public spaces—the zone currently prohibits outdoor music or performance events that can enliven public spaces.
2. Ground floor uses and FAR: In many cases the goal of providing a 50% split between residential and commercial uses has led to placing residential uses on the ground floor along busy streets. The ground floor is better for uses that create pedestrian interest and add vitality to the street. In some cases, the FAR of .6 - 1, as well as the height measurement, have created a situation where a second floor (more appropriate place for residential along busy streets) was not allowed. These constraints should be re-examined. An FAR of 1 to 1 should be considered.

Support Municipalization

Planning Board is enthusiastic about playing an active role in aligning city planning to best take advantage of the opportunities from conversion to a municipal utility. Such support could come in the form of changes to zoning parameters, building codes, and site review criteria to remove barriers and/or introduce incentives to distributed energy generation, shared metering systems, solar gardens, neighborhood geothermal, and other innovations yet unexplored.

Very truly yours,

Aaron Brockett
Chair, City of Boulder Planning Board

On behalf of the board:
Bryan Bowen, Vice-Chair
John Gerstle
Crystal Gray
Leonard May
Liz Payton
John Putnam

Appendix A

1. The public benefits list would require some level of prioritization or weighting of benefits to determine what is appropriate to approve certain addition height and area increases.
2. Explore if a certain number of benefits must be provided from a minimum number of different categories *or if a point system or a hybrid of both are appropriate*.
3. Establish where geographically and to what extent of building footprint projects get to be higher or greater area than the underlying zoning limits and are allowed to extend to 55' or maximum potential area increases. Within this framework, what public benefits must be achieved to allow the increases

Public benefits beyond what is already required to achieve greater intensity than by-right			
Category	Public Benefit	Benefit Provision Factor	Bonus/Modification
Affordable housing	More affordable housing	g%	
	More affordable housing on site	h%	
	More market rate affordable	i%	
	More family oriented affordable	j%	
	For Non-residential - More impact fee for affordable housing.	k%	
	More Diversity of Housing: Coops and Cohousing	l%	
Affordable Business	Incubator space for artists and startups		
	Non-profit office space		
	Preserve service industrial and low cost business space		
Urban design	Uses - Street level activation occupancy	k%	
	Uses – exceptional and desired uses		
	Parks and urban space		
	Alt mode connections not otherwise required		
Architectural Merit	Architectural merit		
	Embedded mechanical		
Public Art	Public Art		
Sustainability	Net zero		
	Embodied Energy (Adaptive reuse of existing buildings)		
	TDM with teeth		
	LEED Gold, Platinum		
Historic Preservation	Landmark and adaptively reuse historic building		

Appendix A

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	Embodied Energy (Adaptive reuse of existing buildings)		
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Historic Preservation	Landmark and adaptively reuse historic building		

CITY OF BOULDER
Planning Board

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December 21, 2015

Dear Mayor Jones and Members of Boulder City Council:

The Planning Board thanks you for this annual opportunity to share our priorities and concerns with you. We also want to thank you for carefully considering our letter from last year; we were pleased to see that many of the issues identified in last year's letter have been addressed in the 2015 Work Plan or are on the 2016 Work Plan. Looking ahead to the 2016 Work Plan, we broadly support the approach that has been mapped out by City Council and Staff. However, we also offer the following comments regarding the City's priorities and planning needs.

1. **Overall Work Plan and Community Engagement**

As an overarching consideration, much has been accomplished during 2015, but at the cost of considerable effort by Staff, Council, the boards and commissions, and the public. It is hard to sustain this level of effort and maintain high-quality products and process. As Council considers the Work Plan and priorities for next year, we encourage Council to ensure that the City -- Council, Planning Board and Staff – engages in only so many things as the City can do very well. It can be hard to get the focus, community engagement and commitment we need if too many things are happening simultaneously. At the same time, the City should make sure there is some reserve of energy and time to allow nimble response to new developments, data, and opportunities to enhance the resilience, inclusiveness, quality of life and strength of the community.

This will be both a challenge and critical need, with vital efforts such as the Comprehensive Plan and Housing Boulder underway, and other initiatives like the Form-Based Code, AMPS and the Downtown Urban Design Guidelines nearing completion.

As we noted in our letter from last year, the City needs to ensure that the public is being fully and consistently engaged during this process. The City has made good progress over the last year in improving notice and outreach. However, the City should keep working to improve involvement and process, including the approaches we identified in last year's letter (attached).

2. **Middle- and Affordable-Housing; Housing Boulder**

Across the nation, rapidly increasing prices and rents continue to make housing less affordable for middle- and lower-income families and residents. Boulder is a prime example. This has been powerfully reinforced by the results of the recent community planning survey, our recent joint meeting regarding the Comprehensive Plan, and feedback from the community during Board meetings, open houses and conversations around town. Accordingly, we expect that Housing Boulder and housing for the middle should be the top priority for 2016. Part of that effort should include education and outreach, as well as

consideration of the tradeoffs and barriers to providing middle-income housing. The relentless market and demographic pressures make speed critical, because our middle is eroding.

This housing need must be addressed throughout the planning process, from the Comprehensive Plan to the City's codes, and to individual decisions. Among other things, we recommend that the following be addressed:

a. Evaluate all regulatory and incentive models, including the City's inclusionary housing program, to improve our ability to integrate affordable housing on site in every development. The Board is concerned that the payment in lieu requirements may be pushing affordable housing out to the periphery;
b. Implement measures to protect existing affordable housing stock, such as the Landmarks Board's proposal to support more subdivision flexibility that might protect existing and historic small dwelling units, and steps to support public or resident ownership of mobile home parks and apartments;
c. Implement new flexibility and fixes for the ADU ordinance, and explore how to improve opportunities for OAUs;
d. Tackle the co-operative housing ordinance;
e. Implement even stronger and more firm requirements for affordable housing in annexations;
f. Broaden our inclusionary housing program to address housing at higher levels of AMI (*e.g.*, 150% AMI) and increasing the goal of permanently affordable housing from the current 10%.
g. Consider conversion of zoning from commercial to residential or mixed use in Comprehensive Plan, but also foster neighborhood businesses that are essential for 15-minute neighborhoods.

3. <u>Community Benefit and Site Review Criteria</u>

As discussed in our letter from last year and supported by the recent community survey, there is a critical need to address and define the role that community benefit should play in site review, as well as to resolve deficiencies in the existing Title 9 site review criteria.

We are glad that these issues are currently included in the proposed Work Plan and are scheduled to happen after completion of the Form-Based Code for Boulder Junction. We strongly recommend that this effort remain a priority in the Work Plan for 2016, because the existing criteria are often not working well to meet City goals and community expectations. As we discussed in last year's letter, the site review criteria need revisions to better address, among other things: (1) the role that community benefit should play in discretionary approvals such as height and FAR increases; (2) the definition of what should qualify as community benefit; (3) the requirement for a diversity and affordability of housing types; (4) explicitly require heightened design excellence; and (5) the currently ambiguous implementation of the energy use minimization/renewable maximization requirements.

4. <u>Area, Neighborhood and Other Focused Plans</u>

The Planning Board continues to believe that the City would benefit from more extensive and better planning in focused areas larger than a particular site, but smaller than the Comprehensive Plan (e.g., area planning and neighborhood planning). We strongly support the inclusion of this type of planning as one of the focus areas in the Comprehensive Plan and encourage steps to further develop these plans. In addition, the Planning Board recommends the following:

a. As discussed at the December 15, 2015, Joint City Council/Planning Board meeting, it will be important to determine the appropriate scope of these plans. The currently-defined "Subcommunities" are not well suited for this purpose, because of the wide range of typologies, geography, transportation elements, and other factors in areas such as Central Boulder, South Boulder or Southwest Boulder.
b. Boulder Junction remains a critical place for focus in 2015, with the completion of the Form-Based Code and consideration of the City's approach to the Pollard Motors site. The City should carefully consider how the approved development in Boulder Junction lines up with the objectives of the Transit Village Area Plan (TVAP), especially with regard to the balance between residential and other uses, types of residential development, etc. The decision regarding how to proceed with the Pollard Motors site will have the largest remaining effect on what the City achieves in the Boulder Junction Phase I development, including the extent of affordable housing.
c. The Broadway Corridor is an area that badly needs focused planning and vision. Broadway is seeing pressure for change (as seen in recent proposals from 385 Broadway to the north end of the City), but lacks a coherent vision as a corridor (or sub-corridors). Broadway Corridor Planning should include or closely coordinate with planning for the Boulder Community Hospital site, University Hill, Downtown (see below) and the North Boulder Subcommunity Plan.
d. Planning Board also supports a Downtown plan to inform and create a vision for urban design, urban form, the public realm, and project review.

5. <u>Zoning and Other Code Revisions</u>

The Zoning Code is overdue for revisions in areas that are outdated or operating suboptimally. In the last five years, only two modest changes to the Zoning Code have been made. As you know, Staff maintains a list of issues (attached to this letter) in the Zoning Code that need attention or revision. These issues often arise in site-level reviews, reflecting mismatches between the City's current vision or direction versus the historic language of the Code. Code changes could better achieve vibrant pedestrian experiences, City objectives for 15-minute neighborhoods, effective mixed-use, design excellence, climate goals, and quality of life. Examples that we believe the City should address in the near future are:

a. Rewrite the sign code, which was also recommended by the urban design guidelines taskforce
b. Updates to the Use Tables to improve streetscape (such as preventing overuse of bank office space on ground floor and/or requiring retail in some locations), and fix mixed use designations to address recurring uses that would improve mixed-use neighborhoods
c. Measures to address barriers to outdoor enclosed long term bike parking and upgraded transit stops
d. Measures to address barriers to more active use of roof-top open space.
e. Measures to require readiness for future photovoltaic systems and electric vehicles

6. <u>Ensuring Resilience</u>

City efforts to promote residence should have a very high priority in the Work Plan in light of the need to protect residents from natural and other hazards. Because new floods, fires and other hazards are matters of "when" and not "if", we need to make sure that these issues are addressed early and thoroughly. This should include:

- Efforts to ensure the adequacy of floodplain definition and maps used for planning decisions, incorporating the lessons from the 2013 floods and ensuring the best information regarding the effects of climate change
- Addressing flood mitigation plans for South Boulder Creek and CU South in the Comprehensive Plan
- Incorporating resiliency into neighborhood-level planning and neighborhoods into resiliency planning
- Consideration of critical facilities (including schools, senior facilities, and daycare) requirements in the wildland-urban interface (WUI)
- Consideration of building, landscape and other requirements in the WUI
- Consideration of food security and local production

7. <u>Incorporating Climate Change into City Planning</u>

As the City considers Comprehensive Plan, Site Review Criteria, building and energy code, and other planning changes, it should fully integrate the City's Climate Commitment. The Planning Board believes that the City should make sure that the City's planning policies and requirements work consistently to contribute towards the glide path needed to accomplish the 80 percent reduction in greenhouse gas emissions. This will require emissions reductions from all sectors of the City, including new construction, existing residential (owned and rental), and commercial, utilities, and transportation.

As part of this effort, the Planning Board supports the ongoing development of building and energy codes that contribute to the necessary emission reductions needed to meet our climate goals. This development should shift from relying on a percentage improvement beyond code to an energy use intensity or some other performance or energy usage cap. In addition, the Planning Board encourages efforts to make it more viable to have energy related innovation such as energy districts, microgrids, and solar gardens. This should include requirements, incentives, codes and other mechanisms that can accelerate development of these next-generation energy innovations and pursue greenhouse gas reductions to the extent possible with or without municipalization of electric utility services in Boulder.

Very truly yours,

Bryan Bowen
Chair, City of Boulder Planning Board

On behalf of the board:

Liz Payton, Vice-Chair	Leonard May
John Gerstle	John Putnam
Crystal Gray	