



Laramie City-Wide Master Drainage Plan – Final

Laramie City-Wide Master Drainage Plan
Laramie, Wyoming
Project #32810147

Prepared for:

City of Laramie
Laramie, Wyoming

11/18/2022



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Prepared for:

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Prepared by:

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11/18/2022

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List of Acronyms

CAD	Computer-Aided Drafting
CIP	Capital Improvement Project
COL	City of Laramie
CUHP	Colorado Urban Hydrograph Procedure
CMP	Corrugated Metal Pipe
FIS	Flood Insurance Study
GIS	Geographic Information System
HDPE	High-Density Polyethylene
HEC-HMS	The Hydrologic Modeling System
I-80	Interstate 80
O&M	Operation and Maintenance
RCP	Reinforced Concrete Pipe
SWMM	Storm Water Management Model
UPRR	Union Pacific Railroad
WDEQ	Wyoming Department of Environmental Quality
Wood	Wood Environment & Infrastructure, Inc.
WRDS	University of Wyoming Water Resources Data System



ES Executive Summary

ES.1 Purpose and Scope

The City of Laramie (COL) has contracted Wood Environment & Infrastructure, Inc. (Wood) for the preparation of this City-Wide Master Drainage Plan. This report summarizes the previous master plans, the compilation of the recommended projects from the previous master plans, the development of a prioritized capital improvement project list, and the compilation of a city-wide storm water system model.

Each of the previous drainage plans evaluated existing storm sewer infrastructure and recommended improvements based on hydrologic and hydraulic modeling of storm events and future development conditions. Each of these reports contained recommended projects which were compiled to create a prioritized capital improvement project list, which ranks the projects based on various benefits.

ES.2 Summary of Previous Studies

Table E1 below is a summary of the previous drainage master plans.

Table E1: Previous Drainage Master Plans

Master Plan	Year Completed	Study Area (acres)	Total Cost of Proposed Projects (Cost in Parenthesis Adjusted to 2022 dollars)	Modeling Software Used
West Laramie	2010	903	\$10.8M* (\$18.9M)	CUHP, XP-SWMM
North Laramie	2013	2,560	\$30.2M* (\$48.3M)	CUHP, XP-SWMM
South Laramie	2017	39,000	\$48.1M* (\$68.3M)	EPA-SWMM
Total			\$89.1M (\$135.5M)	

*Capital cost from year of report

ES.3 Storm Water System Mapping

A key project goal was to create a city-wide map of the City's storm water infrastructure, building on existing mapping data and collecting information to fill data gaps. Storm water mapping was completed in the Geographic Information System (GIS) format.

The mapping effort from the South Laramie Drainage Master Plan was used as a model for the city-wide mapping. Available storm water system mapping was evaluated to determine data gaps. There were six portions of the storm water system that lacked survey-grade data. In general, all of Laramie except for the study area in the South Laramie Master Plan lacked GIS attribute data for the stormwater infrastructure.

GIS attribute data was collected on a mobile phone using the ESRI Collector application. Attribute data was obtained for storm water manholes, pipes, inlets, and outfalls. Wood subcontracted Trihydro Corporation (Trihydro) to assist in collection of survey-grade information where lacking. Elevation and location data were collected for storm sewer manholes, inlets, and outfalls.



ES.4 Capital Improvement Project Tool

Each previous master plan developed a list of recommended projects. The West Laramie Master Plan grouped recommended projects by fiscal year, while the North Laramie and South Laramie master plans grouped recommended projects by reach or drainage basin.

Projects from all three previous master plans were compiled into a single spreadsheet. Projects that have already been constructed were removed from the project list. A CIP Prioritization Tool was created to rank the projects based on various potential benefits for each project. Prioritization was based on the following categories:

- Life-cycle cost per property benefited during 100-year storm event;
- Life-cycle cost per roadway benefited during 100-year storm event;
- Whether the project addresses existing flooding issues during minor storm events;
- Whether the project requires land acquisition and/or a UPRR permit;
- Whether the project provides recreational benefits to the community;
- Whether the project provides water quality benefits; and
- Whether the project enhances community development priorities.

Each category had a weighting factor that contributed to the overall score of each project. The tool can be adjusted to change the existing weighting factors. Three tiers of priority were developed for the compiled list of projects after they were ranked. Table E2 below is a summary of the high-priority projects from the CIP Tool.

Table E2: High-Priority Storm Water Projects from CIP Prioritization Tool

Priority Rank	Project Title	2022 Capital Cost	Predecessor (Priority Rank)
1	Regency Pond*	\$1,653,000	None
2	Optimize pond outlet structure, Nighthawk and 22 nd Street**	\$116,000	None
3	Enlarge Pond CM02, Beaufort & 10 th	\$274,000	None
4	Enlarge Pond NE of 30 th and Reynolds Street	\$274,000	None
5	New Pond east of Jacoby GC	\$11,604,000	None
6	Upgrade existing storm sewer to 54" in Beaufort St. from 8 th to 9 th and along 9 th to Downey	\$890,000	#70 (Upgrade existing storm sewer to 6'x8' RCBC in Downey from 9 th to 7 th , on 7 th to Mitchell, and on Mitchell to outfall)
7	Install new 24" storm sewer from Van Buren Street and Lincoln to Polk and Lincoln	\$181,000	#22
8	Optimize pond outlet structure, Binford and 22 nd Street***	\$33,000	None
9	Optimize pond outlet structure, 22 nd and Reynolds Street***	\$77,000	None
10	Upgrade existing storm sewer to 60" RCP along Canby Street	\$440,000	#37 (New 5'x8' RCBC along Canby Street)



Priority Rank	Project Title	2022 Capital Cost	Predecessor (Priority Rank)
11	LaBonte Park Pond Improvements	\$5,499,000	None
12	New 36" storm sewer from Madison and Adams to Madison and Lincoln	\$905,000	None
13	New 24" storm sewer in Polk from Fillmore to Taylor, 36" north to Van Buren	\$242,000	#22
14	Upgrade to 30" and 36" storm sewer on Harrison from Lincoln to Buchanan	\$298,000	None
15	New Pond RM02, SW of 30 th and Reynolds	\$1,540,000	None
16	Upgrade existing storm sewer to 60" RCP along 6 th Street	\$1,036,000	#41 (Upgrading existing storm sewer to 4'x10' RCBC along Harney Street)
17	Enlarge Pond LM01, NE of 15 th & Harney	\$235,000	None
18	Upgrade existing storm sewer to 60" RCP along 11 th Street	\$440,000	#10
19	New 36" – 48" storm sewer from Wyoming Avenue and Schrader Street to Colorado Avenue and Van Buren Street	\$1,562,000	#22
20	Restore 36" Culvert under UPRR at 1 st & Sanders	\$401,000	None
21	New 30" storm sewer from Franklin and Arthur to Snowy Range Road and Arthur	\$251,000	None
22	New storm sewer in Buchanan from Wyoming to Van Buren, new 48" in Van Buren from Colorado to Adams, new box culvert in Adams from Van Buren to Madison****	\$2,833,000	None
23	New Pond on W Boundary of Turner Tract	\$484,000	None
24	Install structures in Grays Gable to maximize flow to Jacoby Golf Course	\$297,000	#63 (30 th Street Storm Sewer Upgrades)

*Project has been constructed

**Project currently under construction

***Project design has been completed; awaiting funding

****Project currently under design

ES.5 Recommendations

This master plan has consolidated previous master plans for the City of Laramie, creating a prioritized list of capital improvement projects, a combined storm water system GIS map, and a combined rainfall-runoff model. Wood recommends the following next steps:

- **Use CIP Prioritization Tool to Plan Storm Water Improvements:** As funding is identified, use the CIP Prioritization Tool to determine which projects to construct first.
- **Use City-Wide Storm Water Model to Support Decisions on Private Development:** As private development is proposed, the City-Wide model should be consulted to determine whether the



proposed development would occur in accordance with the assumptions used in the master plan. The City-Wide model should be updated as projects and development occur.

- **Use City-Wide Map to Aid Design and Operation & Maintenance of Storm System:** The City-Wide map can be used for initial planning efforts for storm water improvements. City staff can also use it to note and track maintenance concerns or resident reports of flooding issues.
- **Prepare and Adopt a Stormwater Design Criteria Manual:** Preparing a drainage criteria manual, adopted and referenced by ordinance, would allow the City to implement and enforce recommended requirements for new development. The manual would provide a clear definition of the City's stormwater requirements and outline acceptable methods for meeting the requirements. This will aid developers in preparing designs and streamline the City's review of stormwater submittals.
- **Conduct a Stormwater User-fee Rate Study:** To develop a financial strategy for funding capital improvement projects, maintenance, and other stormwater program costs, it is recommended to conduct a user-fee rate study. This study should identify methods for the development of user fees and recommend implementation strategies. It should include public meetings, council briefings, the development of cost models and rate structures, the development of a credit/policy program, and the development of a billing system, billing policy, and integration with the existing billing system.

In addition to constructing the recommended capital improvements, the City should continue to impose flood management requirements on new development and re-development properties. Private flood improvements can help provide incremental relief until public improvement projects can be funded and constructed. The following requirements are recommended for new developments or significant re-development properties:

- **Over-detention:** For locations where downstream capacity is known to be deficient, peak runoff from developed properties should be managed on-site to reduce the 100-year developed peak flow rate to the 10-year historic peak discharge rate. The historic peak discharge rate is defined as the rate of discharge from the site prior to any development (vacant land). This recommended requirement may be clarified or adjusted if the City adopts a drainage criteria manual in the future.
- **Maintenance of private stormwater facilities:** To ensure continued performance of private, on-site stormwater facilities, regular maintenance (removal of sediment, debris, landscape maintenance, etc.) should be required by ordinance, with an easement that would allow the City to enter the property to conduct maintenance (at the landowner's expense) if the landowner fails to meet maintenance requirements.
- **Consideration of Downstream impacts:** As a condition of approval, private development should be required to show that downstream infrastructure (storm sewers, open channels, etc.) is present and has adequate capacity to safely convey the runoff from the 100-year event to the ultimate receiving water body (Spring Creek or Laramie River). On-site improvements should be designed to release runoff at rates that can be safely conveyed by downstream infrastructure.
- **Water Quality:** Wood recommends that the City develop stormwater quality standards that encourage or require the use of LID practices (also called green infrastructure) on new or redeveloped properties both inside and outside the Casper Aquifer Protection Area.

Routine inspection and maintenance of all stormwater facilities is necessary to assure that long-term function is maintained, on both public and private stormwater infrastructure. **It is recommended that**



the City implement a storm water maintenance program that includes inspections of culverts, detention ponds, and outfalls monthly or following rain events greater than 0.5 inches.

It is possible that the EPA could extend MS4 permit requirements to smaller cities or redefine what constitutes an urbanized area in a way such that the COL would be included. MS4 permits are administered in Wyoming by the Wyoming Department of Environmental Quality (WDEQ) on behalf of the EPA. In discussions with the WDEQ, they would also consider an MS4 permit for cities if a nearby water body was impaired or threatened with impairment. Since the Laramie River is designated as an impaired water body in the 2020 Integrated 305(b) and 303(d) Report (WDEQ, 2020) due to sediment from unknown sources, a stormwater permit or other requirements could be applied to the City's stormwater system. **Wood recommends that, where possible, any future storm water improvements be designed to limit sediment discharges.**



1.0 Introduction

1.1 Purpose and Scope

The City of Laramie (COL) has contracted Wood Environment & Infrastructure, Inc. (Wood) for the preparation of this City-Wide Master Drainage Plan. The primary objectives of this report are to:

- 1) Summarize previous master plans;
- 2) Compile the recommended projects from the previous master plans and develop a prioritized capital improvement project list;
- 3) Create a city-wide map of the existing storm water system; and
- 4) Combine previous storm water models to create a city-wide storm water system model.

The COL has conducted master drainage plans for three different areas in Laramie:

- West Laramie Drainage Master Plan (SEH, 2010),
- North Laramie Drainage Master Plan (SEH, 2013), and
- South Laramie Drainage Master Plan (Wood, formerly Amec Foster Wheeler, 2017).

Each plan evaluated existing storm sewer infrastructure and recommended improvements based on hydrologic and hydraulic modeling of storm events and future development conditions.

1.2 Acknowledgements

The following individuals participated in the development of this report:

Table 1: Project Participants and Stakeholders

Participant	Organization
Eric Jaap	City of Laramie
William Winkler	City of Laramie
Eric Milliken	City of Laramie
Shane Johnson	City of Laramie
Shawn Kraft	City of Laramie
Aaron Murray	Wood
Robert McGregor	Wood
Ross Davenport	Wood
John Hininger	Wood
Paul Klemperer	Trihydro



2.0 Previous Studies

The study areas for each of the three previous drainage master plans are shown in Figure 1. The previous master plans are summarized below in Table 3 and provided on CD in Appendix B.

Table 2: Previous Drainage Master Plans

Master Plan	Year Completed	Study Area (acres)	Total Cost of Proposed Projects (Cost in Parenthesis Adjusted to 2022 dollars)	Modeling Software Used
West Laramie	2010	903	\$10.8M* (\$18.9M)	CUHP, XP-SWMM
North Laramie	2013	2,560	\$30.2M* (\$48.3M)	CUHP, XP-SWMM
South Laramie	2017	39,000	\$48.1M* (\$68.3M)	EPA-SWMM
Total			\$89.1M (\$135.5M)	

*Capital cost from year of report

2.1 West Laramie Master Plan

The West Laramie Master Plan was completed in 2010 by Short Elliott Hendrickson Inc. The study encompassed approximately 903 acres of land west of Interstate 80 (I-80), north of Franklin Street, east of Schrader Street and south of Madison Street and drains to the Laramie River.

Hydrographs were generated for existing and proposed development conditions for the 5-, 10-, and 100-year storm events based on soil types, percent of impervious cover, and slope following the Colorado Urban Hydrograph Procedure (CUHP). The hydrographs from the CUHP model were routed through the existing stormwater infrastructure using XP-SWMM software. The XP-SWMM software modeled the quantity and depth of flow in each pipe, open channel, and detention pond, showing locations of predicted flooding.

The outputs from the XP-SWMM model were used to determine capital improvement alternatives. The alternatives were evaluated on reduction of storm water impacts from flooding, water quality benefits, reduction to potential for threat to property and human life, and project costs. The recommended alternatives were grouped based on suggested years for implementation of the improvements from 2010 through 2015. Improvements recommended beyond 2015 were grouped together into a single category referred to as Outyear Projects. In total, there were twenty planned projects with a total 2010 capital cost of \$10,803,808.

Table 3 summarizes the improvements by fiscal year. The proposed improvement phasing map from the report is included as Figure 2. The proposed improvement pipe sizing map from the report is included as Figure 3. One of the recommended projects (the first project listed in Table 3) has been completed, and recent construction has made another project partially obsolete.



Table 3: West Laramie Master Plan Recommended Projects by Fiscal Year

Fiscal Year	Project	Project Summary	2022 Capital Cost
2010	Snowy Range Road and Adams Street to Pond at Grant Street and Monroe Street*	54" pipe beginning at Snowy Range Road and Adams St. decreasing in size to a 48" pipe at Monroe St. and Buchanan St., then continues west to Grant Street Pond. Also includes a 24" outlet pipe from Grant Street Pond to the system and inlets along Monroe St.	\$2,186,000
	Harrison Street and Lincoln Street to Harrison Street and Buchanan Street	36" pipe between Lincoln and Buchanan St., 30" pipe along Lincoln St., 30" pipe along Buchanan St., inlets on Lincoln and Buchanan St.	
2011	Monroe Street and Grant Street to Dadisman Street and Eberhart Street	48" pipe going west along Monroe St. to Cleveland St., then downsizes to 36" pipe along Cleveland St. to Arthur St. Pipe continues south on Arthur St. to Dadisman St. Also includes several inlets.	\$1,434,000
	Monroe Street and Snowy Range Road to Jefferson Street and Snowy Range Road	30" pipe going north on Monroe from Snowy Range Road to West Jefferson St., and then west on West Jefferson St. Also includes several inlets.	
	Monroe Street and Cleveland Street to Kennedy Street and Cleveland Street	30" pipe north of Monroe St. on Cleveland St. to Kennedy St., and then continuing west on Kennedy St. Also includes a couple inlets.	
2012	Van Buren Street and Adams Street to Wyoming Avenue and Johnson Street**	48" pipe along Van Buren St. to Colorado Ave., then downsizes to a 36" pipe and continues south down Colorado Ave. to Wyoming Ave. Then continues west at Wyoming Ave. to Johnson St. Also includes several inlets.	\$2,332,000
	Van Buren Street and Taylor Street to Polk Street and Fillmore Street	36" pipe south of Van Buren St. along Taylor St. to Polk St., and 24" pipe going west from Taylor St. along Polk St. to Fillmore St. Also includes a couple inlets on Polk St.	
	Van Buren Street and Pierce Street to Polk Street and Pierce Street	24" pipe running along Pierce St. and a couple inlets.	
2013	Madison Street and Adams Street to Madison Street and Lincoln Street	36" pipe from McCue Wetlands along Madison St. to detention pond at Madison and Lincoln St. Also includes several inlets along Madison St.	\$1,270,000
2014	Jefferson Street and Johnson Street to Monroe Street and Colorado Avenue*	36" pipe north along Colorado Ave. to Jefferson St., continuing west along Jefferson St. to Johnson St. Also includes inlets on Jefferson St.	\$1,235,000



Fiscal Year	Project	Project Summary	2022 Capital Cost
	Harrison Street and Lincoln Street to Harrison Street and Hayes Street	36" pipe along Harrison St. to Hayes St., as well as several inlets along Harrison St., Hayes St., and Grant St.	
2015	Franklin Street and Adams Street to Franklin Street and Johnson Street	36" pipe along Franklin St. from Adams and Franklin St., transitioning into a 30" pipe going east to Johnson St. Also includes several inlets on Franklin St.	\$1,703,000
	Franklin Street and Arthur Street to Snowy Range Road and Arthur Street	30" pipe south along Arthur St. from Franklin St. to Snowy Range Road.	
Outyear	Kiwanis Park Pond	Pond located immediately north of the park, sized to detain approximately 5.1 AF.	\$8,713,000
	Wyoming Avenue and Schrader Street Pond	Detention pond at Wyoming Ave. and Schrader St. sized to detain approximately 4.2 AF.	
	Wyoming Avenue and Schrader Street to Colorado Avenue and Van Buren Street	48" pipe going west along Van Buren St. to Grant St. and then south along Grant St. to Wyoming Ave. Pipe downsizes to 42" at Wyoming Ave. and continues west to Snowy Range Road. Pipe downsizes to 36" at Snowy Range Road and continues on Wyoming Ave. to the pond and Schrader St. Also includes several inlets along Grant St. and Wyoming Ave.	
	Monroe Street and Taylor Street to Jefferson Street and Taylor Street	24" pipe connecting inlets to the 42" pipe from a 2010 improvement at Monroe St. and Taylor St.	
	Monroe Street and Pierce Street to Wyoming Avenue and Pierce Street	30" pipe on Pierce St. from Monroe St. to Jefferson St. then downsizes to 18" from Jefferson St. to Wyoming St., connecting an inlet at Wyoming Ave. Also includes a few inlets on Pierce St.	
	Van Buren Street and Lincoln Street to Polk Street and Lincoln Street	24" pipe along Polk St. from Van Buren St. to Polk St., connecting to 2012 improvements at Van Buren intersection and inlets along Lincoln St.	
	Jackson Street to Schrader Street Pond to Schrader Street Interception Channel	Interception channel along west side of Schrader St. from Jefferson St. to Jackson St. Outfalls to detention pond sized to detain approximately 5.1 AF. Pond outfalls into 18" storm sewer system on Jackson St.	
Total			\$18,874,000

*Project has been constructed

**Part of this project (from Wyoming & Johnson to Colorado & Polk) is no longer needed due to recent construction near Linford Elementary School.



2.2 North Laramie Master Plan

The North Laramie Master Plan was completed in 2013 by Short Elliott Hendrickson, Inc. The study encompassed approximately four square miles (2,560 acres) generally west of 45th Street, north of Jacoby Golf Course and the University of Wyoming campus, north of Ivinson Street, and east of the Union Pacific Railroad.

The North Laramie Master Plan evaluated rainfall data from the University of Wyoming Water Resources Data System (WRDS), which had an insufficient amount of data to determine the 100-year storm event rainfall depth. Since the 1973 NOAA Atlas Volume II values were comparable to the WRDS data, they were used for the hydrologic model. Survey data for the existing storm water system was collected, and a geotechnical investigation was performed to confirm soil infiltration properties. The study area was modeled using CUHP and XP-SWMM models. The CUHP model provided runoff hydrographs that could be used in XP-SWMM for routing and flood analysis. The North Laramie Master Plan included analysis of the 2-, 5-, 10-, and 100-year storm events under existing and proposed development conditions.

Present flooding areas were identified by resident input during public meetings and through XP-SWMM modeling. The report identified three major areas with flooding potential: the Curtis Street system (along 9th Street and Curtis Street) from increased discharge due to developments, Reynolds Street due to lack of upstream capacity during major storm events, and outfall lines to the Laramie River due to downstream backwater effects. Alternative improvements were proposed and evaluated based on reduction of storm water impacts from flooding, water quality benefits, reduction of the potential impact to human life and property, and overall project cost.

The North Laramie Master Plan separated planned projects into nine reaches, with a total approximate 2013 capital cost of \$30.2M (after performing the capital cost adjustments described in Section 5.2 of this report) for the recommended plan. Costs for individual projects or reaches were not included in the North Laramie Master Plan report, so the costs for each project and reach were estimated based on the unit cost information provided in the report. Table 4 below summarizes the projects by reach. A map showing the recommended plan is included as Figure 4. None of the recommended projects have been completed to date.



Table 4: North Laramie Master Plan Recommended Projects by Reach

Reach	Project Summary	2022 Capital Cost by Reach
1	<ul style="list-style-type: none"> Formalize detention area for 21.9 AF pond in subbasin CU01 (north of 30th and Northview Street). Construct new 7.8 AF pond in subbasin CM01 (northeast of where 9th Street becomes Roger Canyon Road). Enlarge existing detention pond in subbasin CM02 (by Berkley and Beaufort Street) by 1.7 AF. 	\$4,819,000
2	<ul style="list-style-type: none"> Construct new 4.7 AF pond in subbasin CL01 (near where 9th Street becomes Roger Canyon Road). Construct new 7.4 AF pond in subbasin CM02 (near where 9th Street becomes Roger Canyon Road). Upsize existing 18" pipe along Beaufort Street to 54" RCP along Beaufort St. from 8th St. to 9th St., and along 9th St. from Beaufort to Downey St. Remove existing storm sewer and install new 6'x8' RCBC along Downey St. from 9th to 7th St., then south on 7th to Mitchell St., and west on Mitchell St. to the existing outfall channel. 	\$12,511,000
3	<ul style="list-style-type: none"> Enlarge existing pond a southeast corner of 30th St. and Reynolds St. by 1.7 AF and optimize its outlet. Remove existing storm sewer pipe and install new 60" RCP on 30th St. from Grays Gable to Reynolds St. Optimize pond outlet structure in subbasin RM01 (by Reynolds and Bath Avenue). 	\$1,383,000
4	<ul style="list-style-type: none"> Construct new 4.4 AF pond in subbasin RM10 (east of 22nd and Cumulus Drive). Optimize existing pond outlet structure northwest of Nighthawk and 22nd St. Optimize existing pond outlet structure northwest of 22nd and Reynolds St. 	\$865,000
5	<ul style="list-style-type: none"> Optimize outlet structure of existing pond at the southeast corner of 22nd St. and Binford St. Construct new 10 AF pond southwest of 30th St. and Reynolds St. 	\$1,613,000
6	<ul style="list-style-type: none"> Enlarge existing pond on the south side of Reynolds St. by 1.6 AF and optimize the outlet. Remove existing storm sewer pipe along Reynolds St. and install new 60" RCP from Coughlin St. west to 9th St. and then south to Hancock St. Install split to direct flow to existing pipe in Hancock St. and new 5'x8' RCBC storm sewer to LaBonte Park. 	\$2,253,000



Reach	Project Summary	2022 Capital Cost by Reach
7	<ul style="list-style-type: none"> Enlarge existing pond at the northeast corner of 15th and Harney St. to hold additional 1.1 AF and optimize its outlet. Remove existing storm sewer pipe and install new 60" RCP along 11th St. from Gibbon to Canby St. Remove existing storm sewer pipe and install new 60" RCP along Canby St. from 11th St. to 9th St. Remove existing storm sewer pipe and install new 60" RCP along 9th St. from Gibbon to Canby St. Install new 5'x8' RCB along Canby St. from 9th to 8th St. and a 5'x10' RCBC from Canby and 8th St. to LaBonte Park Pond. Remove existing storm sewer pipe and install new 42" RCP along 8th St. from Harney to Canby St. Regrade LaBonte Park pond and 9th St. to increase detention volume by 36.4 AF. Upgrade existing 36"x60" elliptical RCP inlet at 9th and Shields St. to 5'x10' RCBC. Install new 36" RCP outlet to 7th and Shields St. 	\$8,559,000
8	<ul style="list-style-type: none"> Upsize existing 24" RCP with 36" RCP on Shields St. from 7th St. to 4th St., then north to Hancock St., and then increase size to 4'x8' RCBC. Continue the 4'x8' RCBC west on Hancock St. to 2nd St., then north to McConnel St., and then west to the UPRR ROW, where it is upgraded to a 4'x10' RCBC. 	\$7,545,000
9	<ul style="list-style-type: none"> Remove existing storm sewer pipe and install new 60" RCP along 6th St. from Lewis to Canby St. Remove existing storm sewer pipe and install new 42" RCP along 3rd St. from Lewis to Harney St. Remove existing storm sewer pipe and install new 4'x10' RCBC along Canby St. from 6th to 3rd St., then south on 3rd St. to Harney St., and then west on Harney St. under UPR ROW, above existing sanitary sewer line, and outfalls into the Laramie River. 	\$8,683,000
Total		\$48,229,000

2.3 South Laramie Master Plan

The South Laramie Master Plan was completed in 2017 by Wood (formerly Amec Foster Wheeler). The study area includes approximately 61 square miles (39,000 acres) bounded by the North Laramie Master Plan to the north, Pole Mountain ridge to the east, and Wyoming Highway 230 to the west. The study area included the entire Spring Creek basin and several basins that discharge directly to the Laramie River.

The South Laramie Master Plan reviewed previous storm water reports within the study area, field reconnaissance to gather current storm water system information, government resources for environmental data (such as NOAA Atlas for rainfall data and USDA for soil data), and historical flood information. EPA-SWMM was used to model rainfall and runoff for the 2-, 5-, 10-, and 100-year storm events under existing and proposed development conditions. (A proprietary user interface, PC-SWMM was utilized, which runs the open source EPA-SWMM model.) HEC-HMS was used to create a model for an independent check on the EPA-SWMM results.



Alternative projects were modeled to address current and future flooding hazards and were weighted based on effectiveness of reducing flood risk, water quality benefits, impact to human life and property, and overall project cost. The Turner Tract development was analyzed and modeled in greater detail to develop a recommended master plan specifically for the Turner Tract. The recommended Turner Tract plan was incorporated into the South Laramie Master Plan recommendations.

The South Laramie Master Plan grouped planned projects by major basin, with a total anticipated 2018 capital cost of \$79.0M. Table 5 summarizes the planned projects. Recommended improvements maps for the South Laramie Master Plan are included as Figures 5 through 7.

Table 5: South Laramie Master Plan Recommended Projects by Major Basin

Major Basin	Project	Project Description	2022 Capital Cost
Laramie River North	60" Pipe Bore under UPRR ROW at Steele Street	Install additional 60" storm sewer under UPRR ROW beginning at Steele St.	\$2,881,000
	Steele Street System Storm Sewer Upgrades	Upsize existing storm sewer to 36" from Iverson and 5 th to 3 rd and Grand. Upsize existing storm sewer to 42" from 3 rd and Grand to 3 rd and Kearney. Upsize existing storm sewer to 48" from 3 rd and Kearney to 2 nd and Kearney.	\$1,971,000
	Re-purpose 18" Sanitary Sewer	Re-purpose 18" sanitary sewer for use as storm sewer from the intersection of 1 st and Sanders to dead-end of Pine St.	\$132,000
	Clean and Restore 36" Culvert Under UPRR ROW	Clean and restore functionality of 36" culvert at 1 st and Sanders and construct open channel to Laramie River	\$389,000
Spring Creek North	Pond East of Jacoby Golf Course	Construct a new, 247 AF detention pond east of Jacoby Golf Course	\$11,266,000
	Regency Pond*	Construct new 20 AF detention pond upstream of the Regency Dr.	\$5,359,000
	Modify Outlet and Enlarge Pond at Boulder Drive and Beech Street*	Restrict Beech Pond outlet to a circular 24" opening and expand pond from 0.6 AF to 8 AF.	
	Construct Detention Ponds to Support Future Development	Construct a 2.8 AF pond serving subbasin SM022, a 10.2 AF pond serving subbasin SM023, a 2.0 AF pond serving subbasin SM024, and a 3.1 AF pond serving subbasin SM042.	
	Grey's Gable Storm Sewer Upgrades	Capture and route stormwater runoff from Grey's Gable Road to Jacoby Gold Course	\$288,000
	30 th Street Storm Sewer Upgrades	Extend 24" storm sewer on 30 th St. to Jacoby Gold Course Pond outlet.	\$1,054,000
	22 nd Street Storm Sewer Upgrades	Upgrade storm sewer from 36" circular pipe to 6'x4' box culvert on 22 nd St. from Rainbow St. to Spring Creek Channel.	\$2,874,000



Major Basin	Project	Project Description	2022 Capital Cost
	21 st Street Storm Sewer Upgrades	Upgrade storm sewer from existing pipe to 36" circular pipe on 21 st St. from Rainbow Street to Spring Creek Channel.	\$931,000
	13 th Street Storm Sewer Upgrades	On 13 th St., upgrade storm sewer from 15" to 30" from Garfield to Sheridan, from 36" to 4'x3.5' box culvert from Sheridan to Ord, and from 42" to 6'x4' box culvert from Ord St. to Spring Creek Channel.	\$4,008,000
	4'x6' Box Culvert from Boswell Drive to Spring Creek Channel	Install a new 6'x4' box culvert on Boswell Dr. from the east side of the North 1-80 interchange along Boswell Drive to Spring Creek on the east side of Highway 287.	\$1,801,000
Spring Creek South	Pond Serving Northeast Portion of Spring Creek South Basin (450 AF)	Construct a new, 450 AF detention pond south of I-80, upstream of Basin SS015.	\$20,573,000
	Pond Serving Southern Portion of Spring Creek South Basin (175 AF)	Construct a new, 175 AF detention pond south of Hidden Springs Rd., upstream of Basin SS005.	\$9,327,000
	Twin 36" Pipe Bore Under Highway 287	Bore twin, 36" pipe under Highway 287 south of the I-80 and Highway 287 interchange.	\$2,259,000
	Grade New Channel Through Field Southwest of I-80 and Hwy 28	Grade new channel through field located to the southwest of the intersection of I-80 and Highway 287	\$600,000
	Twin 36" Pipe Under I-80 Overpass	Install two 36" pipes under I-80 overpass.	\$510,000
	Re-purpose 12" Sanitary Sewer	Re-purpose 12" sanitary sewer for use as storm sewer from Skyline Road at Highway 287 to Spring Creek at S. 3 rd Street.	\$109,000
Total			\$66,335,000

*Project has been constructed.



3.0 Combine Storm Water System Mapping

A key project goal was to create a city-wide map of the City's storm water infrastructure, building on existing mapping data and collecting information to fill data gaps. Working with the City, it was agreed that Geographic Information System (GIS) format would be a preferable format for storm water mapping over Computer-Aided Drafting (CAD), primarily due to the ability to collect and store large amounts of information about each piece of infrastructure within GIS. In addition, GIS linework can be exported to CAD, if needed.

The mapping effort from the South Laramie Drainage Master Plan was used as a model for the city-wide mapping. The South Laramie Drainage Master Plan included collecting survey-grade location and elevation data for storm sewer manholes and inlets and used hand-held electronic devices to capture attributes for the storm sewer system (condition, size, material, etc.).

3.1 Existing Mapping Data and Data Gaps

Available storm water system mapping was evaluated to determine data gaps. Existing data included:

- GIS mapping from the City with approximate locations of most storm manholes and inlets,
- surveyed locations, elevations, and GIS attribute data for storm water infrastructure in the South Laramie Study Area,
- surveyed locations and elevations for storm water infrastructure in a portion of the North Laramie Study Area,

Survey-grade location and elevation data for the West Laramie Study Area was not available.

3.1.1 Data Gaps

There were six portions of the storm water system that lacked survey-grade data. These areas can be described as follows and are shown in Figure 8:

- 1) the recently constructed storm sewer system in Indian Hills Road,
- 2) 30th Street from Knadler Street north to Cumulus Drive,
- 3) Reynolds Street from 17th Street to 30th Street,
- 4) Grand Avenue and Garfield Street from Regency Drive to Boulder Drive and along Regency Drive,
- 5) 9th Street from Sanders Drive to Symons Street, and Symons Street from 9th to 13th Street, and
- 6) Most of West Laramie, including Snowy Range Road and McCue Street.

In general, all of Laramie except for the study area in the South Laramie Master Plan lacked GIS attribute data.

3.2 Survey Data Collection

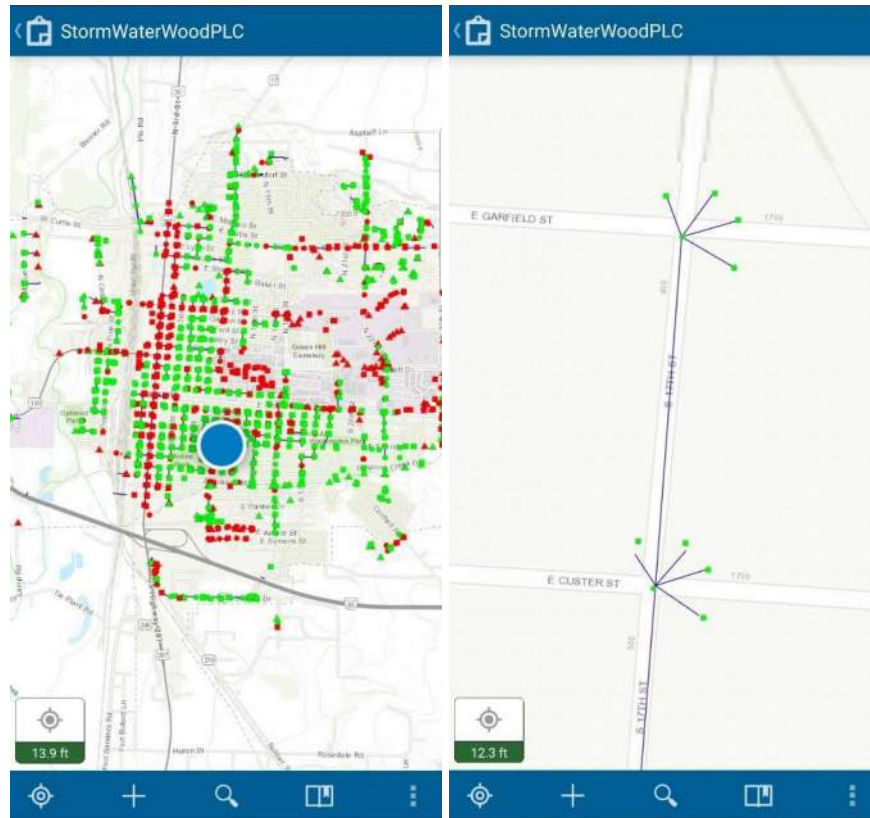
Wood subcontracted Trihydro Corporation (Trihydro) to assist in collection of survey-grade information in the six data gap areas listed above. Elevation and location data were collected for storm sewer manholes, inlets, and outfalls. The survey points were taken at the center of the manhole lid for manholes, over the grate for inlets, and at the top of the pipe for outfalls. This data was entered into the storm sewer GIS system by Wood.



3.3 GIS Data Collection

GIS data was collected in the field using the ESRI Collector application on a mobile phone. Two screenshots of the ESRI Collector application are included below. The Collector application allowed GIS data to be uploaded immediately to the City’s GIS database through cellular data connections.

ESRI Collector App Screenshots



Data was obtained for storm water manholes, pipes, inlets, and outfalls. For manholes, data collectors opened manholes after placing traffic cones nearby. Survey rods and tape measures were used to obtain depth to invert and pipe diameter measurements. Comments noting the condition or features of the relevant piece of storm water infrastructure were recorded. Tables 6 through 9 show the GIS data attributes for each type of infrastructure.

Table 6: Storm Water Manhole Data Collection Attributes

Field Name	Collection Method	Description of Proposed Fields
ID	GIS Field Data	Identification based on new naming convention
Northing	Survey	Northing (surveyed at center of manhole)
Easting	Survey	Easting (surveyed at center of manhole)
Rim_Elev	Survey	Elevation of manhole rim
Vert_Prec	Survey	Vertical precision of elevation data
Horz_Prec	Survey	Horizontal precision of location data
Outflow_Dir	GIS Field Data	Orientation of outflow pipe in manhole (N,S,E,W)
INV_1_Dir	GIS Field Data	Orientation of pipe in manhole (N,S,E,W)
INV_2_Dir	GIS Field Data	Orientation of pipe in manhole (N,S,E,W)
INV_3_Dir	GIS Field Data	Orientation of pipe in manhole (N,S,E,W)



Field Name	Collection Method	Description of Proposed Fields
INV_4_Dir	GIS Field Data	Orientation of pipe in manhole (N,S,E,W)
Rim_to_Inv	GIS Field Data	Distance from rim to manhole invert
INV_Elev	Calculated based on Rim_to_Inv	Invert elevation of manhole center
Install_Date	To be completed by City	
Install_PRJ	To be completed by City	
Maintenance	To be completed by City	
Owner	To be completed by City	Owner of pipe (COL, private, University, etc.)
Steps	GIS Field Data	Presence of manhole steps (Y or N)
Diameter	GIS Field Data	Diameter of manhole, feet
Material	GIS Field Data	Material of manhole (precast, brick, etc.)
Condition	GIS Field Data	Comments on condition of manhole
Comments	Update as Needed	General comments

Table 7: Storm Water Pipe Data Collection Attributes

Field Name	Collection Method	Description of Proposed Fields
PIPE_ID	GIS Field Data	Identification based on new naming convention
PIPE_DIA	GIS Field Data	Diameter of pipe, inches
DESCRIPTION	GIS Field Data	Type of conveyance (main, lateral, open ditch, etc.)
Length	GIS Field Data	Length of pipe
Start_MH	GIS Field Data	Name of upstream manhole
End_MH	GIS Field Data	Name of downstream manhole
Start_Inv	GIS Field Data	Invert elevation of upstream manhole
End_Inv	GIS Field Data	Invert elevation of downstream manhole
Material	GIS Field Data - where visible	Material of pipe (RCP, CMP, HDPE, other)
Owner	To be completed by City	Owner of pipe (COL, private, University, etc.)
Slope	Calculate based on manhole rim elevations	Slope of pipe
Install_Date	To be completed by City	
Install_PRJ	To be completed by City	
Maintenance	To be completed by City	
Condition	GIS Field Data	Comments on condition of pipe
Comments	Update as Needed	General comments

Table 8: Storm Water Inlet Data Collection Attributes

Field Name	Collection Method	Description of Proposed Fields
Comment	Update as Needed	
Vert_Prec	Survey	
Horz_Prec	Survey	
Northing	Survey	
Easting	Survey	
IMAGELINK	Update as Needed	
GlobalID	Maintain Existing Data	



Field Name	Collection Method	Description of Proposed Fields
OBJECTID	Maintain Existing Data	
ID	GIS Field Data	Identification based on new naming convention
Rim_Elev	Survey	Elevation of inlet grate
Rim_to_Inv	GIS Field Data	Distance from grate to bottom of inlet (ft)
Inv_Elev	GIS Field Data	Elevation of bottom of inlet
Type	GIS Field Data	Type of inlet (curb, drop, combination, etc.)
Length	GIS Field Data	Length of inlet opening (measured in feet, parallel to flow direction)
Width	GIS Field Data	Width of inlet opening (measured in feet, perpendicular to flow direction)
Diameter	GIS Field Data	Diameter of inlet opening (feet, if circular)
Owner	To be completed by City	Owner of pipe (COL, private, University, etc.)
Flow_Cond	GIS Field Data	Flow condition (sump or on-grade)
Condition	GIS Field Data	Notes regarding condition of inlet

Table 9: Storm Water Outfall Data Collection Parameters

Field Name	Collection Method	Description of Field
Location Comment	GIS Field Data	Text field, generally refers to location
Inv_Elev	Survey	Elevation of Invert of Pipe
Vert_Prec	Survey	Precision of Survey Location
Horz_Prec	Survey	Precision of Survey Location
Northing	Survey	Northing Location of Point
Easting	Survey	Easting Location of Point
IMAGELINK	Maintain Existing Data	Link to Image on City Server
GlobalID	Maintain Existing Data	Text field, unknown purpose
OBJECTID	Maintain Existing Data	Number field, unknown purpose
COMMENT	Update as Needed	Comments Field
IMAGE	Maintain Existing Data	Has a photo been taken (Y or N)
OUTFALL_ID	GIS Field Data	Identification Based on new naming convention
PIPE_SHAPE	GIS Field Data	Shape of outfall pipe (circular, elliptical, box, other)
PIPE_DIA	GIS Field Data	Diameter of outfall pipe, inches
Material	GIS Field Data	Material of pipe (RCP, CMP, HDPE, other)
Condition	GIS Field Data	Comments on condition of outfall, headwall
Flap Gate	GIS Field Data	Presence of flap gate (Y or N)
Receiving Water	GIS Field Data	Name of water body that outfall discharges to (Spring Creek, Laramie River, other)
Last Inspection Date	To be completed by City	Date of last inspection
Illicit Discharge	GIS Field Data -and Future Use by City	Presence of indicator of potential non-stormwater discharge, i.e. oil, color, turbidity, oil sheet, floatables (Y or N)

3.4 Final Data Processing

After collecting the data using the ESRI Collector Application and importing the data gap survey data into the GIS mapping, the map was reviewed in GIS. The locations of the points were compared with their actual locations, and pipes that were not completely attached to other infrastructure were adjusted. The



map was also examined for comments made during data collection that indicated if a point needed to be deleted or if a point was in the wrong location. A screenshot of an intersection near Linford Elementary School from the updated GIS mapping is included below along with the properties of the manhole in the center of the intersection. The final database is included on CD in Appendix D.

GIS Map and Properties Example

Location: 529,905.303 296,619.407 Feet

Field	Value
FID	588
Elev	7167.18
RIM_ELEV	7167.18
OUTFLOWDIR	WEST
INV_1_DIR	SOUTH
INV_2_DIR	
INV_3_DIR	
INV_4_DIR	
RIMTOINV	4.4
INV_ELEV	7162.78



4.0 Create City-Wide Storm Water System Model

The three previous master plans used a variety of computer models to simulate rainfall and route runoff through existing and proposed storm water infrastructure. A goal for this project was to use the previous models to create a city-wide model of the storm water system that will allow the City to run and update the model in a single platform. This section describes the previous models, the methodology used to combine the models into a single model, and the city-wide model characteristics. The city-wide model was created in EPA-SWMM format, an open-source program, so that the City can update the model in the future without requiring a paid software subscription and without compatibility issues.

4.1 Previous Models

A summary of the models used in previous master plans is provided in Table 10 below. As shown in the table, the model created for the South Laramie Master Plan was the largest, most detailed model, so it was most efficient to bring the other two models into the South Laramie model. Also, since the South Laramie model was assembled using the EPA-SWMM engine, it was already in the desired format. The general procedure used for converting the previous models was:

- 1) Run previous model in native program and verify that output matches published output in master plan report;
- 2) Convert model to EPA-SWMM format and run stand-alone model;
- 3) Compare stand-alone EPA-SWMM output to native model output and verify close agreement;
- 4) Revise model element names, if needed, to avoid duplication with City-Wide model elements; and
- 5) Add stand-alone EPA-SWMM model to South Laramie Master Plan EPA-SWMM model.

Table 10: Summary of Models used in Previous Master Plans

Master Plan	Model	Number of Sub-basins	Approx. Number of Model Nodes/Junctions
West Laramie	Colorado Urban Hydrograph Procedure (CUHP) - hydrology XP-SWMM – hydraulic routing	52	52
North Laramie	Colorado Urban Hydrograph Procedure (CUHP) - hydrology XP-SWMM – hydraulic routing	44	60
South Laramie	PCSWMM – hydrology and hydraulic routing (exported to EPA-SWMM for submittal)	95	203

4.1.1 South Laramie Master Plan Model

The South Laramie Master Plan used PCWMM to model rainfall and runoff. Hydrographs were developed for each sub-basin based on the following characteristics: drainage area, width, length of longest flow path, slope, impervious area, depression storage, and soil infiltration rates. Impervious values for future development conditions were calculated by assuming the undeveloped portion of existing sub-basins would be developed according to current zoning. The hydrographs were routed in PCSWMM through



conveyance elements including detention, open channels, storm sewers, and overland flow. Properties of the existing stormwater infrastructure were determined through data provided by the city and field investigations. The model was calibrated by comparing results to an independent model created in HEC-HMS (a rainfall-runoff model created by the U.S. Army Corps of Engineers). The final PCSWMM model was converted to EPA-SWMM for use by the City.

4.1.2 West Laramie Master Plan Model

The West Laramie Master Plan used the Colorado Urban Hydrograph Procedure (CUHP) to generate hydrographs (runoff flowrate vs. time) for each sub-basin. CUHP is a free program developed by the Urban Drainage and Flood Control District (UDFCD) to generate hydrographs from watersheds based on rainfall characteristics in Denver, Colorado. The runoff hydrograph from each sub-basin was then routed through the proposed stormwater infrastructure using XP-SWMM software. Electronic CUHP files and XP-SWMM files were provided by the City, along with a license key for the XP-SWMM software.

The CUHP files were found to be incompatible with currently available CUHP software, so runoff hydrographs were generated for each sub-basin using EPA-SWMM, based on the sub-basin characteristics (drainage area, length of sub-basin, percent imperviousness, soil type, slope) and rainfall parameters provided in the North Laramie Master Plan report. Though using different methodology, the peak flowrates generated by EPA-SWMM were generally comparable with the published peak flowrates generated by CUHP.

The XP-SWMM files provided for the West Laramie Master Plan model did not include the complete model; the northern half of the model was missing. Due to this and the incompatibility of the CUHP files, the model could not be run in XP-SWMM to verify that it matches the output published in the master plan. The southern half of the model was imported into EPA-SWMM and the routing elements were connected to the sub-basins created in EPA-SWMM. The northern half of the model was re-created in EPA-SWMM based on the dimensions provided in the master plan.

4.1.3 North Laramie Master Plan Model

Background information for the North Laramie Master Plan was taken from topographic maps from the COL, Zoning and Proposed Land Use maps from the COL, NRCS soils maps for Albany County, Flood Insurance Studies and Flood Insurance Rate Maps, rainfall data from three weather stations near the study area maintained by the University of Wyoming Water Resources Data System, and various drainage reports and development plans within the study area. Rainfall data was compared to NOAA Atlas 2, Volume II, Wyoming and the more conservative rainfall depths were used in calculations. In addition to these sources, existing storm sewer infrastructure was surveyed by Coffey Engineering and Surveying, and a geotechnical investigation of the study area was performed by Terracon.

The model included procedures developed by CUHP and analysis using XP-SWMM software. The model was calibrated by comparing hydrographs from the XP-SWMM model to CUHP hydrographs for the 100-year storm event.

4.1.4 Data Gap Area Model

As seen on Figure 1, there is an area between the study limits of the West Laramie Master Plan and North Laramie Master Plan that includes a portion of the City that has not previously been studied or modeled. The Laramie River runs through this area, and significant development has occurred. Additionally, outfalls from both the West Laramie Master Plan and North Laramie Master Plan discharge into this area but are not routed all the way to the Laramie River. Wood created a new model for this data gap area, using PCSWMM, to determine if any capital improvement projects are needed to address flooding issues. The



methodology used in the South Laramie Master Plan was followed for the Data Gap Areas Model and is described below.

Data Gap Area Model Hydrologic Analysis

Thirty sub-basins were delineated based on the City LIDAR topography. Sub-basins for the Data Gap Area Model are shown in Figure 9. The following characteristics were determined for each sub-basin: drainage area, width, flow length, slope, imperviousness, depression storage, and soil infiltration rates. Table C1 in Appendix C lists the sub-basins for the data gap area model and the sub-basin characteristics. Sub-basin lengths were determined by measuring the longest flow path of each sub-basin from the most upstream point to the outlet, using available topography data. The sub-basin width was calculated by taking the sub-basin area divided by the basin length. Slope (%) was established from available topographic data by running the slope tool in ArcGIS 10.2 to establish an average slope for the sub-basin. Impervious values for future development conditions were calculated by assuming the undeveloped portion of existing sub-basins will be developed according to current zoning and then using a typical imperviousness for that zoning category. Table C2 in Appendix C was developed by correlating the UDFCD recommended values to the COL zoning code. An area-weighted average was applied to sub-basins containing more than one city zoning code.

Soil information was downloaded from the USDA website. Based on this information, each soil type was categorized by its designated NRCS hydrologic soil group. Infiltration rates were based on Horton's equation, as recommended by the UDFCD. Horton's equation utilizes an initial infiltration rate, a final (saturated conditions) infiltration rate, and a decay rate to determine the infiltration rate as soils progress from dry to saturated conditions during a storm event. Table C3 in Appendix C shows the recommended Horton's infiltration parameters for each hydrologic soil group (USDCM, 2001). Infiltration parameters for each sub-basin were determined by calculating an area-weighted average of the soil groups present in each sub-basin.

Data Gap Area Model Hydraulic Analysis

PCSWMM was used to route the hydrographs developed for each sub-basin through surface water features such as detention storage, channels, storm sewer infrastructure, and overland flow. Figure 10 shows the PCSWMM routing schematics, illustrating the relative location and connectivity of the PCSWMM network. The routing elements are categorized as conveyance elements (pipes or open channels), storage elements (detention ponds or informal storage areas), design nodes (points where multiple conveyances converge), and outfalls (the end of a model network, typically the discharge point to the Laramie River). Conveyance elements were also added to route the discharges from the West Laramie Master Plan and North Laramie Master Plan to the Laramie River.

Hydraulic analysis was performed using PCSWMM. Pipe sizes and materials were determined using data provided by the City and field investigations. Channel roughness (Manning's n) was selected based on field observations, selecting typical values based on *Open Channel Hydraulics* (Chow, 1959). Table C4 shows the characteristics of each conveyance element in the Data Gap Area Model.

No significant existing detention ponds were identified for inclusion in the Data Gap Area Model. However, the discharge from the McCue Wetlands Pond (West Laramie Master Plan) was routed to the Laramie River as part of the Data Gap Area Model.



Data Gap Area Model Recommendations

The Data Gap Area Model identified two flooding issues. Recommended improvements were developed and cost estimates were prepared. The recommended improvements were included in the Capital Improvement Project List discussed in Section 5 of this report.

- 1) Cedar Street @ Lyon Street: Runoff from existing industrial development in this area will collect on Lyon Street and flow west, collecting at the intersection of Lyon Street and Cedar Street. The existing storm sewer system in Lyon Street does not have adequate capacity to prevent street flooding in this area during minor and major storm events.

Recommended Improvements: Install 24-inch storm sewer in Pine Street to Lyon Street (590 feet) and a 3-foot by 5-foot box culvert in Lyon Street from Pine Street across Cedar Street (750 feet), discharging to vacant land west of Cedar Street. Establish a 5-foot wide by 4-foot deep trapezoidal channel for approximately 2,200 feet to convey flows to the Laramie River.

- 2) McCue Street north of Snowy Range Road: McCue Street is currently adequately served by a 24-inch diameter storm sewer. However, if development occurs between I-80 and McCue Street, this storm sewer will be under-sized for future runoff flows during minor and major storm events.

Recommended Improvements: Upgrade 24-inch storm sewer to a 3-foot by 5-foot box culvert in McCue Street north of Snowy Range Road to the McCue Wetlands (approximately 2,380 feet).

4.2 Combined City-Wide Model

The City-Wide Model was created by combining the previous models and adding the Data Gap Area Model as described above. Since the West Laramie Master Plan developed only a future development, proposed infrastructure model, the City-Wide Model was developed as a future development, proposed infrastructure model. Since master planning typically uses future development conditions, this approach makes sense. All recommended improvement projects from previous master plans (and the Data Gap Area) are included in the City-Wide Model.

4.2.1 Model Overlap Areas

The City-Wide Model was then modified to account for areas where previous models overlapped:

- **West/South Laramie Master Plan study boundary** – Due to improved topography available when the South Laramie Master Plan was created, the study boundary does not match the West Laramie Study boundary. A few sub-basin boundaries from the West Laramie study were adjusted to eliminate the overlapping areas.
- **Grays Gable Road at Jacoby Golf Course** – The North Laramie and South Laramie master plans intersect at Grays Gable Road, near Jacoby Golf Course. Runoff that is captured by inlets and storm sewer pipe in Grays Gable Road enters the South Laramie model, while runoff that bypasses the inlets stays in the North Laramie model. This interaction was captured in the City-Wide Model by sending flows in the storm sewer to the Jacoby Golf Course system and flows in excess of the storm sewer capacity was routed down Grays Gable Road in a street conduit.

4.2.2 Model Element Naming Convention

To maintain consistency and allow users to refer to mapping and results in previous master plans, the naming conventions for model elements (conduits, pipes, junctions, detention ponds, outfalls) were maintained to the extent possible. In some cases, letters were added to the front of each name to



prevent duplication with another master plan element. A summary of the naming conventions used is provided in Table 11 below.

Table 11: Naming Convention for City-Wide Model

Model	Naming Convention used in City-Wide Model
West Laramie	Added "WL" to naming convention from West Laramie Master Plan (ex: "P44" became "WLP44")
North Laramie	Matched North Laramie Master Plan
South Laramie	Matched South Laramie Master Plan
Data Gap Area (newly created model)	All element names starts with letter "C" Sub-Basins: start with "C" (ex. C063) Pipes: start with "CP" (ex. CP31) Streets: start with "CP", end with "S" (ex. CP31-S) Junctions: start with "CJ" (ex. CJ26) Outfalls: start with "CO" (ex. CO10)

4.2.3 Quality Control and Model Calibration

The West Laramie Master Plan did not describe any model calibration methods. Since currently available CUHP software does not have compatibility with the CUHP files from the West Laramie Master Plan, runoff hydrographs were created in EPA-SWMM based on sub-basin characteristics defined in the North Laramie Master Plan report. The peak flowrate results of the EPA-SWMM model were found, in general, to be comparable to the peak flowrates from the CUHP model that were published in the West Laramie Master Plan.

In the North Laramie Master Plan, the hydrographs developed with XPSWMM were calibrated to CUHP hydrographs through an iterative process. A multiplication factor for the XPSWMM model was determined, which was applied to the catchment width.

For the South Laramie Master Plan, the PCSWMM model was compared to the Flood Insurance Study (FIS) for Albany County, Wyoming and Incorporated Areas, which was effective starting June 16, 2011. The flow rates in the PCSWMM model were much higher than the flows from the 2011 FIS, which was attributed to the studies using different methodologies. The FIS model used a USGS regression equation based only on drainage area to determine peak flows. The PCSWMM model used site-specific sub-basin characteristics to develop a more detailed rainfall-runoff model. To verify the results of the PCSWMM model, an independent rainfall-runoff model was created using HEC-HMS, which is developed by the US Army Corps of Engineers. The independent model closely matched the PCSWMM results, with only a 3% difference between models.

4.2.4 Model Results

A summary of the peak flow rates at key locations during a 100-year storm event, for future development conditions with recommended improvements, is included as Table 12.



Table 12: South Laramie Master Plan Summary of Peak Flows during 100-Year Event

Location	Model Element	100-Year Peak Flow, Future Development, Proposed Infrastructure Conditions (cfs)
Spring Creek at Grand Avenue	SN180	755
Spring Creek at 16 th Street	SC145	1,519
Spring Creek at 7 th Street	SN110	2,304
Spring Creek at 3 rd Street	SN105	2,203
Spring Creek at Confluence	LN425	2,546
3 rd Street at Kearney Street (surface)	LN235-S	11
3 rd Street at Kearney Street (storm sewer)	LN235	140
Steele Street and 1 st Street (surface)	LN305-S	185
Steele Street Discharge to Laramie River	LN420	493
Skyline Drive and 15 th Street	SS310	6
Skyline Drive and Soldier Springs Road	SS105-S	233
Skyline Drive and Highway 287	SS305	287
Reynolds Street and 22 nd Street	P2130	74
Reynolds Street and 15 th Street	P2110	310
Reynolds Street and 9 th Street	P2105	293
Hancock Street and 4 th Street	P2020	399
Canby Street Outfall to LaBonte Park	L2808	640
Shields & 9 th Street Outfall to LaBonte Park	L2201	535
Discharge from LaBonte Park Pond	LL10	218
3 rd Street and Curtis Street	P1005	141
Harney Street Outfall to Laramie River	CO06	368
Outfall to Laramie River North of Curtis	NLO1	1,150
Snowy Range Road and Adams Street	WLB36	287
Outfall to McCue Wetlands (Madison Street)	CJ05	175

4.2.5 Use of City-Wide Model

The City-Wide Storm Water Model is included in Appendix D of this report, on CD, in EPA-SWMM format. The City can use this model to evaluate new improvements and changes to proposed improvements and incorporate as-built dimensions of storm water improvements as they are constructed. The model could also be used to evaluate impacts of changes to future development patterns.



5.0 Capital Improvement Project List

5.1 Compilation of Projects

Each previous master plan developed a list of recommended projects. The West Laramie Master Plan grouped recommended projects by fiscal year, while the North Laramie and South Laramie master plans grouped recommended projects by reach or drainage basin. Large project groups were separated into smaller projects more likely to be funded within a single fiscal year and constructed within a single construction season.

Projects from all three previous master plans were compiled into a single spreadsheet. Projects that have already been constructed were removed from the project list. For example, the West Laramie Master Plan identified storm sewer improvements on and near Monroe Street that have been completed. In addition, recent storm water improvements constructed near Linford Elementary School made some of the recommended improvements obsolete.

The following sections describe the process for compiling the recommended projects from each previous master plan and how the projects were evaluated and prioritized.

5.2 Capital Cost Adjustments

As mentioned above, recommended projects were grouped differently by the three previous master plans and individual projects were not always separated out, so costs from the reports could not be directly compared. To preserve each plan's costing approach, individual project cost estimates were re-created using the unit costs and assumptions defined in the applicable master plan report.

The previous master plans were completed in different years, so the cost estimates could not be compared without adjusting for inflation. An annual inflation of 3% was used to bring all capital costs to present-day value.

In addition, the assumed cost to purchase land or easements required for some projects, varied between plans. For consistency, projects from the North and West Laramie master plans were adjusted to reflect the same value for land acquisition used in the South Laramie Master Plan.

Finally, to compare projects based on the total lifecycle cost, the annual cost for operation and maintenance (O&M) of the improvement is required. Only the South Laramie Master Plan determined O&M costs, so O&M costs were calculated for each project from the North and West master plans, using the same cost assumptions from the South Laramie Master Plan. Operation and maintenance costs were taken as annual costs over a 50-year project life. The total O&M cost over 50 years, adjusted for inflation, was added to the capital cost to determine the total life-cycle cost.

5.3 Prioritization Factors

Prioritization of the compiled recommended projects was based on the following categories:

- Life-cycle cost per property benefited during 100-year storm event;
- Life-cycle cost per roadway benefited during 100-year storm event;
- Whether the project addresses existing flooding issues during minor storm events;
- Whether the project requires land acquisition and/or a UPRR permit;
- Whether the project provides recreational benefits to the community;
- Whether the project provides water quality benefits; and



- Whether the project enhances community development priorities.

Every project was awarded points for each category, ranging from zero to ten. The following sections describe each prioritization category in further detail.

5.3.1 Life-cycle Cost per Property Benefited, 100-year Storm

This category is intended to compare the cost-effectiveness of each project based on the number of properties the project would potentially protect from flooding. The cost-benefit ratio normalizes the life-cycle cost of the project by the number of properties benefited. After calculating the life-cycle cost and dividing by the number of properties benefited, the ratio was normalized to a zero to ten scale in proportion to the smallest project ratio.

The number of properties benefited was an approximate value based on potential flooding avoided either downstream or in the immediate vicinity of the improvement project during a 100-year storm event. For example, detention ponds can potentially prevent downstream flooding in small or large downstream areas, depending on the pond size and location. For example, detention ponds which reduce the flow to Spring Creek were given credit for benefiting large numbers of properties along downstream reaches of Spring Creek where the South Laramie Master Plan determined bank overtopping would occur. A storm sewer project may partially benefit properties elsewhere in the storm water system but only the properties directly adjacent to the street where the storm sewer would be installed were included as benefited properties. A typical value of eight properties per city block (four on each side) was used for storm sewer projects.

5.3.2 Life-cycle Cost per Roadway Benefited, 100-year Storm

This category is intended to compare the cost-effectiveness of each project based on the number of arterial and collector roadways potentially protected from flooding. Only arterial and collector roadways were included in this calculation, since these roadways would impact the ability for safe public travel if flooded. This cost-benefit ratio normalizes the life-cycle cost of the project by the estimated number of arterial and collector roadways benefited. After dividing the life-cycle cost by the number of roadways benefited, the ratio was normalized to a zero to ten scale in proportion to the smallest project ratio.

The Major Street Plan of the COL and Albany County, Wyoming, developed by Wyoming Department of Transportation, District 1, was utilized to identify arterial and collector roadways. An arterial or collector roadway crossed by a project was counted as one roadway, while a project following an arterial or collector roadway was counted as one roadway per city block benefited.

5.3.3 Addresses Flooding During Minor Storm Events

For this category, each project was evaluated to determine whether it would alleviate an existing known flooding issue during a minor (10-year or more frequent) storm event, based on modeling from previous master plans or observations from recent storm events. Projects in West Laramie that would occur on roads that are not currently paved were awarded points in this category, as they would alleviate nuisance flooding in these areas. Projects were given a "Yes" or "No" rating. Projects rated as "Yes" were awarded ten points, while projects rated as "No" were awarded zero points.

5.3.4 Requires Land Acquisition and/or UPRR Permit

This category was created to evaluate two aspects regarding the constructability of the project that could delay, increase costs, or prevent the construction of the project:



- whether the project is not located on land owned by the City and would require negotiation and payment to acquire ownership or an easement on the land; and
- whether the project requires work on land owned by Union Pacific Railroad (UPRR), which would require a permit.

An online ownership map from the Albany County Assessor's Office was used with approximate locations of projects to determine if a project may require land acquisition or a UPRR permit. Since the cost of the land was accounted for in the capital cost category, the project was awarded 10 points if neither land acquisition nor a UPRR permit is required, 5 points if one of the two items is required, or zero points if both land acquisition and a UPRR permit is required.

5.3.5 Community Recreational Benefits

Some proposed projects can provide benefits to the community beyond flood control through recreational, aesthetic, and other land use opportunities for City residents. Projects that include construction of detention ponds received points in this category, as detention ponds can provide multi-use opportunities during dry weather, including use for parks and trails. New detention ponds were awarded ten points, expansions of existing detention ponds were awarded two points, and optimizations of existing pond outlet structures were awarded one point. Other projects, including storm sewer upgrade projects, were awarded zero points.

5.3.6 Water Quality Benefits

While a permit for storm water discharges by the City has not been required, it is possible that the Wyoming Department of Environmental Quality (WDEQ) could implement a permit, particularly since the Laramie River has been designated as an impaired water body. Storm water quality can also impact sensitive areas, such as the Casper Aquifer Protection Area.

Some of the ways that storm water improvements can remove pollutants include sedimentation of particulates, filtration through soil or engineered media, adsorption/absorption onto soil, or biological uptake by plants and microbes. The primary water quality improvement method included in the three previous master plans was extended detention ponds, in which additional detention volume is provided (above that required for flood control) and slowly released over 24 to 48 hours. The longer residence time for this portion of the pond allows smaller suspended particles to aggregate and settle out.

The inclusion of additional volume for water quality was recommended for detention ponds in all three master plans. Therefore, this category awarded ten points for detention pond projects. Otherwise, the project did not receive points in this category. One exception to this was the Regency Pond, which has been constructed. To meet flood control goals, no additional volume for water quality was included in the design.

5.3.7 Community Development Priorities

Consideration was given to projects that would support areas of Laramie where development is expected, as these projects would provide the infrastructure that would ease the impact of development and possibly encourage development by decreasing the infrastructure burden on developers. Project were awarded ten points if they served areas identified for future development such as the Turner Tract, undeveloped areas in West Laramie, and the Cirrus Sky developments.



5.4 Weighting Factors

To allow for the relative importance of each category, a weighting factor between zero and ten was assigned to each category. The individual score for each category was then multiplied by the weighting factor. For example, if a project received a score of 10 for the “Life-cycle Cost per Property Benefited” category, and the weighting factor assigned to this category was 10, then this category would contribute 100 points to the Total Priority Score for that project. The Total Priority Score for each project was then calculated by summing the products of the category score and weighting factors for each category.

Weighting factors were assigned to each category as shown in Table 13. Preventing flood damage to private property and maintaining safe passage on roadways are important to protecting public safety, therefore the Cost per Property Benefited and Cost per Roadway Benefited categories were given the highest weighting factors. The Water Quality Benefits category was assigned the lowest weighting factor since the City currently does not have a storm water discharge permit that would require storm water quality treatment. The Community Development Priorities category was assigned a low weighting factor, as projects serving future development will not typically provide benefits until the future development has occurred.

Table 13: Weighting Factor for Each Category

Category	Weighting Factor
Cost per Property Benefited, 100-year Storm	10
Cost per Roadway Benefited, 100-year Storm	7
Addresses Existing Minor Storm Flooding Issues	5
Land Acquisition and/or UPRR Permit not required	4
Community Recreational Benefits	3
Community Development Priorities	2
Water Quality Benefits	1

Should the City determine that changes to the weighting factors are justified, the Capital Improvement Project (CIP) Prioritization Tool developed through this effort allows the user to adjust the weighting factors and re-prioritize the projects accordingly.

5.5 Capital Improvement Project Prioritization Tool

Using the methodology described above, a CIP Prioritization spreadsheet tool was developed to rank the compiled storm water projects by Total Priority Score. The CIP Prioritization Tool sorts the projects into high, medium, and low priority, representing the top third, middle third, and bottom third prioritization scores, respectively. To show the geographic distribution of the ranked projects, the City Council Ward for each project is provided. An example of the CIP Prioritization Tool calculation is provided below. Any required “predecessor” projects are also shown in the CIP Prioritization Tool. A predecessor project is defined as a project requiring construction before the ranked project could occur. For example, a project to enlarge a storm sewer system could not be constructed until a predecessor project to enlarge the downstream system was completed.



Table 14: CIP Prioritization Tool Example

Weighting factor of 10 multiplied by category score of 9.2 contributes 92 points to Total Priority Score

Sums products of category scores and weighting factors

Project is located in Council Ward 3

Weighting Factor		10	7	3	1	4	5	2			
Project Title	Capital Cost	Cost per Property Benefited, 100-year Storm	Cost per Roadway Benefited, 100-year Storm	Community Recreational Benefits	Water Quality Benefits (Yes=10)	Requires Land Acquisition and/or UPRR Permit (No = 10, Both = 0)	Addresses Existing Minor Storm Flooding Issues (Yes=10)	Community Development Priorities (Yes=10)	Total Priority Score	Neighborhood Distribution (City Council Ward)	Predecessors
Regency Pond	\$2,148,567	9.2	3.6	10.0	0.0	10.0	10.0	10.0	257.4	3	0
Optimize pond outlet structure, Nighthawk and 22nd Street	\$116,000	7.9	10.0	1.0	0.0	10.0	0.0	10.0	212.0	3	0
Enlarge Pond, CM02, Beaufort & 10th	\$273,711	4.5	2.7	2.0	10.0	10.0	10.0	10.0	189.4	2	0
Enlarge Pond, NE of 30th and Reynolds Street	\$273,711	3.5	6.2	2.0	10.0	10.0	10.0	0.0	184.4	3	0
New Pond E. of Jacoby GC	\$11,604,470	10.0	0.8	10.0	10.0	5.0	0.0	0.0	165.5	3	0
Upgrade existing storm sewer to 54" RCP in Beaufort St. from 8th to 9th and along 9th from Beaufort to Downey.	\$890,002	3.4	3.1	0.0	0.0	10.0	10.0	10.0	165.2	2	Upgrade existing storm sewer to 6'x8' RCBC
Install new 24" storm sewer from Van Buren and Lincoln to Polk and Lincoln	\$181,099	3.6	2.3	0.0	0.0	10.0	10.0	10.0	162.5	1	Buchanan & Wyoming to Adams & Madison; Van Buren & Colorado to Van Buren & Buchanan
Optimize pond outlet structure, Binford and 22nd Street	\$33,000	4.7	10.0	1.0	0.0	10.0	0.0	0.0	160.4	3	0
Optimize pond outlet structure, 22nd and Reynolds Street	\$77,000	1.6	10.0	1.0	0.0	10.0	0.0	10.0	148.8	3	0
Upgrade existing storm sewer to 60" RCP along Canby Street	\$439,998	4.0	2.5	0.0	0.0	10.0	10.0	0.0	147.6	2	New 5'x8' RCBC along Canby Street
LaBonte Park Pond	\$5,499,235	1.3	0.2	10.0	10.0	10.0	10.0	0.0	144.7	2	0
Install new 36" storm sewer from Madison and Adams to Madison and Lincoln	\$904,720	0.7	3.6	0.0	0.0	10.0	10.0	10.0	142.6	1	0
Install new 24" storm sewer in Polk from Fillmore to Taylor, 36" north to Van Buren	\$241,699	5.1	0.0	0.0	0.0	10.0	10.0	0.0	141.4	1	Buchanan & Wyoming to Adams & Madison
Upgrade to 30" and 36" storm sewer on Harrison Street from Lincoln to Buchanan Street	\$298,022	5.1	0.0	0.0	0.0	10.0	10.0	0.0	141.0	1	0

High-priority projects (top third of scores) shown in red

"0" Indicates project requires no predecessors



Table 14 shows the projects that ranked as high priority (top third). The complete CIP Prioritization Tool output is included on CD in Appendix D.

Table 15: High-Priority Storm Water Projects from CIP Prioritization Tool

Priority Rank	Project Title	2022 Capital Cost	Predecessor (Priority Rank)
1	Regency Pond*	\$1,653,000	None
2	Optimize pond outlet structure, Nighthawk and 22 nd Street**	\$116,000	None
3	Enlarge Pond CM02, Beaufort & 10 th	\$274,000	None
4	Enlarge Pond NE of 30 th and Reynolds Street	\$274,000	None
5	New Pond east of Jacoby GC	\$11,604,000	None
6	Upgrade existing storm sewer to 54" in Beaufort St. from 8 th to 9 th and along 9 th to Downey	\$890,000	#70 (Upgrade existing storm sewer to 6'x8' RCBC in Downey from 9 th to 7 th , on 7 th to Mitchell, and on Mitchell to outfall)
7	Install new 24" storm sewer from Van Buren Street and Lincoln to Polk and Lincoln	\$181,000	#22
8	Optimize pond outlet structure, Binford and 22 nd Street***	\$33,000	None
9	Optimize pond outlet structure, 22 nd and Reynolds Street***	\$77,000	None
10	Upgrade existing storm sewer to 60" RCP along Canby Street	\$440,000	#37 (New 5'x8' RCBC along Canby Street)
11	LaBonte Park Pond Improvements	\$5,499,000	None
12	New 36" storm sewer from Madison and Adams to Madison and Lincoln	\$905,000	None
13	New 24" storm sewer in Polk from Fillmore to Taylor, 36" north to Van Buren	\$242,000	#22
14	Upgrade to 30" and 36" storm sewer on Harrison from Lincoln to Buchanan	\$298,000	None
15	New Pond RM02, SW of 30 th and Reynolds	\$1,540,000	None



Priority Rank	Project Title	2022 Capital Cost	Predecessor (Priority Rank)
16	Upgrade existing storm sewer to 60" RCP along 6 th Street	\$1,036,000	#41 (Upgrading existing storm sewer to 4'x10' RCBC along Harney Street)
17	Enlarge Pond LM01, NE of 15 th & Harney	\$235,000	None
18	Upgrade existing storm sewer to 60" RCP along 11 th Street	\$440,000	#10
19	New 36" – 48" storm sewer from Wyoming Avenue and Schrader Street to Colorado Avenue and Van Buren Street	\$1,562,000	#22
20	Restore 36" Culvert under UPRR at 1 st & Sanders	\$401,000	None
21	New 30" storm sewer from Franklin and Arthur to Snowy Range Road and Arthur	\$251,000	None
22	New storm sewer in Buchanan from Wyoming to Van Buren, new 48" in Van Buren from Colorado to Adams, new box culvert in Adams from Van Buren to Madison****	\$2,833,000	None
23	New Pond on W Boundary of Turner Tract	\$484,000	None
24	Install structures in Grays Gable to maximize flow to Jacoby Golf Course	\$297,000	#63 (30 th Street Storm Sewer Upgrades)

*Project has been constructed

**Project currently under construction

***Project design has been completed; awaiting funding

****Project currently under design



6.0 Recommendations

6.1 Use of Master Plan

This master plan has consolidated previous master plans for the City of Laramie, creating a prioritized list of capital improvement projects, a combined storm water system GIS map, and a combined rainfall-runoff model. Wood recommends the following next steps:

- **Use CIP Prioritization Tool to Plan Storm Water Improvements:** As funding is identified, use the CIP Prioritization Tool to determine which projects to construct first. The CIP Tool can and should be modified by changing weighting factors to reflect changes in relative importance, adding new projects as they are identified, and removing projects that are constructed or become obsolete. The priority rankings should not be considered as the final determination in which high-priority project should be the “next” to be constructed, as there are other factors to consider, such as concurrence with other utility or roadway improvements. Rather, the rankings should provide defensible evidence that any of the high-priority projects are worthwhile.
- **Use City-Wide Storm Water Model to Support Decisions on Private Development:** As private development is proposed, the City-Wide model should be consulted to determine whether the proposed development would occur in accordance with the assumptions used in the master plan. This would include checking the following, at a minimum:
 - Whether the proposed drainage flow paths and discharge points conflict with the model,
 - Whether the proposed imperviousness of the development is less than or equal to the imperviousness used in the model,
 - Whether any proposed infrastructure conflicts with existing or planned storm water system infrastructure, and
 - Whether the proposed discharges from the development will exceed the downstream capacity of the existing storm water system.

The City-Wide model should be updated as projects and development occur.

- **Use City-Wide Map to Aid Design and Operation & Maintenance of Storm System:** The City-Wide map can be used for initial planning efforts for storm water improvements. City staff can also use it to note and track maintenance concerns or resident reports of flooding issues.
- **Prepare and Adopt a Stormwater Design Criteria Manual:** Preparing a drainage criteria manual, adopted and referenced by ordinance, would allow the City to implement and enforce recommended requirements for new development. The manual would provide a clear definition of the City’s stormwater requirements and outline acceptable methods for meeting the requirements. This will aid developers in preparing designs and streamline the City’s review of stormwater submittals.
- **Conduct a Stormwater User-fee Rate Study:** To develop a financial strategy for funding capital improvement projects, maintenance, and other stormwater program costs, it is recommended to conduct a user-fee rate study. This study should identify methods for the development of user fees and recommend implementation strategies. It should include public meetings, council briefings, the development of cost models and rate structures, the development of a credit/policy program, and the development of a billing system, billing policy, and integration with the existing billing system.



6.2 Future Development

In addition to constructing the recommended capital improvements, the City should continue to impose flood management requirements on new development and re-development properties. Private flood improvements can help provide incremental relief until public improvement projects can be funded and constructed. The following requirements are recommended for new developments or significant re-development properties:

- **Over-detention:** For locations where downstream capacity is known to be deficient, peak runoff from developed properties should be managed on-site to reduce the 100-year developed peak flow rate to the 10-year historic peak discharge rate. The historic peak discharge rate is defined as the rate of discharge from the site prior to any development (vacant land). This recommended requirement may be clarified or adjusted if the City adopts a drainage criteria manual in the future.
 - It is recommended that the City consider allowing developers the option to forego construction of on-site flood management if they contribute to the cost of regional flood management facilities that serve the property in question. This may be attractive to developers as it may provide more developable land, while the City can recoup some of the costs of regional facilities. Payments could be based on the fraction of impervious area represented by the development, or similar method.
- **Maintenance of private stormwater facilities:** To ensure continued performance of private, on-site stormwater facilities, regular maintenance (removal of sediment, debris, landscape maintenance, etc.) should be required by ordinance, with an easement that would allow the City to enter the property to conduct maintenance (at the landowner's expense) if the landowner fails to meet maintenance requirements.
- **Consideration of Downstream impacts:** As a condition of approval, private development should be required to show that downstream infrastructure (storm sewers, open channels, etc.) is present and has adequate capacity to safely convey the runoff from the 100-year event to the ultimate receiving water body (Spring Creek or Laramie River). On-site improvements should be designed to release runoff at rates that can be safely conveyed by downstream infrastructure. This may require developments to construct or fund downstream improvements to carry their point discharges across downstream property that used to accept sheet flows, unless it can be shown that the point discharge will not damage downstream property.
- **Water Quality:** Wood recommends that the City develop stormwater quality standards that encourage or require the use of LID practices (also called green infrastructure) on new or redeveloped properties both inside and outside the Casper Aquifer Protection Area.

6.3 Operations and Maintenance

Routine inspection and maintenance of all stormwater facilities is necessary to assure that long-term function is maintained, on both public and private stormwater infrastructure. For this reason, annual O&M costs were estimated and included in the life-cycle cost of each prioritized project. Culvert inlets and outlets should be cleared of excess vegetation and sediment to maintain design capacity. Regular maintenance of the existing and proposed detention ponds should include mowing and removal of sediment, debris and trash in order to maintain functionality. The City regularly maintains storm inlets as part of street maintenance. **It is recommended that the City consider implementing a storm water maintenance program that includes inspections of culverts, detention ponds, and outfalls monthly or following rain events greater than 0.5 inches.**



6.4 Water Quality

The United States Environmental Protection Agency (EPA) regulates stormwater discharges from municipal separate storm sewer systems (MS4s) through the National Pollutant Discharge Elimination System (NPDES). Under Phase I regulations, cities with populations over 100,000 require permit coverage. Phase II regulations extend this requirement to areas specified as urbanized. Currently, the COL is not classified as an urbanized area.

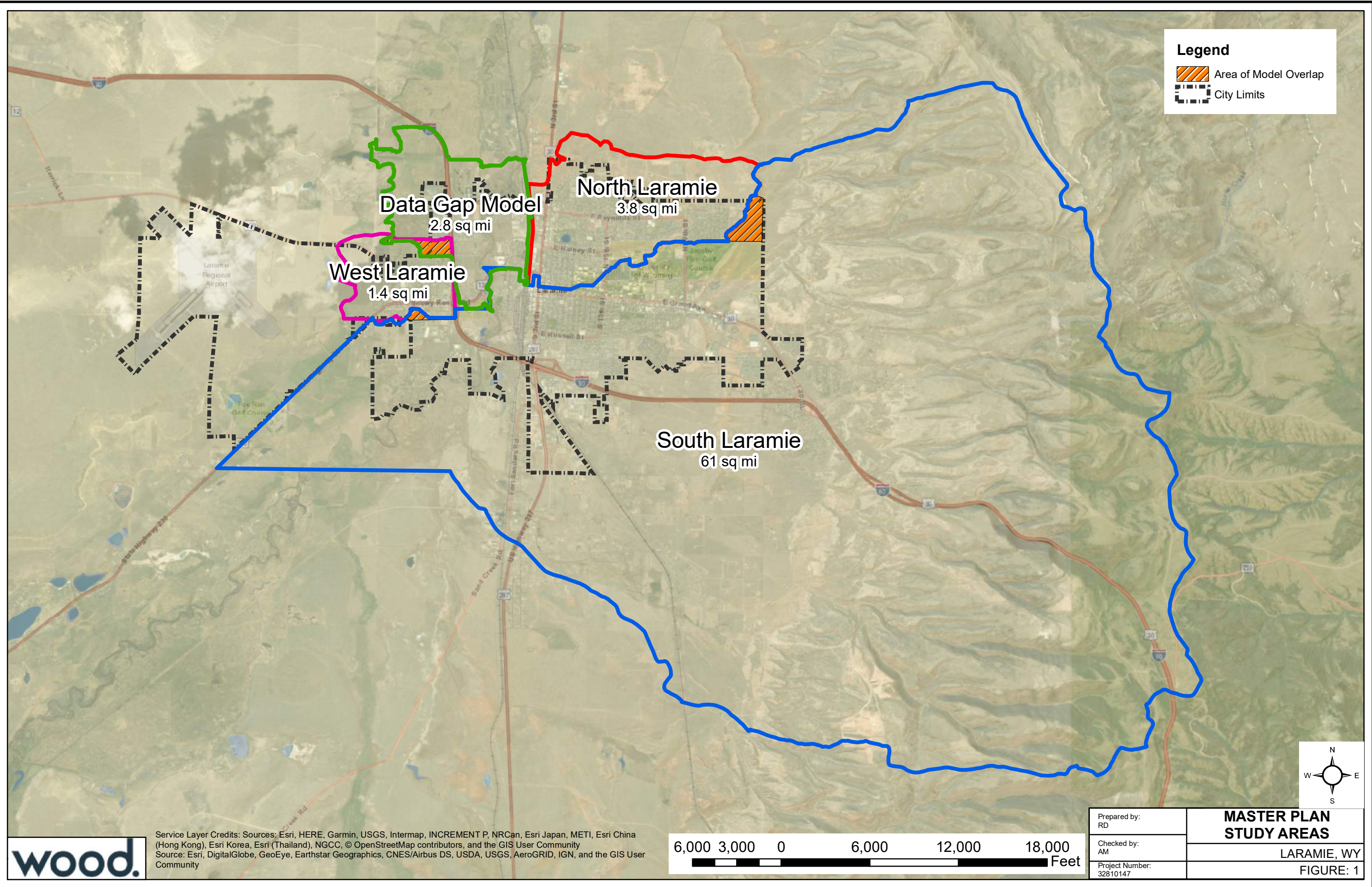
It is possible that the EPA could extend MS4 permit requirements to smaller cities or redefine what constitutes an urbanized area in a way such that the COL would be included. MS4 permits are administered in Wyoming by the WDEQ on behalf of the EPA. In discussions with the WDEQ, they would also consider an MS4 permit for cities if a nearby water body was impaired or threatened with impairment. Since the Laramie River is designated as an impaired water body in the 2020 Integrated 305(b) and 303(d) Report (WDEQ, 2020) due to sediment from unknown sources, a stormwater permit or other requirements could be applied to the City's stormwater system. **Wood recommends that, where possible, future storm water improvements be designed to limit sediment discharges.** A proactive approach could help avoid a permit or provide a smooth transition into permitted status.

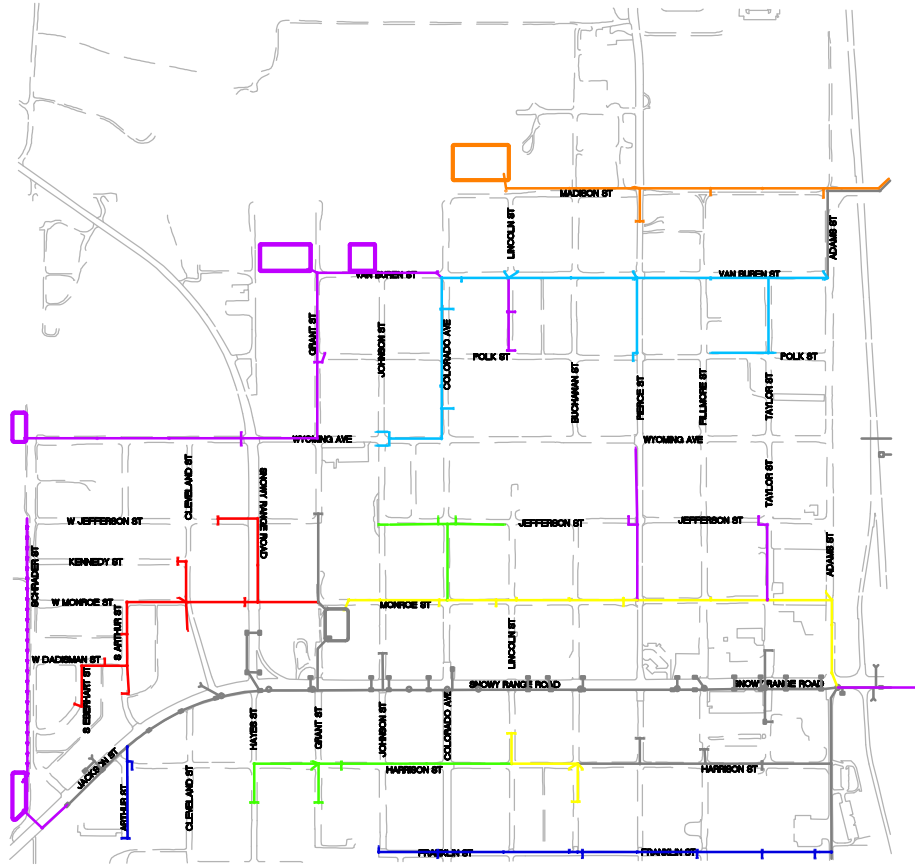









Appendix A

Figures







-  FY 2010
-  FY 2011
-  FY 2012
-  FY 2013
-  FY 2014
-  FY 2015
-  PHASE OUTYEAR
-  EXISTING (INCLUDING FY 2009)

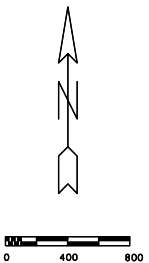
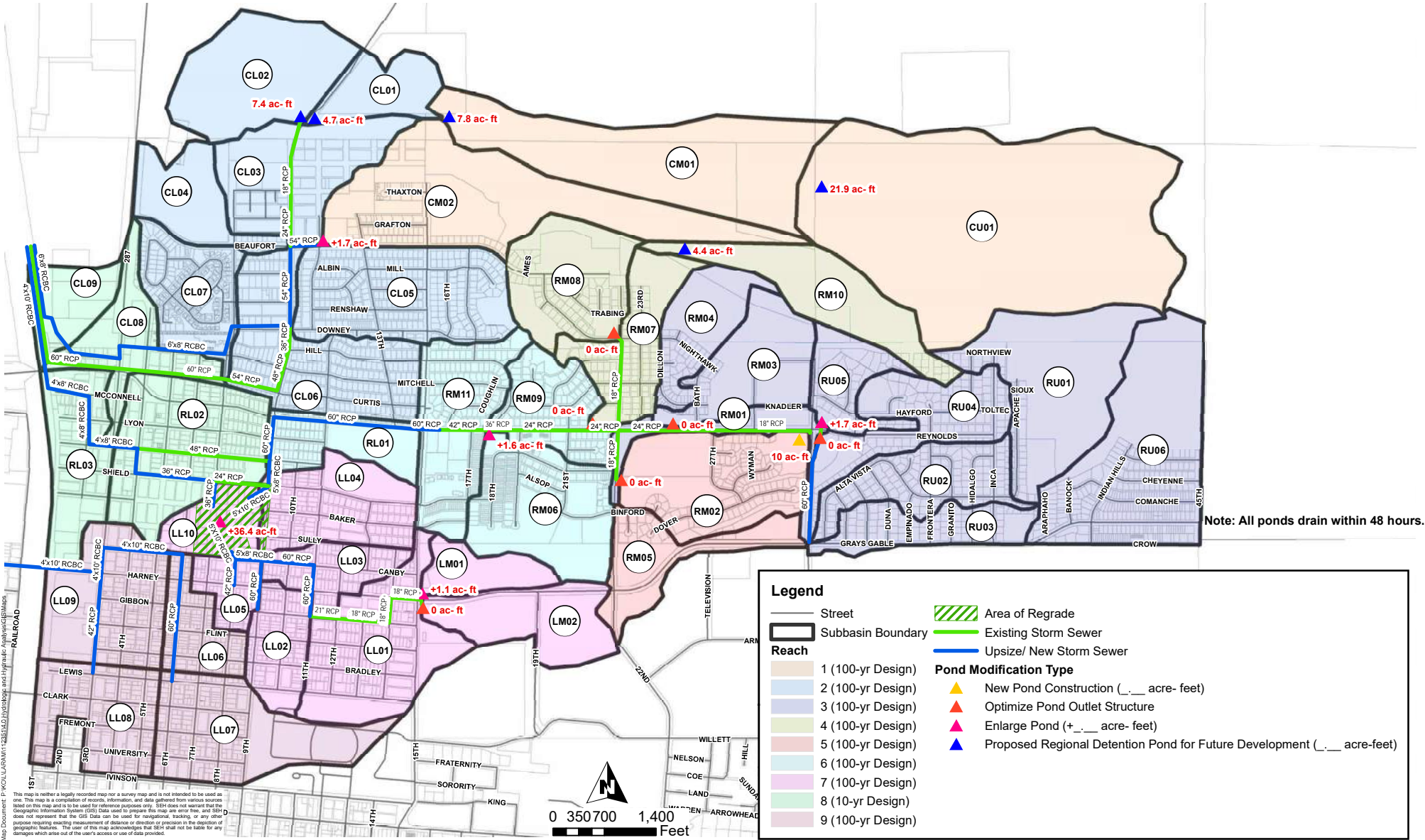


FIGURE 2: PROPOSED IMPROVEMENT PHASING WEST LARAMIE MDP WEST LARAMIE, WY



FIGURE 3: PROPOSED IMPROVEMENT SIZING
WEST LARAMIE MDP
WEST LARAMIE, WY



Map Document: P:\KOCALARAM112381\MXD\Hydrologic\Analysis\GIS\Mapas

This map is neither a legally recorded map nor a survey map and is not intended to be used as one. This map is a compilation of records, information, and data gathered from various sources based on this map and is to be used for reference purposes only. SEH does not warrant that the Geographic Information System (GIS) Data used to prepare this map are error free, and SEH does not represent that the GIS Data can be used for navigational, tracking, or any other purpose requiring accurate measurement of distance or direction or precision in the depiction of geographic features. The user of this map acknowledges that SEH shall not be liable for any damages which arise out of the user's access or use of data provided.

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Print Date: 03/2012

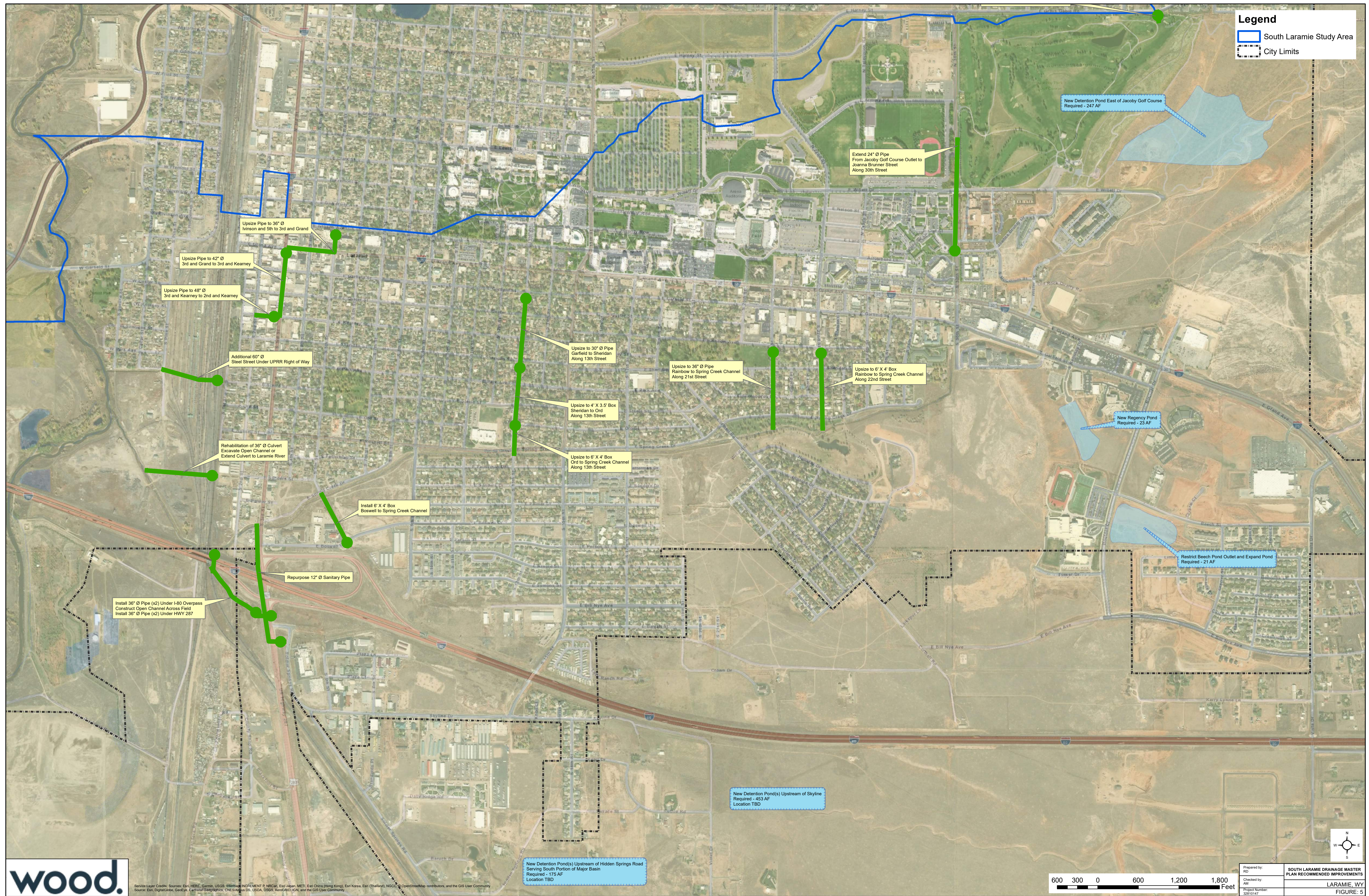
Map by: KRJ
Projection: NAD_1983_StatePlane_Wyoming_East_FIPS_4901_Feet
Source:

NORTH LARAMIE DRAINAGE MASTER PLAN
Laramie, Wyoming

FIGURE 4:
Recommended Plan

Legend

- South Laramie Study Area
- City Limits



Install 36" Ø Pipe (x2) Under I-80 Overpass
Construct Open Channel Across Field
Install 36" Ø Pipe (x2) Under HWY 287

Rehabilitation of 36" Ø Culvert
Excavate Open Channel or
Extend Culvert to Laramie River

Upsize Pipe to 48" Ø
3rd and Kearney to 2nd and Kearney

Upsize Pipe to 42" Ø
3rd and Grand to 3rd and Kearney

Upsize Pipe to 36" Ø
Ninson and 5th to 3rd and Grand

Repurpose 12" Ø Sanitary Pipe

Install 6' X 4' Box
Borwell to Spring Creek Channel

Upsize to 6' X 4' Box
Ord to Spring Creek Channel
Along 13th Street

Upsize to 4' X 3.5' Box
Sheridan to Ord
Along 13th Street

Upsize to 36" Ø Pipe
Garfield to Sheridan
Along 13th Street

Upsize to 6' X 4' Box
Rainbow to Spring Creek Channel
Along 22nd Street

Extend 24" Ø Pipe
From Jacoby Golf Course Outlet to
Joanna Brunner Street
Along 30th Street

New Detention Pond East of Jacoby Golf Course
Required - 247 AF

New Regency Pond
Required - 23 AF

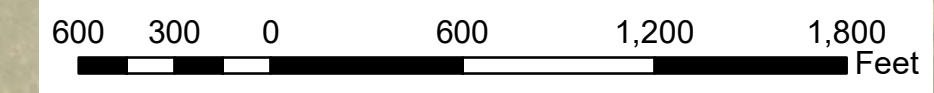
Restrict Beech Pond Outlet and Expand Pond
Required - 21 AF

New Detention Pond(s) Upstream of Skyline
Required - 463 AF
Location TBD

New Detention Pond(s) Upstream of Hidden Springs Road
Serving South Portion of Major Basin
Required - 175 AF
Location TBD



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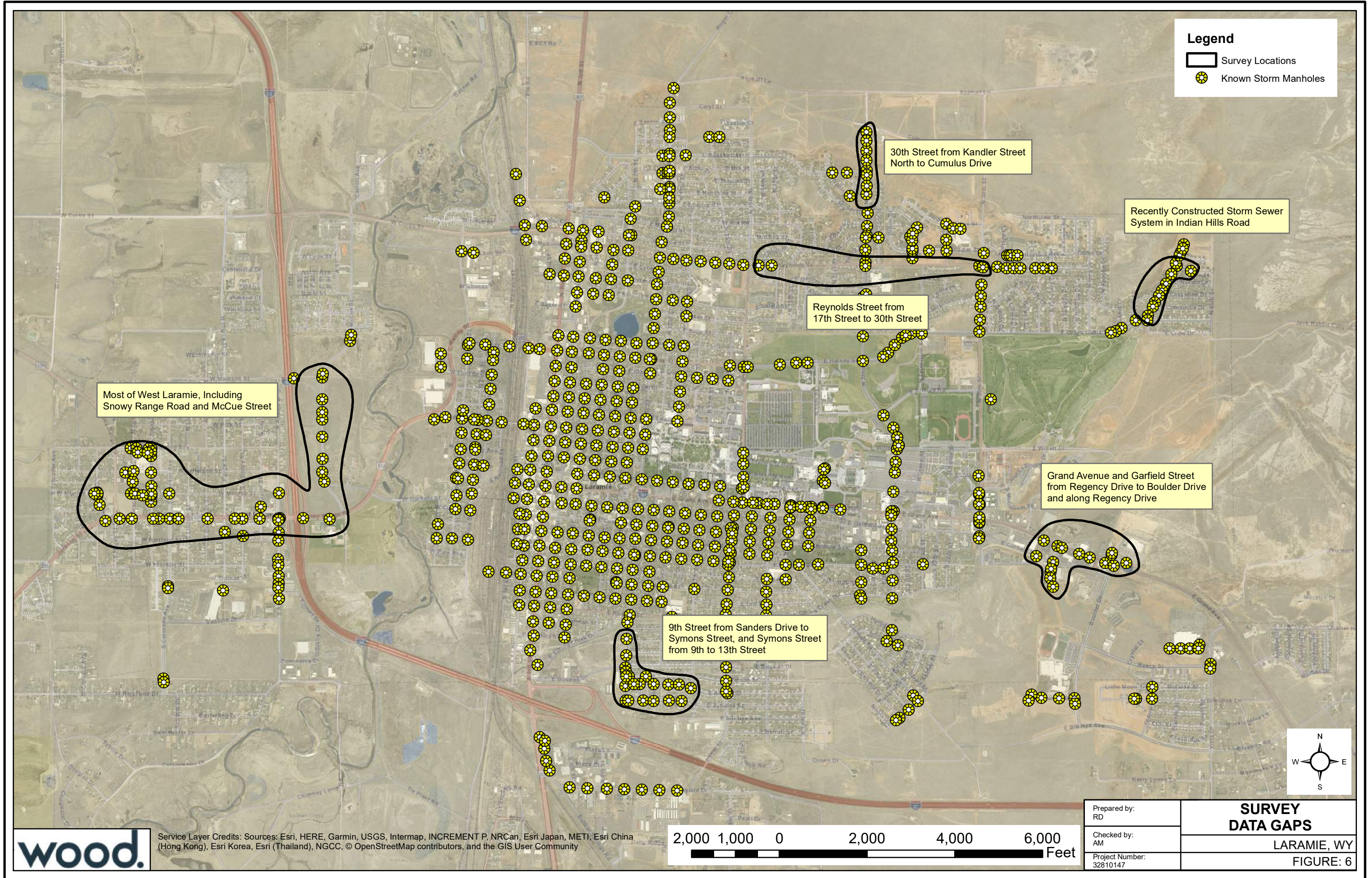


Prepared by:
RD

Checked by:
AM

Project Number:
32810147

SOUTH LARAMIE DRAINAGE MASTER
PLAN RECOMMENDED IMPROVEMENTS
LARAMIE, WY
FIGURE 5



Legend

- Survey Locations
- ★ Known Storm Manholes

Most of West Laramie, Including Snowy Range Road and McCue Street

30th Street from Kandler Street North to Cumulus Drive

Recently Constructed Storm Sewer System in Indian Hills Road

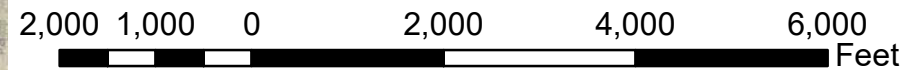
Reynolds Street from 17th Street to 30th Street

Grand Avenue and Garfield Street from Regency Drive to Boulder Drive and along Regency Drive

9th Street from Sanders Drive to Symons Street, and Symons Street from 9th to 13th Street



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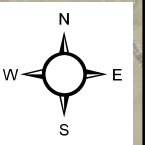


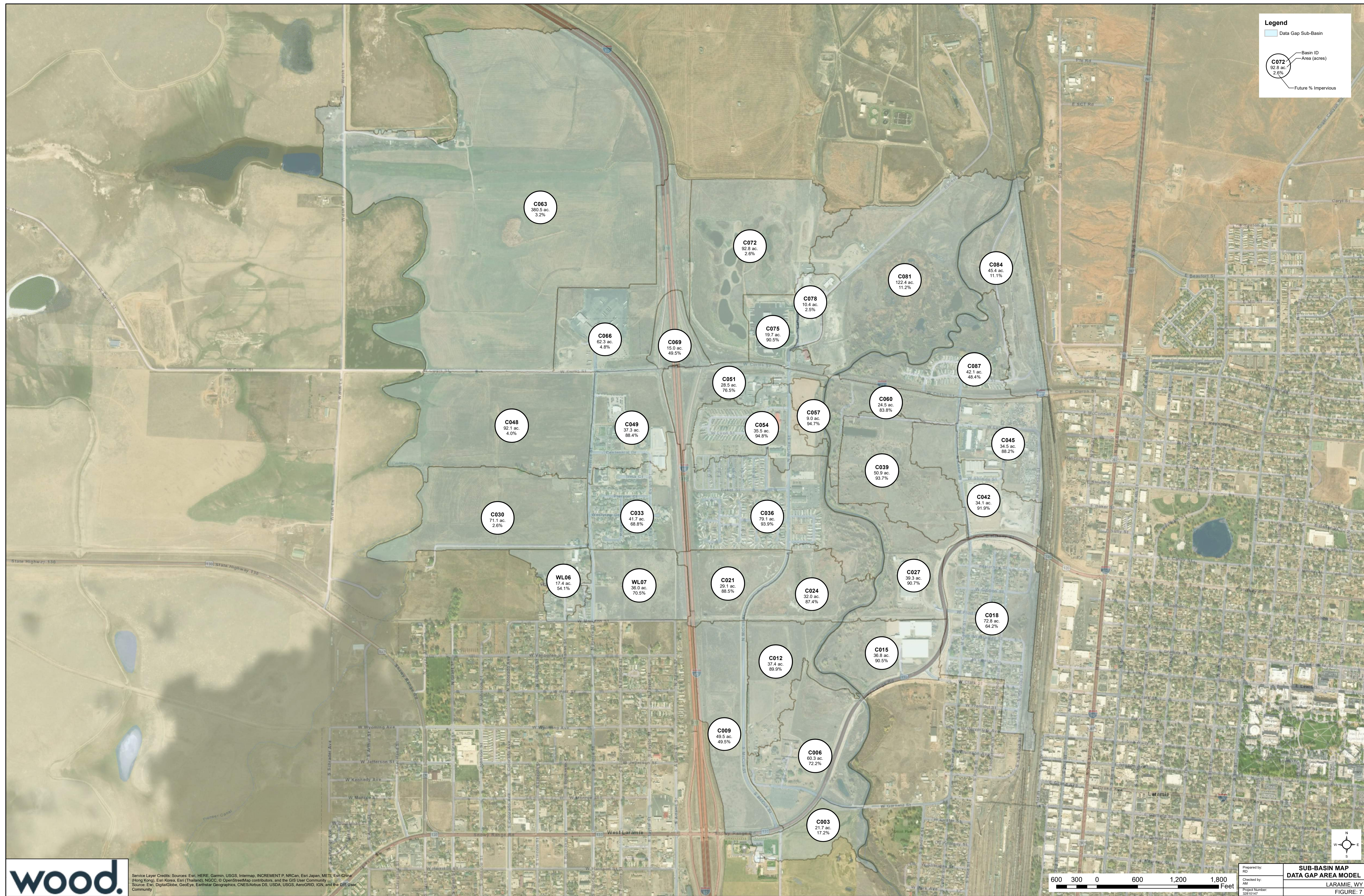
Prepared by: RD
Checked by: AM
Project Number: 32810147

SURVEY DATA GAPS

LARAMIE, WY

FIGURE: 6



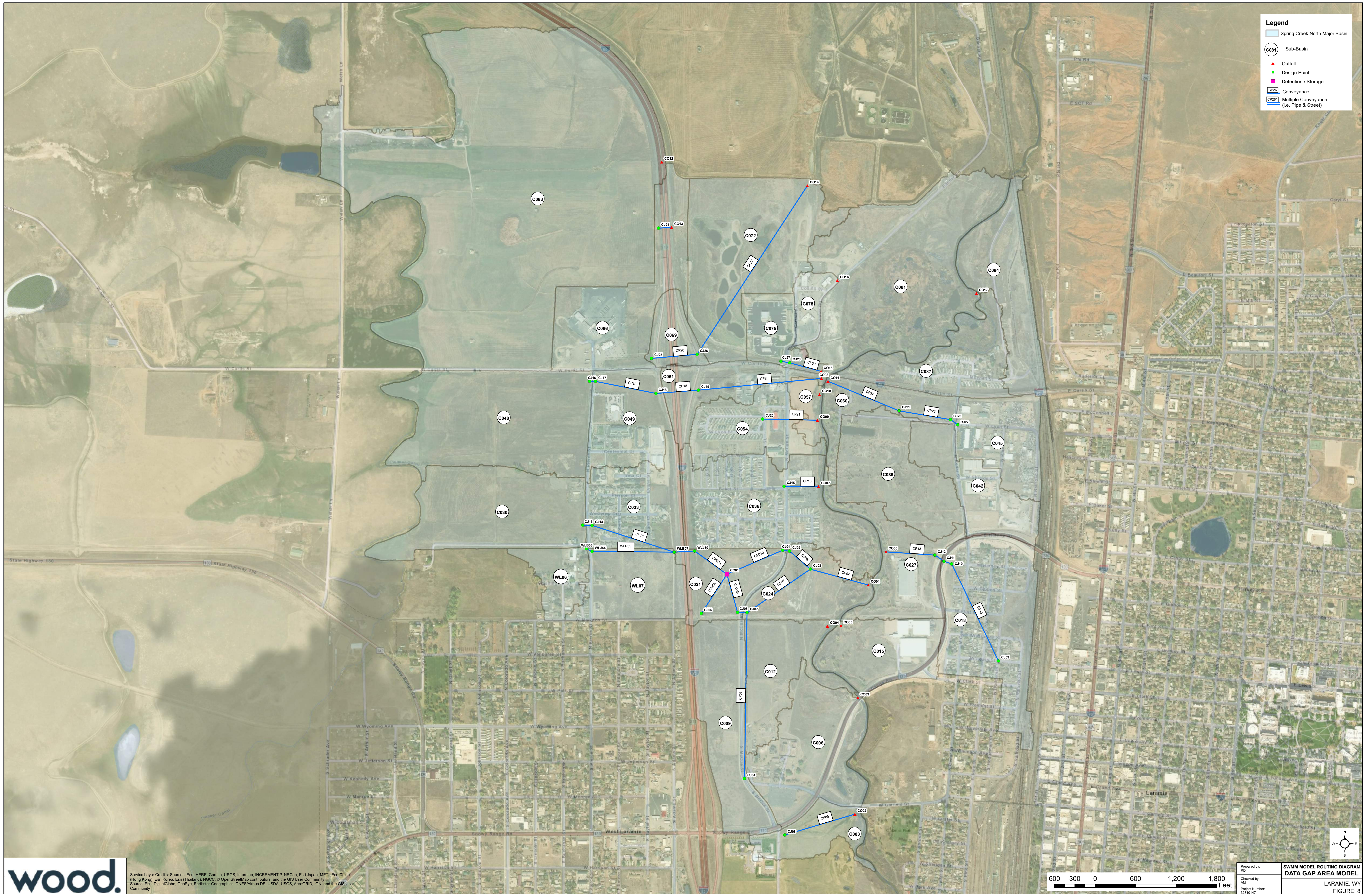


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 Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Prepared by: RD
 Checked by: AM
 Project Number: 32810147

**SUB-BASIN MAP
 DATA GAP AREA MODEL**
 LARAMIE, WY
 FIGURE 7



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 Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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 Checked by: AM
 Project Number: 32810147

**SWMM MODEL ROUTING DIAGRAM
 DATA GAP AREA MODEL**

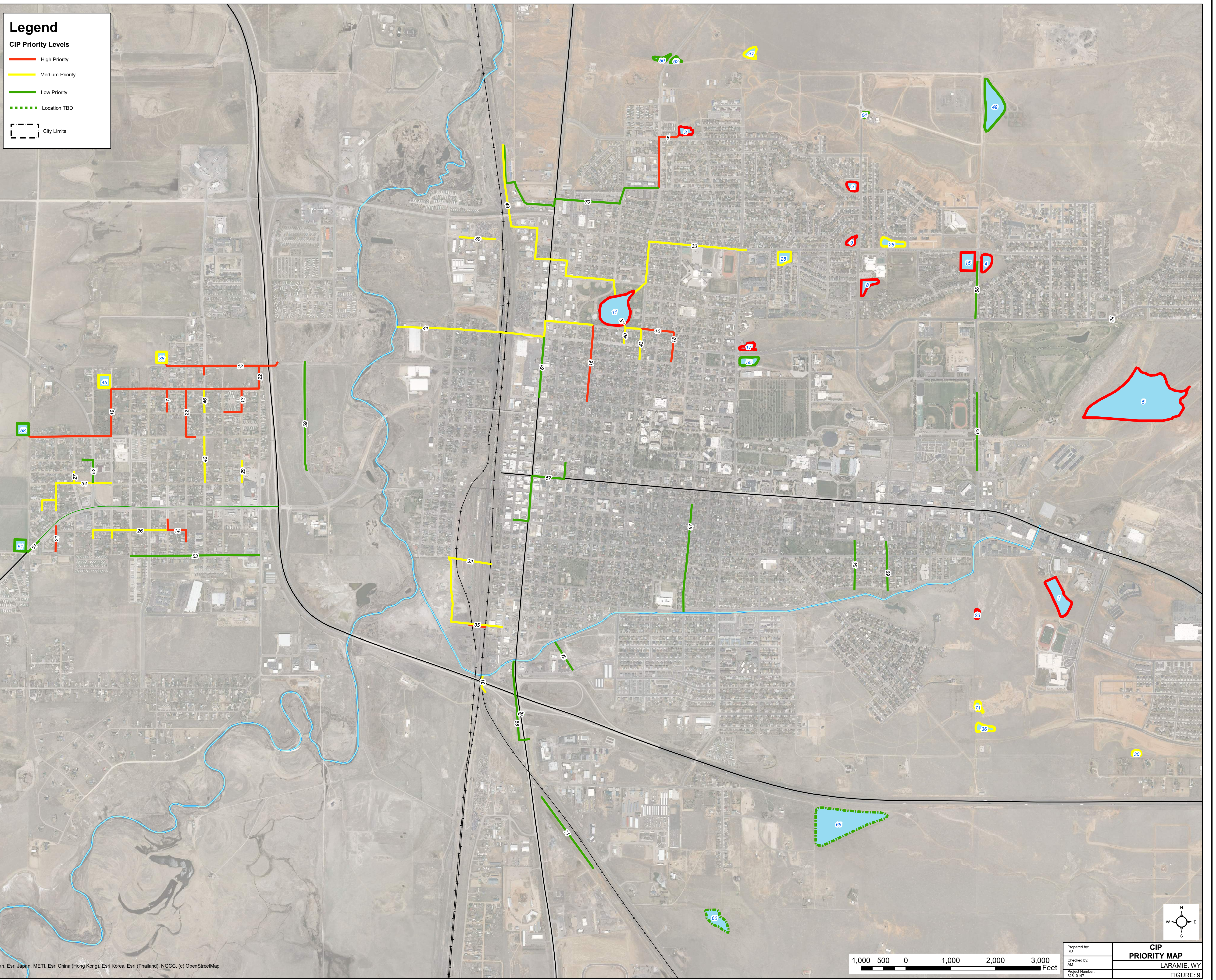
LARAMIE, WY
 FIGURE: 8

Priority Ranking	Project Title
1	Regency Pond
2	Optimize pond outlet structure, Nighthawk and 22nd Street
3	Enlarge Pond, CM02, Beaufort & 28th
4	Enlarge Pond, NE of 30th and Reynolds Street
5	New Pond E. of Jacoby GC
6	Upgrade existing storm sewer to 54" RCP in Beaufort St. from 8th to 9th and along 9th from Beaufort to Downing.
7	Install new 24" storm sewer from Van Buren and Lincoln to Park and Lincoln
8	Optimize pond outlet structure, Bedford and 22nd Street
9	Optimize pond outlet structure, 22nd and Reynolds Street
10	Upgrade existing storm sewer to 48" RCP along Canby Street
11	LaBonne Park Pond
12	Install new 30" storm sewer from Madison and Adams to Madison and Lincoln
13	Install new 24" storm sewer in Park from Fillmore to Taylor, 30" north to Van Buren
14	Upgrade to 30" and 36" storm sewer on Harrison Street from Lincoln to Buchanan Street
15	New Pond RM02, SW of 30th and Reynolds
16	Upgrade existing storm sewer to 60" RCP along 9th Street
17	Enlarge Pond RM02, NE of 10th & Henry
18	Upgrade existing storm sewer to 48" RCP along 13th Street
19	New 30" - 48" storm sewer from Wyoming Avenue and Schrader Street to Colorado Avenue and Van Buren Street
20	Restore 36-inch Culvert Under LPRB at 511 & Sanders
21	New 30" storm sewer from Franklin Street and Arthur Street to Snowy Range Road and Arthur Street
22	New storm sewer in Buchanan from Wyoming to Van Buren, new 48" in Van Buren from Colorado to Adams, new box culvert in Adams from Van Buren to Madison
23	New Pond on W Boundary of Turner Tract
24	Install structures in Grays Gables to minimize flow to Jacoby Golf Course
25	30" Pipe Bore Under LPRB at Becho Street
26	Harrison Street and Lincoln Street and Hayes Street
27	Monroe Street and Cleveland Street to Kennedy Street and Cleveland Street
28	Enlarge Pond, south of Reynolds Street between 7th and 19th Street
29	Monroe Street and Taylor Street to Jefferson Street and Taylor Street
30	New Pond on S Border of Turner Tract
31	Twin 30" Pipe Under 381 Overpass
32	30" Pipe Bore Under LPRB at Becho Street
33	Upgrade existing storm sewer to 60" RCP along Reynolds Street
34	Dashman Street and Eberhard Street to Monroe Street and Grant Street
35	Re-purpose 18-inch Sanitary Sewer Line
36	New Pond SE Corner Turner Tract
37	New 5x8' RCBC along Canby Street
38	Madison Street and Adams Street to Madison Street and Lincoln Street (Madison Street Pond)
39	Van Buren Street and Pierce Street to Park Street and Pierce Street
40	Upgrade existing storm sewer to 42" RCP along 8th Street
41	Upgrade existing storm sewer to 42" RCP along Hamley Street
42	Monroe Street and Pierce Street to Wyoming Avenue and Pierce Street
43	Upgrade existing storm sewer to 60" RCP along 9th Street
44	New Pond SE Corner Turner Tract
45	Stevens Park Pond
46	Van Buren Street and Pierce Street to Park Street and Pierce Street
47	Proposed Regional Detention Pond for Future Development, CM05
48	Upgrade existing storm sewer pipe in Resch &
49	Proposed Regional Detention Pond for Future Development, CM03
50	Proposed Regional Detention Pond for Future Development, CM02
51	Jackson Street to Schrader Street Pond to Schrader Street Interception Channel
52	Monroe Street and Snowy Range Road to Jefferson Street and Snowy Range Road
53	New 30" storm sewer in Franklin from Johnson to Buchanan, new 36" in Franklin from Buchanan to Adams
54	24th Street Storm Sewer Upgrades
55	Optimize pond outlet structure, 29th and Hamley Street
56	Upgrade existing storm sewer to 60" RCP along 30th Street
57	Steele St. System Storm Sewer Upgrades
58	Wyoming Avenue and Schrader Street Pond
59	Upgrade McCue Street pipe to RCP box culvert
60	Pond Serving Southern Portion of Spring Creek South Basin (175 AF)
61	Upgrade existing storm sewer pipe to 42" RCP along 3rd Street
62	Proposed Regional Detention Pond for Future Development, CM04
63	30th Street Storm Sewer Upgrades
64	Proposed Regional Detention Pond for Future Development, RM03
65	Pond Serving Northeast Portion of Spring Creek South Basin (450 AF)
66	Twin 30" Pipe Bore Under Highway 287
67	13th Street Storm Sewer Upgrades
68	Re-purpose 12" Sanitary Sewer
69	22nd Street Storm Sewer Upgrades
70	Upgrade existing storm sewer to 6x8' RCBC in Downing from 9th to 7th, on 7th to Mitchell, and on Mitchell to outfall
71	Grade New Channel Through Field Southwest of I-80 and Hwy 287
72	4x6' Box Culvert from Boswell Drive to Spring Creek Channel

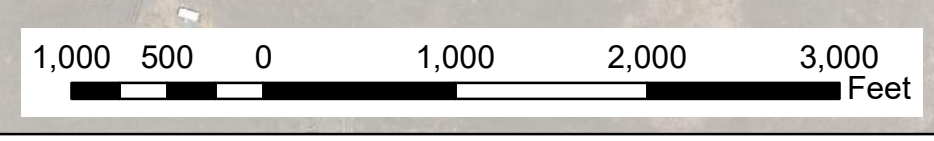
Legend

CIP Priority Levels

- High Priority
- Medium Priority
- Low Priority
- Location TBD
- City Limits



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Prepared by: RD	CIP PRIORITY MAP LARAMIE, WY
Checked by: AM	
Project Number: 32810147	

FIGURE: 9

Appendix B (On CD)

Previous Master Plans



Appendix C

Data Gap Model Input



Table C1: Sub-basin Characteristics for Data Gap Area Model

Sub-Basin	Area (ac)	Width (ft)	Flow Length (ft)	Slope (%)	Future Imperv. (%)	Max. Infil. Rate (in/hr)	Min. Infil. Rate (in/hr)	Decay Constant (1/hr)	Peak Runoff (cfs)
C003	21.7	463	2037	6.2	17.2	3.62	0.20	6.48	29
C006	60.3	799	3285	5.9	72.2	3.02	0.16	6.48	176
C009	49.5	603	3578	4.4	85.9	2.00	0.10	6.48	147
C012	37.4	483	3370	3.9	89.9	2.34	0.12	6.48	110
C015	36.8	728	2202	6.4	90.5	4.00	0.23	6.48	136
C018	72.8	859	3694	4.3	64.2	4.02	0.23	6.48	173
C021	29.1	625	2030	7.5	88.5	2.00	0.10	6.48	122
C024	32.0	411	3390	5.3	87.4	2.88	0.16	6.48	98
C027	39.3	975	1754	7.0	90.7	4.00	0.23	6.48	162
C030	71.1	824	3763	3.0	2.6	3.97	0.22	6.48	42
C033	41.7	772	2352	5.8	68.8	3.07	0.17	6.48	134
C036	79.1	1158	2978	4.8	93.9	2.51	0.13	6.48	249
C039	50.9	709	3129	5.3	93.7	4.00	0.23	6.48	158
C042	34.1	518	2870	5.4	91.9	4.00	0.23	6.48	109
C045	34.5	723	2082	4.9	88.2	4.00	0.23	6.48	122
C048	92.1	889	4517	3.2	4.0	3.99	0.13	6.48	57
C049	37.3	759	2139	5.5	88.4	3.17	0.17	6.48	138
C051	28.5	396	3132	8.5	76.5	2.25	0.12	6.48	97
C054	35.5	419	3692	4.1	94.8	2.25	0.11	6.48	101
C057	9.0	499	785	7.7	94.7	3.29	0.18	6.48	47
C060	24.5	401	2665	8.1	83.8	4.00	0.23	6.48	85
C063	380.5	2787	5946	3.2	3.2	4.00	0.23	6.48	179
C066	62.3	543	5003	4.8	68.5	3.57	0.20	6.48	144
C069	15.0	377	1731	10.4	49.5	2.00	0.10	6.48	55
C072	92.8	978	4135	3.7	2.6	3.43	0.19	6.48	62
C075	19.7	861	996	5.3	90.5	3.96	0.22	6.48	92
C078	10.4	287	1582	2.5	94.0	4.00	0.23	6.48	37
C081	122.4	1562	3414	7.2	11.2	3.99	0.23	6.48	102
C084	45.4	594	3332	6.7	11.1	4.00	0.23	6.48	37
C087	42.1	1535	1196	7.1	48.4	4.00	0.23	6.48	124



Table C2: Recommended Imperviousness Values by Zoning Code

City Zoning Code	Description	Percent Imperviousness
AE	Airport Enterprise	15*
AG	Agriculture	2
AV	Aviation	15*
B1	Limited Business	95
B2	General Business	95
BIR	Business in Residential	65
C2	Commercial Wholesale	95
DC	Downtown Commercial	95
I1	Light Industrial	80
I2	Industrial Park	90
IP	Industrial Park	90*
LM	Limited Manufacturing	90*
LR	Low-Density Residential	30
NB	Neighborhood Business	85
O	Open Zone	2
R1	Low-Density Residential	30**
R2	Medium-Density Residential	75**
R2M	Medium-Density Residential with Independent Manufactured Home	60**
R3	Multifamily	70
R3	PUD	70
RR	Rural Residential	30**
TO	Technology Office	95



Table C3: Horton's Infiltration Parameters

Parameter	NRCS Hydrologic Soil Group Classification			
	A	B	C	D
Initial Infiltration Rate (in/hr)	5	4	2	1
Final Infiltration Rate (in/hr)	0.45	0.225	0.1	0.025
Decay Rate – α (in/hr)	2.52	6.48	6.48	6.48



Table C4: Conveyance Element Characteristics for Data Gap Area Model

Conduit Name	Type	Length (ft)	Manning's Coeff.	Cross-Section	Diameter/Height (ft)	Width (ft)	Barrels	Slope (ft/ft)
CP01	pipe	105	0.012	ARCH	1.5	2.42	2	0.0033
CP02A	open channel	20	varies	IRREGULAR				0.1286
CP02B	open channel	20	varies	IRREGULAR				0.0195
CP03	open channel	413	varies	IRREGULAR				0.0014
CP04	open channel	1,368	varies	IRREGULAR				0.0012
CP05A	open channel	20	varies	IRREGULAR				0.2331
CP05B	open channel	20	varies	IRREGULAR				0.1153
CP06	pipe	118	0.012	CIRCULAR	1		1	0.0039
CP07	open channel	1,211	varies	IRREGULAR				0.0026
CP08	box culvert	2,381	0.012	RECT_CLOSED	3	5	1	0.0019
CP08-S	street	2,381	0.013	IRREGULAR				0.0031
CP09	open channel	1,173	varies	IRREGULAR				0.0035
CP10	pipe	2,344	0.012	CIRCULAR	1.5		1	0.0017
CP10-S	street	2,344	0.013	IRREGULAR				0.0029
CP11	open channel	113	varies	IRREGULAR				0.0058
CP12	pipe	137	0.016	CIRCULAR	4		2	0.0024
CP13	open channel	838	varies	IRREGULAR				0.0010
CP14	pipe	92	0.012	CIRCULAR	2		1	0.0219
CP15	open channel	1,579	varies	IRREGULAR				0.0107
CP16	pipe	475	0.012	CIRCULAR	2		2	0.0044
CP17	pipe	90	0.01	CIRCULAR	2		1	0.0173
CP18	box culvert	419	0.012	RECT_CLOSED	2.42	3.75	1	0.0103
CP19	open channel	907	varies	IRREGULAR				0.0070
CP20	open channel	400	varies	IRREGULAR				0.0303
CP21	pipe	420	0.01	CIRCULAR	2		1	0.0078
CP22	open channel	1,356	varies	IRREGULAR				0.0018



Conduit Name	Type	Length (ft)	Manning's Coeff.	Cross-Section	Diameter/Height (ft)	Width (ft)	Barrels	Slope (ft/ft)
CP23	open channel	852	varies	IRREGULAR				0.0019
CP24	box culvert	128	0.012	RECT_CLOSED	3	5	1	0.0024
CP24S	street	50	0.013	IRREGULAR				0.0563
CP25	pipe	191	0.012	CIRCULAR	2		1	0.0063
CP26	pipe	566	0.012	CIRCULAR	2		1	0.0046
CP27	open channel	80	varies	IRREGULAR				0.1239
CP28	pipe	115	0.01	CIRCULAR	4		1	0.0022
CP29	open channel	484	varies	IRREGULAR				0.0109
CP30	box culvert	690	0.012	RECT_CLOSED	3	5	1	0.0027
CP30-S	street	690	0.013	IRREGULAR				0.0035
CP31	pipe	590	0.012	CIRCULAR	2		1	0.0021
CP31-S	street	590	0.013	IRREGULAR				0.0021



Appendix D (on CD)

- **City-Wide Storm Water System GIS Database**
- **City-Wide EPA-SWMM Model**
- **CIP Prioritization Tool**

