West Bountiful City

Storm Drain
Capital Facilities Plan

August 2008

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1.0 EXECUTIVE SUMMARY

The Storm Drainage Capital Facilities Plan identifies locations in developed areas within West Bountiful City that have inadequate storm drainage infrastructure and the planned storm drainage needs for undeveloped areas that are expected to develop according the City's zoning plan. This study incorporated several methods of data collection for the analysis of the storm drainage system which included collecting input from West Bountiful City public works employees, site visits, video recordings using remote controlled video equipment within storm drain pipes, and a hydrologic computer model.

The City was divided into 23 watershed sub-basins which were arranged so that there were 6 watershed zones. The zones were named according to the manner in which runoff from that zone was conveyed across the Legacy Parkway.

Improvement projects were identified through the analysis. A total of 16 improvement projects and 4 managerial type projects were identified. Project costs were identified as being either a system improvement, existing deficiency, or a combination of these. System improvements costs are funded using money from storm drain impact fees, whereas cost for existing deficiencies will be funded by other monies. The total cost estimated to complete all projects identified is $5,876,225. Total system improvement and existing deficiency costs are $2,713,142 and $3,163,084, respectively.

Table 1-1: Summary of Project Costs

Priority	Existing Deficiency Costs	System Improvement Costs	Total Cost of Projects
High	$762,632	$1,130,296	$1,892,928
Medium	$877,261	$589,998	$1,467,259
Low	$1,523,191	$992,847	$2,516,038
Total	**$3,163,084**	**$2,713,141**	**$5,876,225**

2.0 ABBREVIATIONS

AGRC	–	Automated Geographic Reference Center
CFP	–	Capital Facilities Plan
CMP	–	Corrugated Metal Pipe
CRS	–	Caldwell Richards Sorensen
DSB	–	Deuell-Stone-Barton Canal
NOAA	–	National Oceanic and Atmospheric Administration
NRCS	–	Natural Resources Conservation Service
RCP	–	Reinforced Concrete Pipe
SDCFP	–	Storm Drainage Capital Facilities Plan
UTA	–	Utah Transit Authority

3.0 INTRODUCTION

3.1 Background

This document is a Storm Drainage Capital Facilities Plan (SDCFP) and, is an update to the previous SDCFP, repaired by the City in 2002. It provides an evaluation of the existing storm drain system as well as recommendations for future modifications. Improvements necessary to maintain an adequate and consistent level of service are identified and prioritized. Changes in growth patterns, system degradation, and escalating construction costs make in necessary to periodically reevaluate the storm drain system needs and update the SDCFP in order to maintain an adequate level of service and to verify that funding sources are adequate to support the future needs of the storm drain system.

3.2 Scope of Investigation

Caldwell Richards Sorensen (CRS) entered into a contract with West Bountiful to evaluate the City's storm water conveyance and detention system. This evaluation included the collection of information regarding storm drain pipes, ditches, and detention areas. Specific interests included appraisal of the current performance and physical characteristics of the storm drain system. The system was analyzed for both existing and built-out conditions using a hydrologic computer model. Improvement projects were identified to address any deficiencies, current and projected, within the system. Cost were estimated for each improvement project and target completion dates were assigned. Factors that were not considered in the analysis of the storm drainage system are as follows:

- *Hydrologic and hydraulic analysis of Davis County canals* – It is assumed in this analysis that sufficient capacity exists within these waterways such that any backwater effects are negligible.
- *Snowmelt conditions* – Periods of peak snowmelt may decrease available capacity in the existing storm drain system, thus creating a potential for flooding to occur.
- *Subsurface drainage systems* – Sump pumps, foundation drains, and other privately owned systems exist in many areas throughout the city, and are intended to control flooding caused by groundwater. These subsurface drainage systems often discharge into the city's storm drain system. Quantification of the amount of water discharged to the storm drain system by subsurface drainage systems is extremely difficult and was not included in the scope of this project.
- *Clogging of inlets and storm drains* – This investigation assumes that the inlet structures and water conveyance systems are free from excessive debris and other items of potential clogging. It also assumes that all pipes, inlet structures, and outlet structures are fully functional.
- *I-15 Runoff* – This investigation assumes that all runoff generated from I-15 is conveyed through systems that are not part of the City's storm drain system and thus will not affect the performance of the West Bountiful City existing storm drainage system.

- *Computer Model* – The hydrologic analysis performed for this project included a computer model. The model is large scale and should be used as a guide to determine approximate system needs. Design of actual improvement projects should include a more detailed analysis of the drainage area in the vicinity of the project.

The SDCFP documents the storm drainage system analysis performed by CRS and presents the recommended system improvement projects to be included in the City's Capital Improvement Program.

4.0 EXISTING CONDITIONS

The performance of the existing storm drain system was analyzed by (1) defining the watershed area, (2) collecting information regarding the existing infrastructure from city Public Works personnel, and (3) creating a large scale computer model of the system. Each of the steps that aided with identifying deficiencies within the system are discussed below.

4.1 Study Area

The future West Bountiful City boundary, which includes areas planned for annexation, defines the limits of the watershed boundary analyzed in this study. The area encompassed by the future City boundary is approximately 3.55 square miles. Based on contour data obtained from the Utah Automated Geographic Reference Center (AGRC), the area was divided into 23 sub-basins which make up six watershed zones. The zones are named as follows: West, Northwest, Northeast, DSB, Millcreek, and A1-A2. The map shown in Figure 4.1 shows the delineation of the six watershed zones.

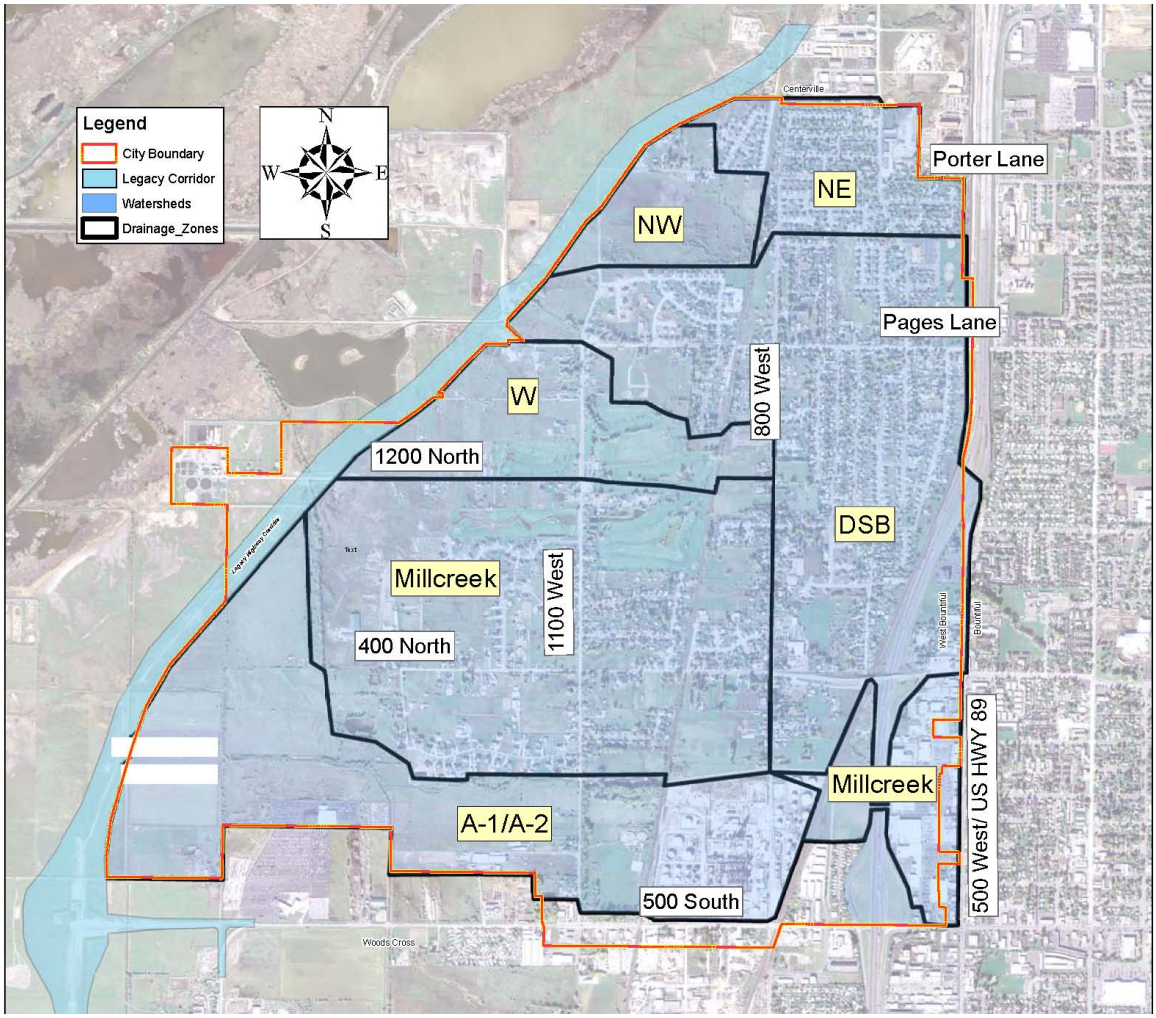

Figure 4.1: Delineation of watershed zones.

The zone names represent how or where flows are conveyed across the Legacy Parkway, for example, the Millcreek zone represents all sub-basins that convey storm water through the Millcreek Canal across the Legacy Parkway.

4.2 Infrastructure

In general, storm water surface flows are conveyed in a northwesterly direction across each sub-basin where they are collected in County owned and maintained canals, there are four county owned canals within the city boundary. These canals are listed as follows from the most northern to the most southern: Deuel-Stone-Burton (DSB) Canal, Millcreek Canal, A-2 Canal and A-I Canal. Through these canals, runoff is ultimately carried across the Legacy Parkway to the Great Salt Lake. The exception to this scenario occurs at locations adjacent to the extreme western city boundary where non-County owned storm drain pipes have been installed beneath the Legacy Parkway. A map of the documented storm drain system is shown in Figure 4.2.

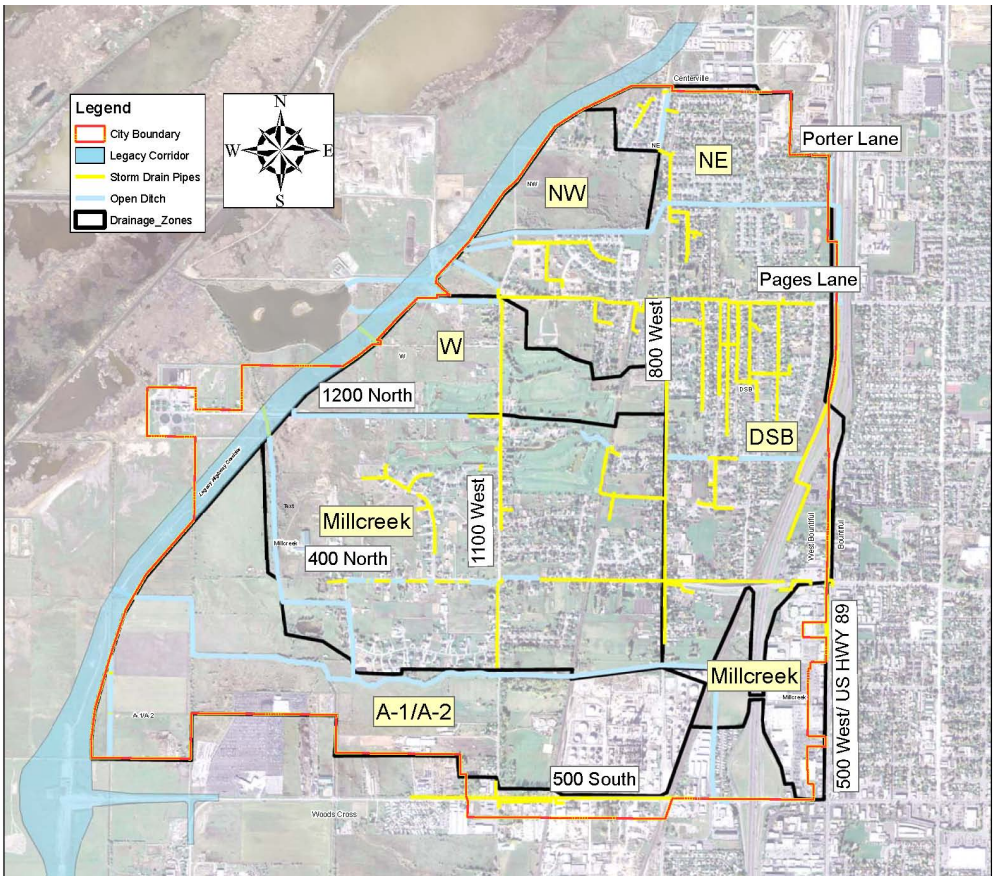

Figure 4.2: Existing storm drain infrastructure layout.

The Legacy Parkway, 1100 West, 800 West, I-15, and the UTA Rail Corridor each create physical divisions that require flows to be piped, and in some cases pumped, in order to convey flows across them. Exact locations of many of these crossings are not well documented. Therefore, all such crossings are not included in the scope of this analysis.

Through visual inspection and from information provided by the Public Works employees, various types of problems with the existing storm drainage infrastructure have been identified.

- Some residential developments have poorly functioning storm drain systems. This is due to a variety of problems including undersized pipes, limited access for maintenance, and old and deteriorating infrastructure.
- Several residential developments have incorporated a hodge-podge of subsurface drains and irrigation systems along side and back property lines. These systems are not well documented and as a result have not been properly maintained. No subsurface drains were considered in this analysis.
- Several neighborhoods only use surface drainage features such as gutters and road side ditches to convey storm water. It is typical of these systems to include a single inlet and discharge pipe in order to convey runoff into the storm drainage system. This scenario is prone to flooding due to debris clogging the grate and pipe.
- There are multiple locations where storm drain infrastructure was installed semi recently, but due to poor installation processes and/or materials the pipes are now damaged or otherwise unable to function as intended.
- In undeveloped or agricultural areas storm drainage is handled by a combination of culverts and ditches. Unfortunately, many of these culverts are undersized and the ditches are a frequent maintenance issue.

4.3 Computer Model

Haestad Methods PondPack Version 8.0 modeling software was used to create a model of the storm drainage system. Each zone was modeled separately for both existing and built-out conditions. Results from these analyses are discussed in the following Section 4.4. Figure 4.3 is a depiction of the user interface for the hydrologic computer modeling software. This software requires input for meteorological, hydrologic, and hydraulic parameters. Each of these parameters is discussed below.

4.3.1 Meteorological Parameters

Site specific rainfall data was obtained from the National Oceanic and Atmospheric Administration's (NOAA's) National Weather Service Precipitation Frequency Data Server. An NRCS Type-II 24-Hour synthetic storm distribution was applied to the rainfall, which was assumed to have an even distribution over the entire watershed. Both the 10 and 100-year frequency storms were analyzed using this rainfall distribution to assess the performance of the storm drain system infrastructure.

4.3.2 Hydrologic Parameters

Runoff was estimated using the Natural Resources Conservation Service (NRCS) formerly known as the Soil Conservation Service (SCS), Runoff Curve Number method. Multiple field investigations were completed in order to determine land cover and soil characteristics, both of which are essential to determining curve number values. Using this information, curve numbers were determined from curve number tables provided in the SCS TR-55 manual. Times of concentration for each sub-basin were determined using the Velocity Method, from TR-55. Routing of flows through pipes and channels was done using the Modified Puls method. Values used for each of these parameters can be found in the appendix.

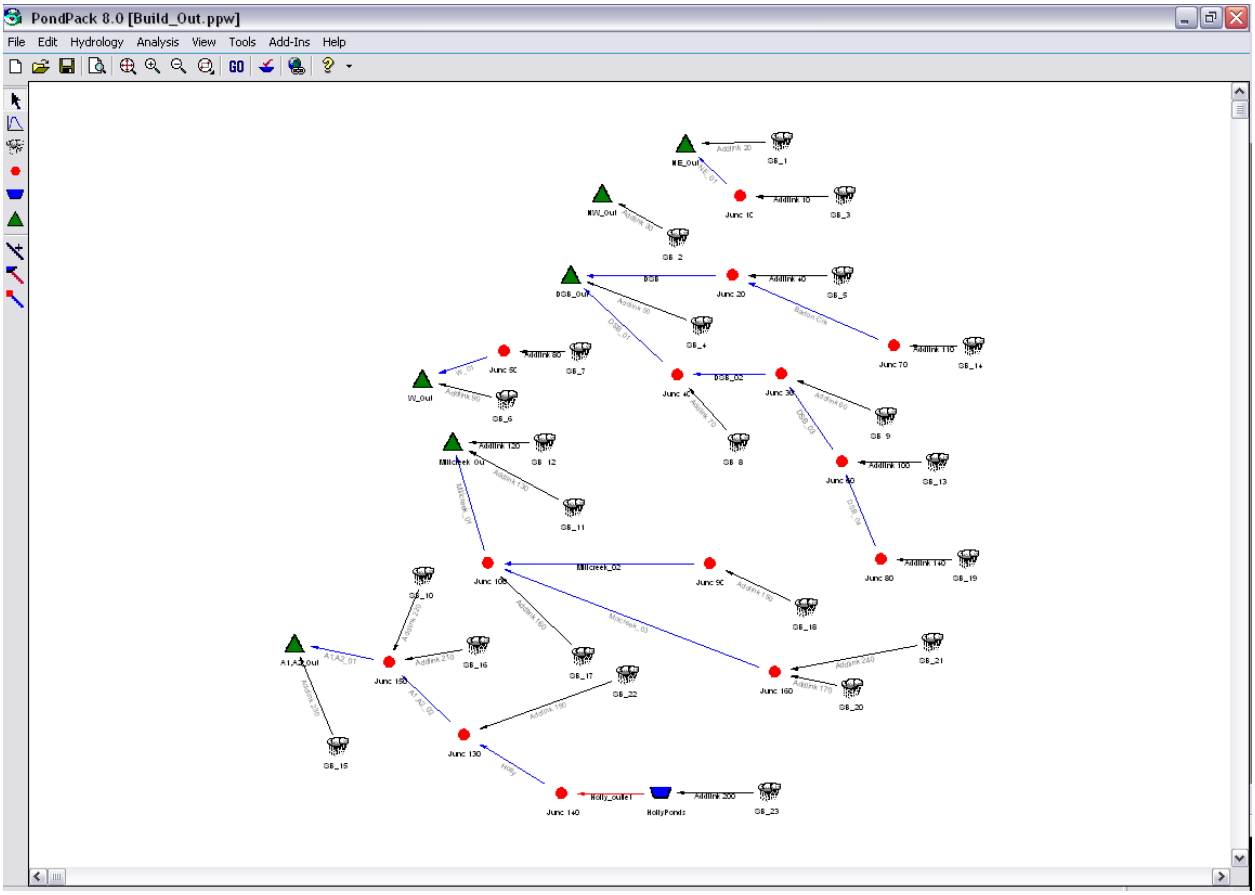

Figure 4.3. Pond Pack Model Schematic

4.3.3 Hydraulic Parameters

Hydraulic parameters only pertain to flow within ditches or pipes. Flow capacities were determined using Manning's Equation. Manning's roughness values for pipes were assigned using a table of recommended values produced by the United States Federal Highway Administration (FHWA). Roughness values for flow in ditches were determined similarly, however, visual inspection of each ditch was done in order to assign appropriate roughness values. Bed slopes for both ditches and pipes were determined from either survey/design/as-built data, topographic data from AGRC, or by visual inspection. Values used for each of these parameters can be found in the appendix.

4.4 Results

Peak flows were increased for every watershed zone except the Northwest Zone. Table 4-1 presents the peak flows for each of the watershed zones based on existing conditions. Each zone has its own set of unique issues with storm water infrastructure. A brief discussion of these issues is given in the following paragraphs for each of the watershed zones.

Table 4-1. Existing Flow

Watershed Zone Name	Area (acres)	Existing 10-Year Peak Flow (cfs)
Northeast	126.4	52.94
Northwest	88.1	13.9
DSB	546.5	159.12
West	171.0	24.75
Millcreek	702.2	142.18
A-1/A-2	478.7	52.9

4.4.1 Northeast Zone

The northeast zone is almost entirely developed. The most common land use is medium density single family residential lots, with most of the homes built in the early 1980s. Surface flow in the gutters is the primary method of conveyance for storm water runoff. Runoff is collected through two curb inlets and then sent west through an 18" concrete pipe that discharges into an open ditch along the Utah Transit Authority (UTA) Rail Corridor. One home, located immediately to the west of where the curb inlets are located, has flooded multiple times. Recently, a wetland detention basin was constructed within this zone to reduce peak flows before discharging runoff. Multiple culverts across the Legacy Parkway convey runoff to the north and west.

4.4.2 Northwest Zone

Nearly all of the area within the northwest zone is undeveloped. No existing deficiencies were identified within this zone. Storm water flows within this zone are generally conveyed overland and through private ditches. Multiple culverts across the Legacy Parkway convey storm water to the west.

4.4.3 West Zone

The west zone encompasses a handful of older residential developments, a portion of the Lakeside Golf Course, and a large portion of undeveloped land. The storm drain pipe along 1100 West was inspected with a remote controlled video recording device by Twin "D" Inc. in March 2008. This inspection resulted in several deficiencies being identified within this zone. Additionally, a portion of the runoff from this zone is conveyed to the Legacy Parkway through an overgrown ditch and undersized culverts, which require frequent maintenance.

4.4.4 DSB Zone

This zone is very large and encompasses most of the residential developments within the city, a moderately sized commercial area located north of 400 north and east of I-15, several areas where recent development projects have occurred, and a small portion of undeveloped land. Many of the older developments have undersized storm drain pipes. Additionally, a portion of the runoff from this zone is conveyed to the Legacy Parkway through an open ditch that is in dire need of maintenance to remove debris and vegetation.

4.4.5 Millcreek Zone

This zone is quite large and diverse in regard to land use. The entire West Bountiful Commons commercial center is within this zone as well as a handful of older residences, the several recent residential developments, a portion of the Lakeside Golf Course, and a large portion of undeveloped land. Much of the storm drain pipe along the major roads within this zone needs to be replaced. Open ditches located at various locations throughout this zone require regular maintenance and many culverts that convey ditch flows are undersized.

4.4.6 A-1/A-2 Zone

This zone includes the entire Holly Oil Refinery property, several residential areas, and a large portion of undeveloped land in the southwest corner of the City. Much of the runoff from Holly property is detained in an area termed the “Phillip’s Ponds”. This scenario was included in the model. No existing deficiencies were identified within this zone.

5.0 FUTURE CONDITIONS

5.1 Growth and Demand Projections

Future conditions are based on a built out scenario, which is expected to be realized by 2028. Future runoff quantities were determined by assuming that presently undeveloped lands will be developed according to the Future Land Use Plan contained in the West Bountiful City General Plan. The Future Land Use Plan is shown below in Figure 5.1.

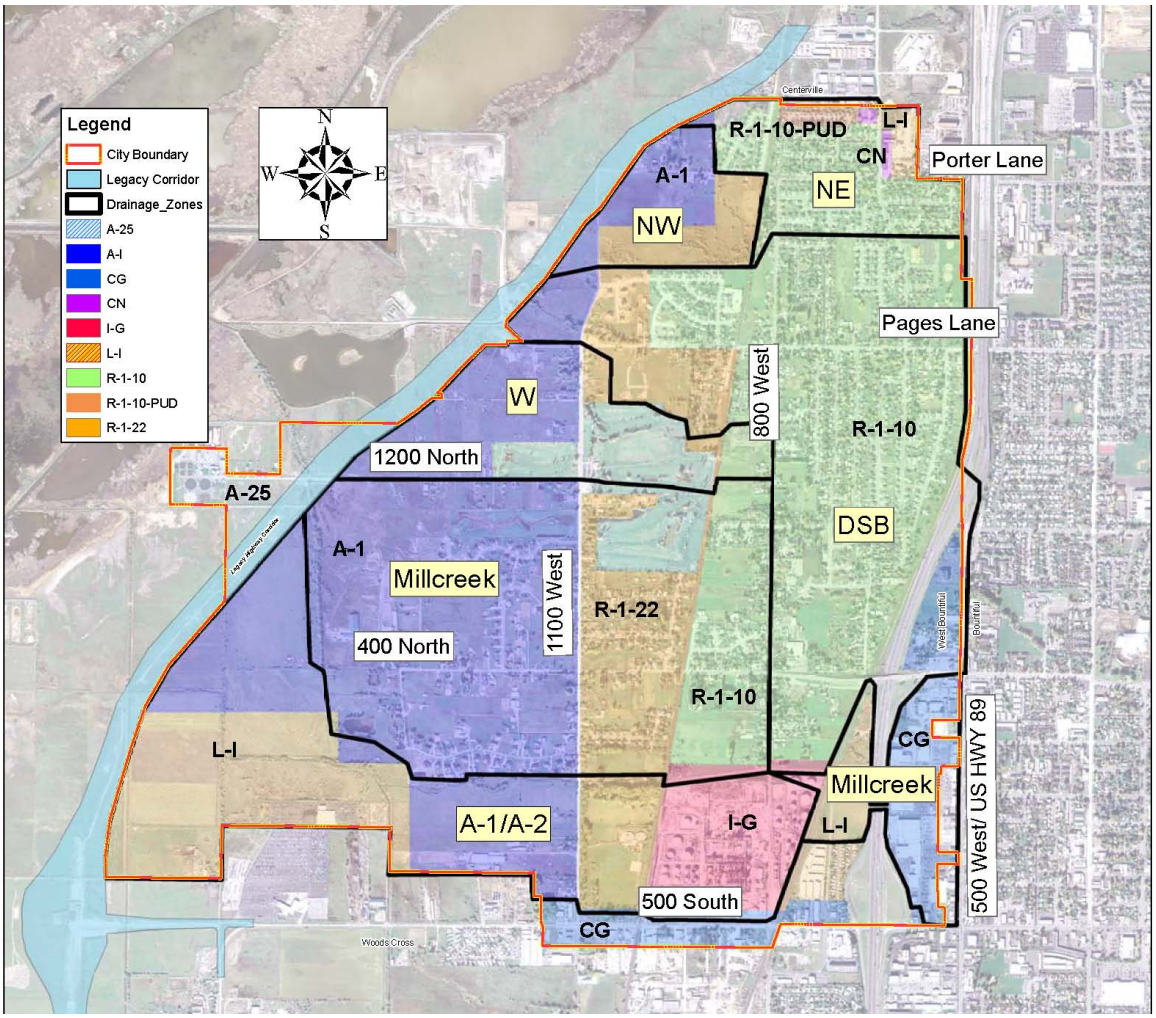

Figure 5.1. Future Land Use Plan.

As development progresses into currently undeveloped areas, peak flows with their increase. There are approximately 934 acres of currently undeveloped land within the future City boundary, including land that is anticipated to be annexed. The majority of this undeveloped land is located west of 1100 West. Much of this land is zoned to allow for a minimum residential

lot size of 1 acre, however, there is a significant portion located in the southwest corner of the city that is zoned for light industrial use. Multiple improvement projects were identified within the city required to meet the drainage needs at built-out conditions. Each of these projects is discussed in the following chapter. Table 5-1 presents the expected peak flows at built-out conditions and provides a comparisons with the existing peak flows.

Table 5-1. Existing and Built-Out Conditions Flow Comparison

Watershed Zone Name	Area (acres)	Existing 10-Year Peak Flow (cfs)	Built-Out 10-Year Peak Flow (cfs)
Northeast	126.4	52.94	56.28
Northwest	88.1	13.9	13.9
DSB	546.5	159.12	217.74
West	171.0	24.75	36.01
Millcreek	702.2	142.18	195.61
A-1/A-2	478.7	52.9	179.43

6.0 RECOMMENDATIONS

6.1 Evaluation Criteria

City standards require that all storm drain pipe designs must adequately convey flows for the 10-year 30 minute rainfall event. The minimum allowable storm drain pipe diameter for all new construction is 15 inches. Additionally, all detention basin designs are required to detain flows generated by the 100-year rainfall event with a maximum discharge equal to the flow generated by the 10-year 30 minute rainfall event. The current City standard permits the use of the rational method for developments smaller than 25 acres. Due to the large scale of this analysis, an NRCS Type-II 24-hour rainfall distribution was used to analyze the adequacy and needs of the City storm drainage system. This storm distribution was analyzed for the 10 and 100-year rainfall events.

Storm drain system deficiencies were identified using a hydrologic model and by collecting input from City Public Works employees who are very knowledgeable of the performance of the system. Improvement projects have been created in response to each deficiency that currently exists and/or is expected to exist within the system at built-out conditions. Each project was assigned a project number and is described in the following section of this report. Each project is identified as being a high, medium, or low priority.

6.2 Storm Drain Capital Improvement Plan

Table 6-1 provides a summary of the recommended improvement projects. A depiction of all storm drain improvement project locations is given in Figure 5.1. Additionally, cost estimates are provided in the appendix for each of the projects listed below.

Table 6-1: Summary of Recommended Improvement Projects

Number of Projects By Type				
Priority	Conveyance	Detention	Additional	Total
High	7	0	3	10
Medium	2	3	1	6
Low	4	0	0	4
Total	13	3	4	20

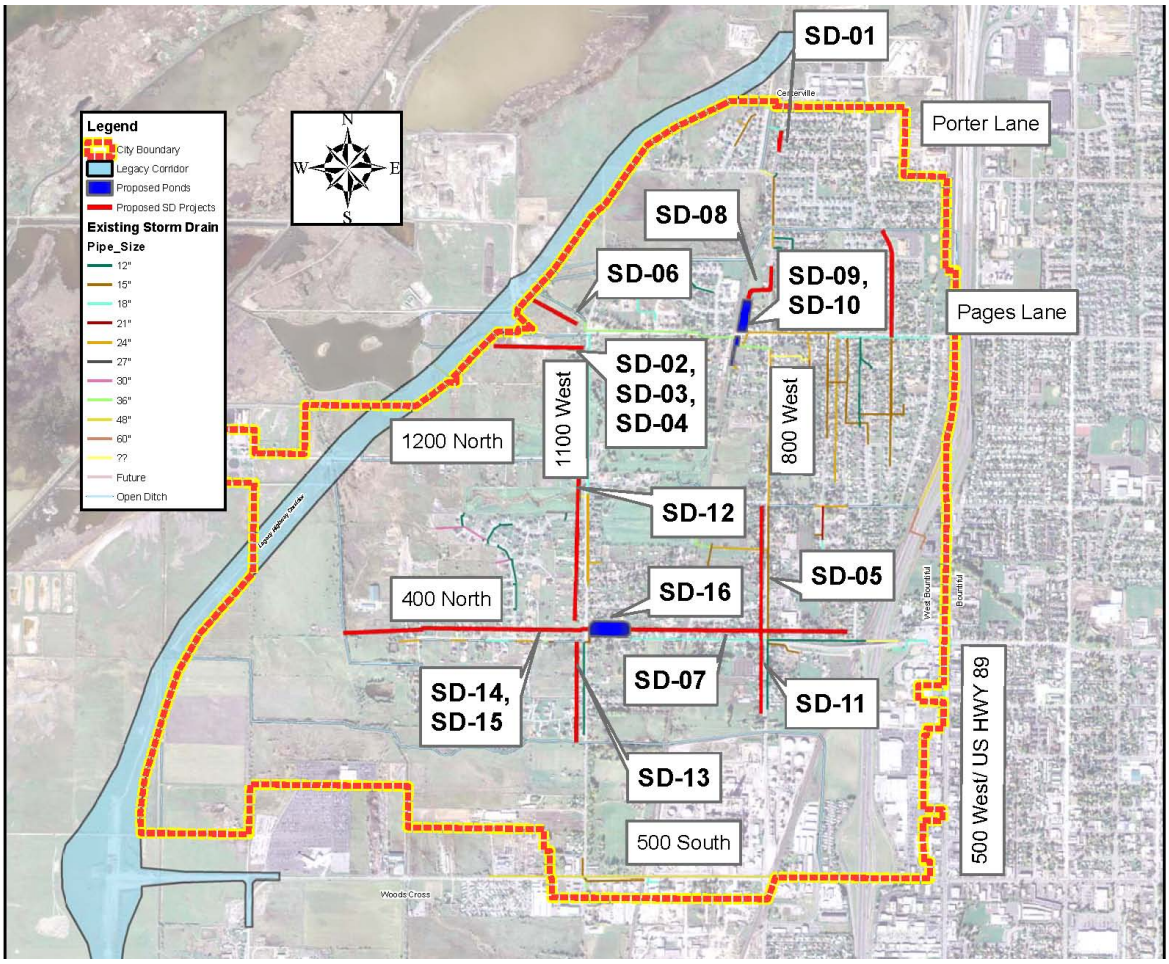

Figure 6.1. Storm Drain Improvement Projects.

6.2.1 Northeast Zone Projects

SD-01 – High Priority, Conveyance

- Location-On 800 West from 2250 North to 2300 North
- Description-Install approximately 400 feet of new 15 inch concrete storm drain pipe and three new inlet boxes
- Need-This area has had increasingly more frequent flooding due to the fact that there are only two inlet grates for the entire neighborhood. This addition would alleviate the problem by allowing multiple locations for the flow to enter the storm drain system in case other inlet(s) are clogged.
- Completion Date-2012
- Special Considerations-There is a land drain that connects to the existing inlet box on the east side of 800 West. Maintenance of the drain pipe is not the responsibility of the City; however, its performance can affect the performance of the storm drain system.

6.2.2 Northwest Zone Projects

No improvement projects were identified within this zone.

6.2.3 West Zone Projects

SD-02 – High Priority, Conveyance

- Location-On Pages Lane from 1100 West to the Legacy Parkway
- Description-Clean ditch and upsize all culverts with 24 inch concrete pipe
- Need-The ditch needs regular maintenance to clean out sediment and vegetation. Many of the culverts are undersized and pose a flooding risk to adjacent properties.
- Completion Date-2010
- Special Considerations-None

SD-03 – Low Priority, Conveyance

- Location-On Pages Lane from 1100 West to the Legacy Parkway
- Description-Install 2,500 feet of new 30 inch concrete pipe
- Need-The West Bountiful General Plan calls for all ditches to be replaced with pipes as development reaches full build-out conditions. This project was created to comply with the General Plan.
- Completion Date-2022
- Special Considerations-There may be residents that use water from the ditch for irrigation purposes. Whether or not to continue this option to the residences needs to be determined.

SD-04 – High Priority, Conveyance

- Location-1100 West and Pages Lane
- Description-Replace undersized storm drain pipe with new 18 inch concrete pipe
- Need-The existing pipe is undersized and was installed improperly.
- Completion Date-2014
- Special Considerations-None

6.2.4 DSB Zone

SD-05 – Low Priority, Conveyance

- Location-On 800 West from 400 North to 1000 North
- Description-Replace existing storm drain with 800 feet of 24 inch concrete pipe and 1000 feet of 18 inch concrete pipe. Install 12 new inlet boxes.
- Need-The existing infrastructure does not have the capacity to meet growth related demands.
- Completion Date-2020
- Special Considerations-None

SD-06 – High Priority, Conveyance

- Location-Immediately north of Pages Lane and west of 1100 West
- Description-Removal of trees and vegetation from ditch
- Need-The ditch is currently obstructed due to vegetative growth which causes water to back up and pose a flooding risk to nearby properties.
- Completion Date-2009
- Special Considerations-None

SD-07 – High Priority Conveyance

- Location-On 400 North from 660 West to 1100 West
- Description-Replace existing pipe with 4,065 feet of new 24 inch concrete pipe
- Need-The current storm drain system in this area has several sizes and materials of pipe, most of which is undersized and/or has surpassed its design life.
- Completion Date-2012
- Special Considerations-This project should be coordinated with the replacement of the 400 North waterline and road reconstruction projects.

SD-08 – Low Priority Conveyance

- Location-On 800 West from the DSB Canal to Pages Lane
- Description-Replace existing pipe with 2600 feet of 24 inch concrete pipe and install 14 new inlet boxes
- Need- The existing infrastructure does not have the capacity to meet growth related demands.
- Completion Date-2026
- Special Considerations-None

SD-09 – Medium Priority, Detention

- Location-Southeast corner of Pages Lane and the UTA Rail Corridor
- Description-Expand existing detention pond
- Need-Eliminate the need to upsize storm drain pipes downstream of this location due to growth related demands
- Completion Date-2015
- Special Considerations-Permission from UTA to use the rail corridor. The rail corridor is planned to be converted to a public trail through the rails to trails program.

SD-10 – Medium Priority, Detention

- Location-Northeast corner of Pages Lane and the UTA Rail Corridor
- Description-Construct new detention pond

- Need-This will, in combination with Project SD-09, aid in eliminating the need to upsize storm drain pipes downstream of this location as growth occurs.
- Completion Date-2015
- Special Considerations-Land acquisition should be completed as soon as possible to avoid the cost of appreciating land values.

6.2.5 Millcreek Zone

SD-11 – Medium Priority, Conveyance

- Location-On 800 West from Mill Creek Canal to 400 North
- Description-Replace existing pipe with 1400 feet of 15 inch concrete pipe and 8 new inlets. Configure system to reroute all flows at this location toward the west on 400 North.
- Need-Improve the efficiency of the system and allow additional capacity from new developments north of 400 North.
- Completion Date-2018
- Special Considerations-None

SD-12 – Medium Priority, Conveyance

- Location-On 1100 West from 400 North to 1200 North
- Description-Replace several damaged pipe sections:
  - 65 feet of 24 inch CMP
  - 220 feet of 27 inch CMP
  - 20 feet of 30 inch CMP
- Need-Damaged pipe sections were identified during a camera inspection of the storm drain system. The damaged sections have the potential to restrict flows and pose a flooding risk to properties along 1100 West
- Completion Date-2014
- Special Considerations-None

SD-13 – High Priority, Conveyance

- Location-On 1100 West from Mill Creek Canal to 400 North
- Description-Replace existing pipe with 660 feet of 15 inch concrete pipe and 900 feet of 30 inch concrete pipe, install 12 new inlets, and install 3 new irrigation turnouts
- Need-The existing system is in disrepair and does not have the capacity to meet future growth demands
- Completion Date-2013
- Special Considerations-Ensure that residents with existing water rights are provided with a way to remove water from the pipe for irrigation purposes.

SD-14 – High Priority, Conveyance

- Location-On 400 North from 1100 West to 1450 West

- Description-Clean ditch and upsize all culverts with 30 inch concrete pipe
- Need-The ditch needs regular maintenance to clean out sediment and vegetation. Many of the culverts are undersized and pose a flooding risk to adjacent properties.
- Completion Date-2010
- Special Considerations-None

SD-15 – Low Priority, Conveyance

- Location-On 400 North from 1100 West to 1450 West
- Description-Install 2,875 feet of new 36 inch concrete pipe
- Need-The West Bountiful General Plan calls for all ditches to be replaced with pipes as development reaches full build-out conditions. This project was created to comply with the General Plan.
- Completion Date-2022
- Special Considerations-There may be residents that use water from the ditch for irrigation purposes. Whether or not to continue this option to the residences needs to be determined.

SD-16 – Medium Priority, Detention

- Location-Northeast corner of 400 North and 1100 West
- Description-Construct new detention pond
- Need-Aid in eliminating the need to upsize storm drain pipes downstream of this location as growth occurs.
- Completion Date-2015
- Special Considerations-Land acquisition should be completed as soon as possible to avoid the cost of appreciating land values.

6.2.6 A-1/A-2 Zone

No improvement projects were identified within this zone.

6.2.7 Additional Projects

SD-17 – High Priority

- Location-Not Applicable
- Description-Prepare Capital Facilities Plan
- Need-To determine new Impact Fee rates and identify improvement projects
- Completion Date-2008
- Special Considerations-None

Prepare the SDCFP.

SD-18 – High Priority

- Location- Not Applicable
- Description-Update Storm Water Impact Fees

- Need-Future development will exceed the capacity of the existing system
- Completion Date-2008
- Special Considerations-None

Update storm drainage impact fees.

SD-19 – Medium Priority

- Location- Not Applicable
- Description-Update Capital Facilities Plan in 5 Years
- Need-Record improvement projects that have been completed and identify projects so that system can perform acceptably
- Completion Date-2013
- Special Considerations-None

SD-20 – High Priority

- Location- Not Applicable
- Description-Update Storm Water Management Plan
- Need-Recent changes by the State of Utah Division of Water Quality require that the SWMP be updated for compliance the General UPDES Permit
- Completion Date-2009
- Special Considerations-None

Update the Storm Water Management Plan to remain in compliance with the General UPDES Permit.

6.3 Costs

Costs were determined for each project. The overall planned cost to complete all projects identified is $5,876,225. The timing until the completion of all identified projects is planned to span from 2008 to 2026. Costs were split into two components, *existing deficiencies* and *system improvements*.

An existing deficiency is described as the portion of a storm drainage project that is made necessary because the existing system is currently inadequate to convey flows generated by the 10-year 30 minute rainfall event. Existing deficiencies are not related to future development and often these projects include maintenance activities.

System improvements are projects or portions of projects that have been identified to improve the existing system so that increased runoff from recent and/or future development can be adequately handled. Projects such as storm drain analyses and preparation of storm drain management plans are considered system improvement projects. System improvement projects are funded by money generated from storm drain impact fees.

A complete list of recommended projects identified by this analysis is located in the Appendix of this report. A summary of the costs are shown below in

Table 6-2.

Table 6-2: Summary of Project Costs

Priority	Existing Deficiency Costs	System Improvement Costs	Total Cost of Projects
High	$762,632	$1,130,296	$1,892,928
Medium	$877,261	$589,998	$1,467,259
Low	$1,523,191	$992,847	$2,516,038
Total	**$3,163,084**	**$2,713,141**	**$5,876,225**

7.0 REFERENCES

Old impact fee document

General Plan

Soil Conservation Service, Technical Release No. 55, Washington D.C., 1986.

Precipitation Frequency Data Server. National Oceanic & Atmospheric Administration's National Weather Service. 30 May 2008. <http://hdsc.nws.noaa.gov/hdsc/pfds/index.html>.

WinTR-55 User Manual. Jan. 1975. Natural Resources Conservation Service. Revision Date 19 Apr. 2002. <http://www.wsi.nrcs.usda.gov/products/W2Q/H&H/docs/WinTR55/user_man_2002.doc>.

8.0 APPENDIX

Model Results

Project List and Estimated Costs

APPENDIX: MODEL RESULTS

APPENDIX: PROJECT LIST AND ESTIMATED COSTS