City of Cheyenne
Board of Public Utilities

# Volume 7 – Wastewater Collection

## 2013 Cheyenne Water and Wastewater Master Plans

### Final

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ONE COMPANY | *Many Solutions*

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# Abbreviations and Acronyms

| | |
|---|---|
| AC | Acre |
| ADF | Average Daily Flow |
| BOPU | Board of Public Utilities |
| BSF | Base Sanitary Flow |
| CCTV | Closed-circuit Television |
| CCWRF | Crow Creek Water Reclamation Facility |
| CFS | Cubic feet per second |
| CIP | Capital Improvement Plan |
| CIPP | Cured-in-Place Pipe |
| CIPU | Cast Iron Pipe Unlined |
| City | City of Cheyenne |
| CLHDPE | Concrete Lined with High Density Polyethylene |
| CMMS | Computerized Maintenance Management System |
| CoF | Consequence of Failure |
| DCWRF | Dry Creek Water Reclamation Facility |
| dia | Diameter |
| DIP | Ductile Iron Pipe |
| EAM | Enterprise Asset Management |
| EPA | Environmental Protection Agency |
| FRP | Fiberglass Reinforced Pipe |
| FOG | Fats, Oils and Greases |
| ft | Feet |
| ft/s | Feet per second |
| gal | Gallon |
| gpcd | Gallons per Capita per Day |
| gpd/ac | Gallons per Day per Acre |

| | |
|---|---|
| GIS | Geographic Information System |
| gpm | Gallons per Minute |
| HDPE | High Density Polyethylene |
| I/I | Infiltration and Inflow |
| LxWxH | Length x Width x Height |
| LoF | Likelihood of Failure |
| Master Plans | 2013 Cheyenne Water and Wastewater Master Plans |
| MDF | Maximum Day Flow |
| MG | Million Gallons |
| mgd | Million Gallons per Day |
| MINDF | Minimum Daily Flow |
| NASSCO | National Association of Sewer Service Companies |
| NOAA | National Oceanic and Atmospheric Administration |
| PHF | Peak Hour Flow |
| PVC | Polyvinyl Chloride |
| q/Q | Flow over Full Pipe Flow |
| RCP | Reinforced Concrete Pipe |
| RDII | Rainfall-dependent Infiltration and Inflow |
| sq ft | Square Feet |
| SCWSD | South Cheyenne Water & Sewer District |
| SSO | Sanitary Sewer Overflow |
| VCP | Vitrified Clay Pipe |
| Volume 2 | Volume 2 – Future Capacity Requirements |
| Volume 7 | Volume 7 – Wastewater Collection |
| Volume 8 | Volume 8 – Wastewater Treatment |
| Volume 9 | Volume 9 – Financial Plan and Cost of Service Allocation |
| Volume 10 | Volume 10 – Information Technology Master Plan |
| Warren AFB | F.E. Warren Air Force Base |

| | |
|---|---|
| WDEQ | Wyoming Department of Environmental Quality |
| WRF | Water Reclamation Facility |
| yr | Year |

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# 7.1 Introduction

This Volume describes the existing wastewater collection facilities for the City of Cheyenne (City) Board of Public Utilities (BOPU) and presents recommendations for improvements due to existing capacity deficiencies, pipe condition and/or system growth over the three planning periods: near-term (2014-2023), mid-term (2024-2033) and long-term (2034-2063).

Wastewater collection system modeling provides insight into how wastewater is collected throughout the system and where there may be areas that have capacity issues including surcharged pipes or sanitary sewer overflows (SSOs). This Volume presents an evaluation of the existing collection system and recommends improvements to eliminate current capacity deficiencies and meet future flow needs. Although the actual rate, location and timing of growth are unknown, a long-range capital improvement framework allows BOPU to evaluate and prioritize improvements as the growth occurs. Collection system performance requires adequate capacity to convey and pump, where necessary, maximum day and peak hour flows.

The following items are documented in this Volume:

- Summary of existing system facilities and operation.
- Update of the hydraulic model, including updates to model facilities, allocation of flow, validation using field data and addition of analysis scenarios.
- Analysis of the collection system under maximum day flows (MDF) and peak hour flows (PHF) during wet-weather conditions.
- Analysis of existing and future lift station capacities and locations.
- Recommendations for system flow monitoring.
- Development of a method for collection system assessment for main rehabilitation and replacement.
- Recommendations for a preventative maintenance plan including asset management, condition inspection, main cleaning, root control, fats, oils and grease (FOG)/industrial pre-treatment program and odor complaint and sewer backup tracking.
- Summary of recommendations for infrastructure improvements, flow monitoring, collection assessment and preventative maintenance.
- Presentation of capital improvement projects with estimated costs for the near-term and mid-term planning periods.

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## 7.2 Existing Collection System

This section summarizes the existing system including sewer basins, mains and interceptors and lift stations, wetwells and forcemains. Figure 7-1 shows the existing sewer service boundary, collection system, major facilities and sewer basin boundaries.

### 7.2.1 Sewer Basins

There are four drainage basins in the current sewer service area: Crow Creek, Dry Creek, Clear Creek and Allison Draw. Wastewater from these drainage basins flows, generally by gravity, to one or both of the Water Reclamation Facilities (WRFs). Crow Creek and Clear Creek convey flow to Crow Creek Water Reclamation Facility (CCWRF) while Dry Creek and Allison Draw convey flow to Dry Creek Water Reclamation Facility (DCWRF). Several existing areas within the service area must be pumped to gravity interceptors that convey the flow to the WRFs. A fifth drainage basin, Child's Draw, lies north of the service area and cannot flow by gravity to either WRF and is currently not served by the collection system. In the future, a portion of Child's Draw could be served with a lift station.

Within the four served drainage basins, there are a total of thirteen sewer basins. The sewer basins are defined primarily by topography and collection system connectivity. They represent either major areas of gravity collection with a downstream connecting interceptor to other sewer basins or a WRF or areas of gravity collection that are pumped via a lift station to a downstream sewer basin. Table 7-1 summarizes the thirteen existing sewer basins.

**Table 7-1**
**Existing Sewer Basins**

| Name | Drainage Basin | Area (Acres) | Gravity or Pumped |
|---|---|---|---|
| Capital North | Crow Creek | 2,529 | Gravity |
| Capital South | Crow Creek | 1,967 | Gravity |
| Clear Creek | Clear Creek | 6,547 | Gravity/Pumped |
| Dry Creek North | Dry Creek | 4,927 | Gravity |
| Dry Creek South | Dry Creek | 4,393 | Gravity/Pumped |
| Goodman | Crow Creek | 36 | Pumped |
| Henderson | Crow Creek | 1,307 | Gravity |
| Holliday | Crow Creek | 1,380 | Gravity |
| Lincolnway | Crow Creek | 1,224 | Gravity |
| North Range Business Park | Crow Creek | 1,961 | Gravity |
| South Cheyenne | Allison Draw | 3,844 | Gravity |
| The Pointe 1 | Dry Creek | 168 | Pumped |
| The Pointe 2 | Dry Creek | 180 | Pumped |
| Warren Air Force Base | Crow Creek | 4,501 | Gravity |

### 7.2.2 Mains and Interceptors

The existing collection system consists of approximately 327 miles of active mains and interceptor pipelines ranging in size from 4 to 42 inches and 8,559 manholes. Mains are pipelines generally categorized with diameters from 4 to 16 inches while interceptors are pipelines generally categorized with diameters from 18 inches and larger. Table 7-2 lists the total length of mains and interceptors by diameter from the pipe inventory as of December 2012 and by material and pipe diameter from the geographic information system (GIS) database as of March 2013. The GIS database manholes as well as pipe lengths and materials were used as the basis for hydraulic modeling of the distribution system.

**Table 7-2**
**Sewer Pipelines by Material and Diameter**

| | | GIS Database (March 2013) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter | Pipe Inventory (December 2012) | Cast Iron Pipe Unlined (CIPU) | Concrete lined with High Density Polyethylene | Ductile Iron Pipe (DIP) | Fiberglass Reinforced Pipe (FRP) | High Density Polyethylene (HDPE) | Polyvinyl Chloride Pipe (PVC) | Reinforced Concrete Pipe (RCP) | Vitrified Clay Pipe (VCP) | Unknown | Total Length (ft) |
| Length of Mains (ft) | | | | | | | | | | | |
| 4" | 0 | 626 | - | - | - | - | 2,906 | - | 966 | 3,693 | 8,191 |
| 6" | 83,447 | 369 | - | - | - | 372 | 18,465 | 723 | 41,520 | 39,698 | 101,147 |
| 8" | 1,169,778 | 1,708 | - | 1,752 | - | 10,718 | 647,450 | 5,097 | 535,239 | 253,774 | 1,442,134 |
| 9” | 14,607 | - | - | - | - | - | - | - | - | - | 0 |
| 10" | 75,552 | - | 352 | - | - | 1,921 | 23,826 | 2,151 | 38,912 | 6,968 | 74,129 |
| 11” | 245 | - | - | - | - | - | - | - | - | - | 0 |
| 12" | 130,464 | 253 | - | - | - | 483 | 82,250 | 1,206 | 98,046 | 4,137 | 186,374 |
| 14" | 1,790 | - | - | - | - | - | - | 191 | 2,057 | - | 2,248 |
| 15" | 61,513 | 215 | - | - | - | 3,115 | 27,246 | 46 | 32,752 | - | 63,374 |
| 16" | 3,985 | - | - | 1,476 | - | - | 493 | - | 3,147 | - | 5,115 |
| Length of Interceptors (ft) | | | | | | | | | | | |
| 18" | 39,976 | 248 | - | - | 1,105 | - | 9,429 | 282 | 30,783 | - | 41,847 |
| 21" | 16,356 | - | - | - | - | 265 | 8,010 | 2,967 | 10,696 | 1,119 | 23,057 |
| 24" | 21,564 | 176 | - | - | - | 4,056 | 6,316 | 7,747 | 17,365 | - | 35,659 |
| 27" | 21,787 | - | - | - | - | 517 | 42 | 9,675 | 4,787 | - | 15,021 |
| 30" | 51,095 | - | - | - | - | - | 39 | 30,266 | 9,601 | 3,451 | 43,357 |
| 33" | 13,854 | - | - | - | - | - | - | 9,215 | - | - | 9,215 |
| 36" | 17,868 | - | - | - | - | - | 253 | 11,038 | 9 | - | 11,300 |
| 40" | 0 | - | - | - | - | - | - | 2,956 | - | - | 2,956 |
| 42" | 3,300 | - | 3,278 | - | - | - | - | - | 34 | - | 3,312 |
| Total | 1,727,541 | 3,595 | 3,630 | 3,228 | 1,105 | 21,446 | 826,726 | 83,559 | 825,913 | 312,839 | 2,068,438 |

### 7.2.3 Lift Stations, Wetwells and Forcemains

Five BOPU operated and maintained lift stations are included in the analysis and hydraulic model. There are several private lift stations that deliver wastewater to the collection system; however, they were not included in the analyses, since they have low discharge flows, below 15 gpm, and are not expected to increase in flow in the future. To account for these private lift stations, point flow loads for the private Army Air Heli Station and Harmony lift stations were assigned to the nearest model junction, representing the typical pumped flow. The remaining private lift stations were considered too small to impact the collection system analysis and were included in the model as standard wastewater loads. Table 7-3, Table 7-4 and

Table 7-5 summarize the existing lift station pumps, wetwells and forcemains, respectively.

**Table 7-3**
**Existing Collection Lift Station Pump Data**

| Name | Sewer Basin | Pumps | | | Pumping Capacity | |
|---|---|---|---|---|---|---|
| | | Number | Rated Capacity (gpm) | Rated Head (ft) | Total (gpm) | Firm (gpm) |
| Goodman | Goodman | 2 | 150 | 39.5 | 300 | 150 |
| North Park | Dry Creek | 2 | 100 | 40 | 200 | 100 |
| The Pointe 1 | The Pointe 1 | 1 | 800 | 34 | 1,425 | 625 |
| | | 1 | 625 | 41 | | |
| The Pointe 2 | The Pointe 2 | 2 | 250 | 103 | 500 | 250 |
| Wyoming Welcome Center | Clear Creek | 1 | 15 | 21 | 555 | 285 |
| | | 1 | 100 | 21 | | |
| | | 1 | 170 | 21 | | |
| | | 1 | 270 | 21 | | |

**Table 7-4**
**Existing Collection Lift Station Wetwell Data**

| Name | Shape | Dimensions (LxWxH ft) | Equivalent Diameter[1] (ft) | Bottom Elevation (ft) | Minimum Level (ft) | Maximum Level (ft) |
|---|---|---|---|---|---|---|
| Goodman | Circular | 6 (dia.) x 16 | 6.0 | 6,068.0 | 6,070.0 | 6,083.0 |
| North Park | Square | 12x12x12 | 13.5 | 6,075.2 | 6,077.0 | 6,088.0 |
| The Pointe 1 | Square | 8x8x18 | 9.0 | 6,144.0 | 6,146.0 | 6,160.0 |
| The Pointe 2 | Square | 8x8x20 | 9.0 | 6,130.7 | 6,131.0 | 6,151.5 |
| Wyoming Welcome Center | Square | 8x8x18 | 9.0 | 6,326.2 | 6,328.0 | 6,344.0 |

[1] Equivalent diameter for non-circular wetwells is the cross-sectional area converted to a circular diameter.

**Table 7-5**
**Existing Collection Lift Station Forcemain Data**

| Name | Size (inches) | Material | Velocity at firm capacity of lift station (ft/s) |
|---|---|---|---|
| The Pointe 1 | 6 | PVC | 7.1 |
| The Pointe 2 | 6 | PVC | 2.8 |
| Goodman | 4 | Unlined Cast Iron | 3.8 |
| North Park | 4 | PVC | 2.6 |
| Wyoming Welcome Center | 4 | PVC | 7.3 |

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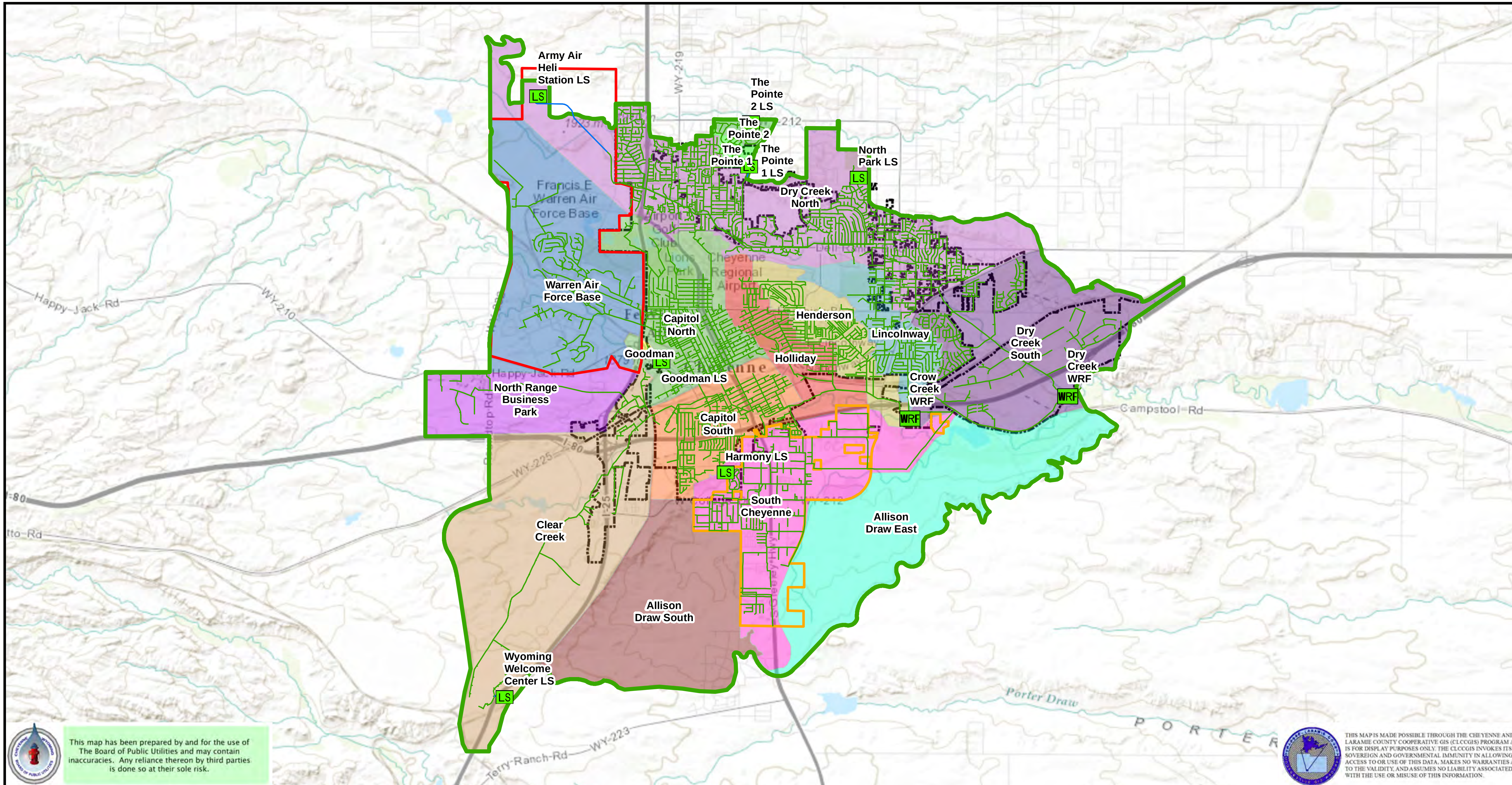



## Legend

- WRF Water Reclamation Facility
- LS Lift Station
- Gravity Main

**Existing Sewer Basins**

- Allison Draw East
- Allison Draw South
- Capitol North
- Capitol South
- Clear Creek
- Dry Creek North
- Dry Creek South
- Goodman
- Henderson
- Holliday
- Lincolnway
- North Range Business Park
- South Cheyenne
- The Pointe 1
- The Pointe 2
- Warren Air Force Base

- City of Cheyenne
- Sewer Service Area Boundary
- F.E. Warren Air Force Base
- South Cheyenne

1 inch = 2 miles

N

# Figure 7-1
# Existing Wastewater Collection System

Volume 7 - Wastewater Collection

Note: Allison Draw East and Allison Draw South do not have any existing sewer service but are within the sewer service boundary.



Last Updated: 10/4/2013

## 7.3 Model Development and Validation

BOPU has already created a hydraulic wastewater model using the ESRI GIS-based InfoSewer software (Version 10.0 Update 4) by Innovyze. HDR utilized the existing hydraulic model as a basis of analysis for this study. The existing version of the InfoSewer model was updated with 2012 flow loads and current operational procedures.

### 7.3.1 System Components

The hydraulic model contains collection system mains, manholes, lift station wetwells and pumps and outlets representing the WRFs.

**Mains**

The hydraulic model contains 118.5 miles of the existing collection pipelines which is approximately 30% of the total piping in the system. All interceptor pipelines, larger collector mains, and other mains with available data are modeled. Most of the non-modeled pipelines, typically less than 12-inches in diameter, are due to missing or invalid inverts; this data should continue to be collected and added to the GIS for future modeling. Rim elevations and “measure downs” should be used to calculate invert elevations, starting at the most downstream end of each main or interceptor and working upstream to collect this data. Mains from 4- to 42-inch diameter were modeled. Small mains and those serving individual customers are not included in the model as models deal with average conditions and are not capable of simulating the flow variation in the upstream reaches of the system very well. Modeled pipe diameters and inverts were checked for obvious discrepancies by examining the pipe profiles and invalid inverts were corrected based on feedback from BOPU staff. These diameter and invert modifications were tracked within the model with ‘Edited’ and ‘Comments’ fields so the base GIS sewer data can be updated accordingly.

**Manholes**

The hydraulic model contains 2,499 manholes in the existing collection system which is approximately 30% of the total manholes in the system. The non-modeled manholes are those that were connected to the non-modeled pipelines. The modeled manholes are used for loading the collection system with different flow components based on the served area. Rim elevations should be based on survey-grade or a LIDAR elevation source. Manhole invert elevations should be the lowest of the pipe inverts connecting to the manhole.

**Lift Station Pumps and Wetwells**

The lift station pumps and wetwells were modified in the model to correspond to existing conditions including pumping capacity and wetwell size for the Goodman, North Park, The Pointe 1 and The Pointe 2 lift stations. Appendix 7-A contains the existing pump curves used during model development and validation. Point loads were assigned to the nearest downstream manhole for the Army Air Heli Station, Harmony and Wyoming Welcome Center lift stations since they are small lift stations and/or had missing input data preventing inclusion in to the model.

**Outlets**

Two outlets were included in the model, one for CCWRF and one for DCWRF. These outlet locations were used to compare the model predicted WRF influent flows to both existing observed and future projected flows.

**Pipe Roughness Parameters**

The collection system model uses Manning's Equation to represent pipe roughness for open channel flow.

$$Q = \frac{1.49}{n} A R^{\frac{2}{3}} \sqrt{S}$$

where:

Q = Flow, cfs

n = Manning’s roughness coefficient

A = Area, sq ft

R = Hydraulic radius, ft

S = Slope, ft/ft

Manning's roughness coefficient increases with increasing pipe roughness. Manning’s roughness coefficients are assigned in the model to each type of pipe based on the material and age. Table 7-6 lists a matrix of roughness coefficients used in the model for existing gravity pipes. For the future model scenarios, all proposed gravity pipes are assumed to be PVC with a roughness coefficient of 0.011. Forcemain roughness was assigned with Hazen-Williams roughness coefficients (C value) of 110.

**Table 7-6**
**Matrix of Pipe Materials, Age and Roughness Coefficients**

| Material / Decade | CIPP | CIPU | CLHDPE/ HDPE | DIP | FRP | PVC | RCP | VCP | UNKNOWN |
|---|---|---|---|---|---|---|---|---|---|
| 0 (Unknown) | 0.014 | 0.015 | 0.012 | 0.014 | 0.012 | 0.012 | 0.016 | 0.015 | 0.015 |
| 1930 | 0.015 | 0.016 | - | - | - | - | 0.017 | 0.016 | 0.016 |
| 1940 | 0.015 | 0.016 | - | - | - | - | 0.017 | 0.016 | 0.016 |
| 1950 | 0.015 | 0.016 | - | - | - | - | 0.016 | 0.015 | 0.015 |
| 1960 | 0.014 | 0.015 | - | 0.014 | - | - | 0.016 | 0.015 | 0.015 |
| 1970 | 0.014 | 0.015 | - | 0.014 | - | 0.012 | 0.015 | 0.014 | 0.014 |
| 1980 | 0.013 | 0.014 | - | 0.013 | - | 0.012 | 0.014 | 0.014 | 0.014 |
| 1990 | - | - | 0.012 | 0.013 | 0.012 | 0.012 | 0.014 | 0.014 | 0.014 |
| 2000 | - | - | 0.011 | 0.012 | 0.011 | 0.011 | 0.013 | - | 0.013 |
| 2010 | - | - | 0.011 | 0.012 | 0.011 | 0.011 | 0.013 | - | 0.013 |

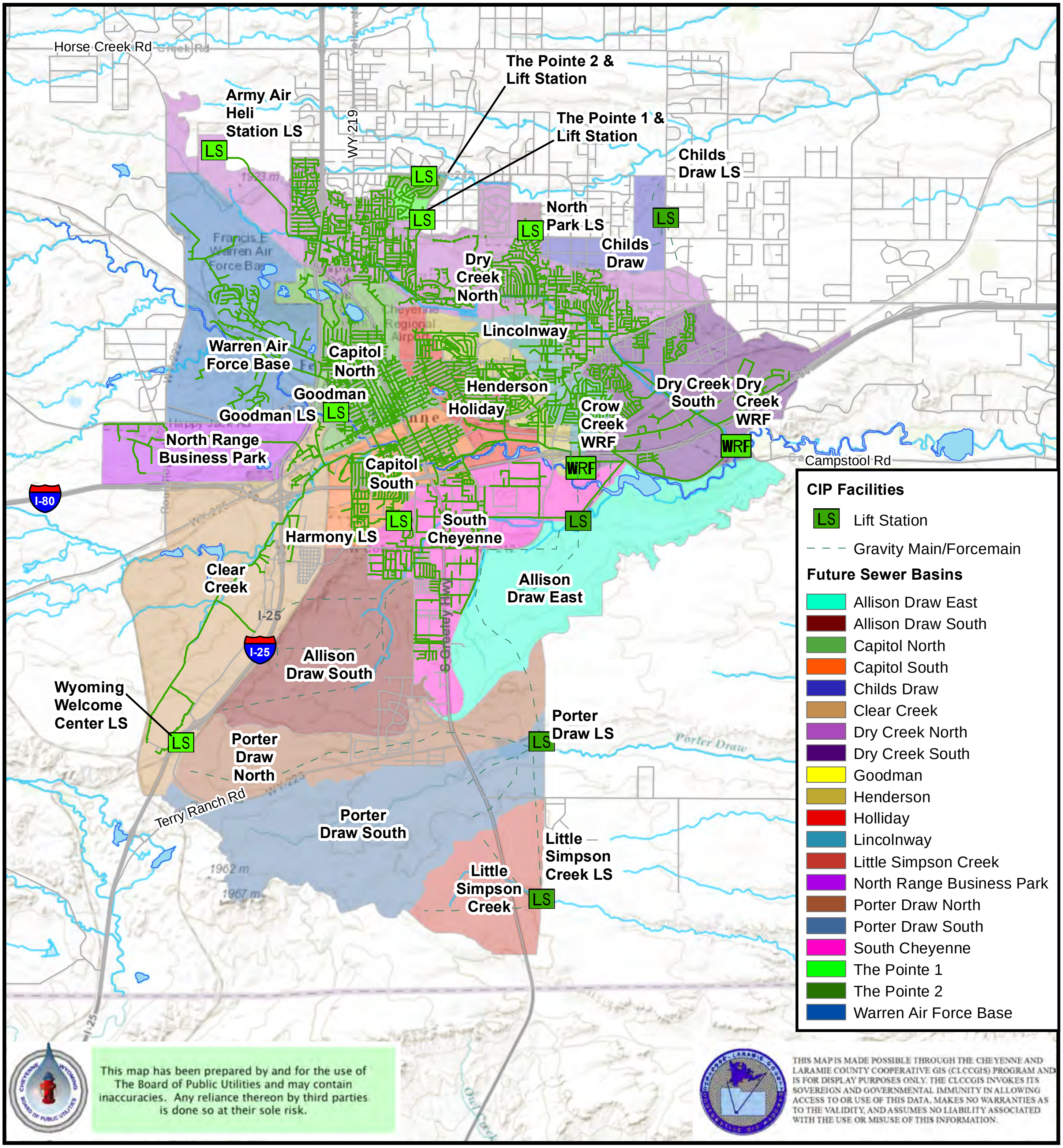
### 7.3.2 Future Sewer Basins

The existing sewer basins were extended and several new sewer basins were added to model the future development areas. The sewer basins were expanded with gravity or pumped flow pipes based on topography and the existing and future interceptor connectivity.

Figure 7-2 shows the developed future sewer basins.

**Table 7-7**
**Future Sewer Basins**

| Name | Drainage Basin | Area (acres) | Gravity and/or Pumped |
|---|---|---|---|
| Allison Draw East | Dry Creek | 4,672 | Gravity |
| Allison Draw South | Dry Creek | 4,084 | Gravity |
| Capitol North | Crow Creek | 2,529 | Gravity |
| Capitol South | Crow Creek | 1,967 | Gravity |
| Childs Draw | Crow Creek | 161 | Gravity |
| Clear Creek | Clear Creek | 6,547 | Gravity/Pumped |
| Dry Creek North | Dry Creek | 6,927 | Gravity |
| Dry Creek South | Dry Creek | 4,393 | Gravity/Pumped |
| Goodman | Crow Creek | 36 | Pumped |
| Henderson | Crow Creek | 1,307 | Gravity |
| Holliday | Crow Creek | 1,380 | Gravity |
| Lincolnway | Crow Creek | 1,224 | Gravity |
| Little Simpson Creek | Dry Creek | 2,232 | Pumped |
| North Range Business Park | Crow Creek | 1,961 | Gravity |
| Porter Draw North | Dry Creek | 3,402 | Pumped |
| Porter Draw South | Dry Creek | 5,759 | Pumped |
| South Cheyenne | Allison Draw | 3,844 | Gravity |
| The Pointe 1 | Dry Creek | 168 | Pumped |
| The Pointe 2 | Dry Creek | 180 | Pumped |
| Warren Air Force Base | Crow Creek | 4,501 | Gravity |




## Legend

- City of Cheyenne
- Water Service Area Boundary
- F.E. Warren Air Force Base
- South Cheyenne
- WRF Water Reclamation Facility
- LS Lift Station
- Gravity Main/Forcemain
- Creeks
- Roads
- Lakes

1 inch = 3 miles

N

Last Updated: 10/4/2013

**Figure 7-2**
**Future Sewer Basins**

### 7.3.3 Flow Data Analysis

Using Marsh-McBirney Flodars™ temporary flow monitors, collection system flow depths were monitored by BOPU every 15 minutes at a total of 31 different locations during the spring/summer peak wet-weather season from 2010 to 2012. The flow depths were analyzed to derive flow rates using the Manning's equation. Only 28 flow monitoring locations provided usable data for the flow data analysis as shown in Figure 7-3. The provided flow data was analyzed and filtered to develop dry-weather and wet-weather flow components for model flow allocation. From those flow components, sewer basin-wide base infiltration and rainfall dependent infiltration and inflow (RDII) allowances were established.

#### Flow Components

Total flow hydrographs represent the fluctuation of wastewater flow over time and consist of dry- and wet-weather flow components. These components are described in more detail below and are shown on Figure 7-4.

***Dry-Weather Flow Components***

Average daily flow (ADF) is comprised of base sanitary flow (BSF) and base infiltration (BI). BI consists of mostly groundwater that seeps into a collection system through defective pipes, pipe joints and manhole structures below the manhole corbel and chimney. The rate of infiltration depends on the depth of groundwater above the defects, the size of the defects and the percentage of the collection system that is submerged. Variation in groundwater levels and the associated infiltration is both seasonal and weather-dependent. ADF is the expected wastewater flow on a day with no precipitation events and no residual influence of previous precipitation events. ADF can vary seasonally as groundwater levels change (causing the fluctuations in the base infiltration). Daily fluctuations in ADF are mostly attributable to variations BSF including domestic, industrial and commercial wastewater contributions. These daily fluctuations in wastewater flows over the course of the day are represented by peaking factors, flow allowances and/or diurnal curves. Since the hydraulic modeling is based on steady state simulations, only peaking factors and flow allowances have been used for this study. ADF diurnal patterns were not developed as part of this modeling effort.

***Wet-Weather Flow Components***

Wet-weather flows are comprised of rainfall dependent infiltration and inflow (RDII). Wet-weather infiltration is the additional infiltration that occurs due to rainfall induced higher groundwater conditions and is typically seen in the hours or days following significant rain events. Inflow is rainfall-related water that enters a collection system from sources such as private laterals, downspouts, manhole defects, foundation piping and cross-connections with storm drains. Inflow is directly influenced by the intensity and duration of a storm event and, therefore, is not a fixed quantity.

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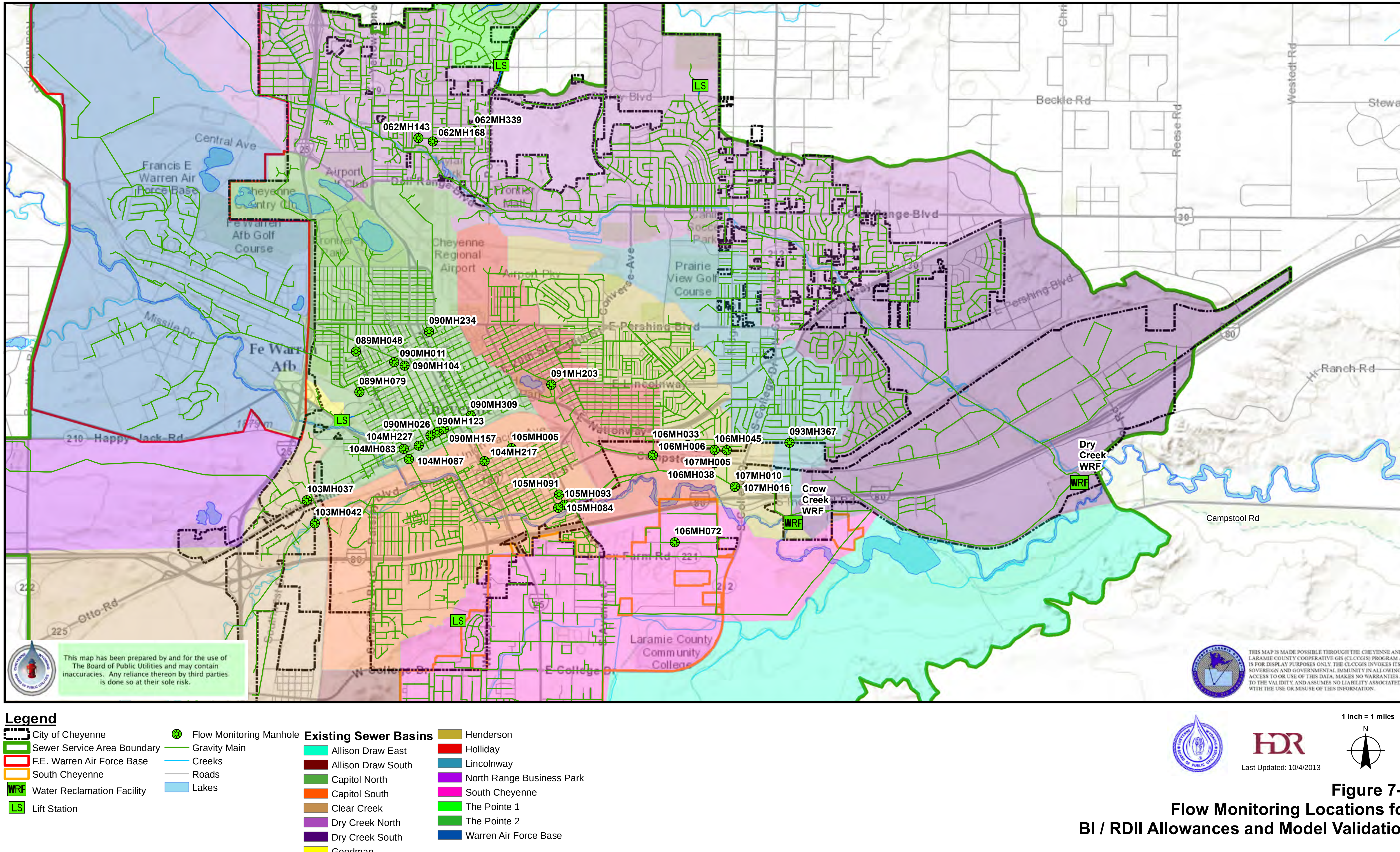
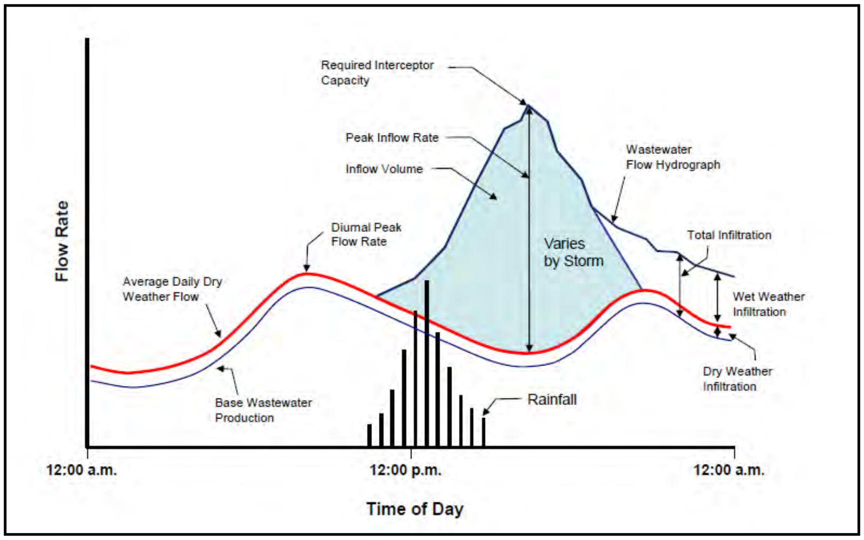



**Figure 7-3**
**Flow Monitoring Locations for BI / RDII Allowances and Model Validation**

**Figure 7-4**
**Typical Collection System Flow Components**




### Base Infiltration

The BI allocation to the hydraulic model was based on an area-weighted allowance in gallons per day per acre (gpd/ac). For each sewer basin, an initial BI allowance was calculated from the temporary flow monitoring and WRF influent meter data using the Stevens-Schutzbach Method defined as:

$$BI = \frac{0.4\,(MINDF)}{1-0.6\left(\frac{MINDF}{ADF}\right)^{ADF^{0.7}}}$$

where:

BI = Base Infiltration (mgd)

MINDF = Minimum Daily Flow (mgd)

ADF = Average Daily Flow (mgd)

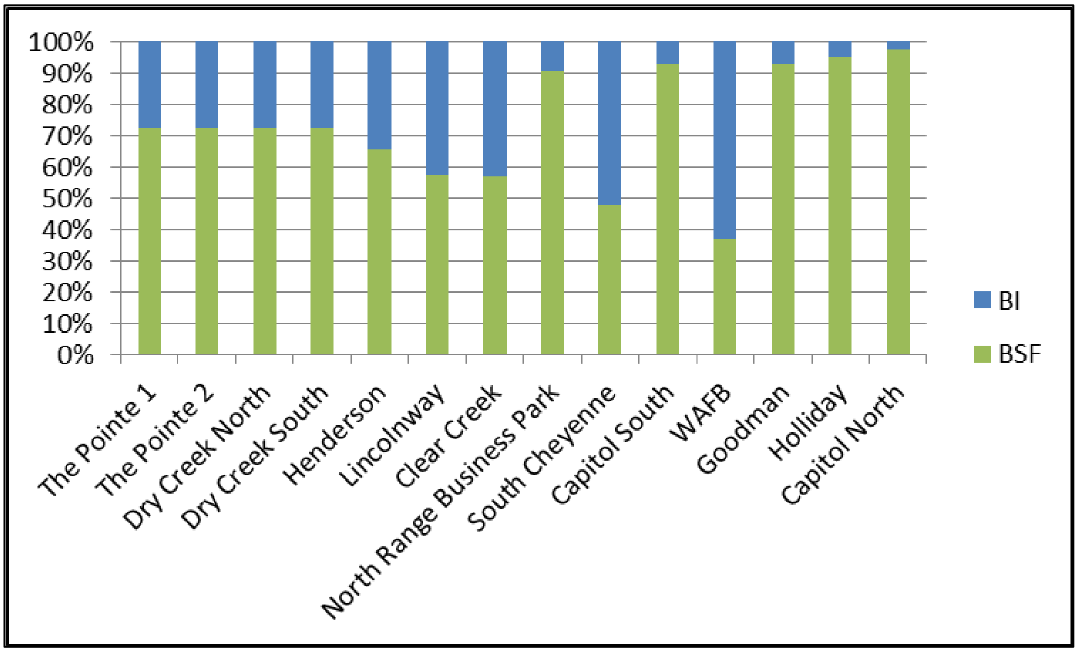
The minimum daily flow (MINDF) and ADF from the 2010 and 2012 flow monitoring data were averaged over their entire flow monitoring period. Several flow monitors were removed from the analysis due to obvious invalid data (significantly less downstream flow than upstream, invalid instantaneous peaks during dry-weather, potential manhole ID misidentification, etc.). From the MINDF and ADF flows, BI for each flow monitor was calculated and BI as a percent of ADF was established. The BI equation above does not account for industrial flows during the night; however, currently in collection system, there are no significant night-time industrial contributors with the exception of Frontier Refinery whose flow is accounted for in the model using separate flow meter data.

The percent BI values were averaged for each sewer basin to establish the initial BI allowances. Through the validation process described in Section 7.3.5, the BI allowances were modified to correspond to observed flows as best as possible across the flow monitoring locations and at the WRFs. The resulting validated existing BI allowances by sewer basin are presented in Table 7-8. The average of the BI allowances by sewer basins corresponds to what was calculated in Volume 2 for the system-wide I/I rate for 2012 of 28%. Chart 7-1 shows the percentage of BSF and BI by sewer basin sorted by the greatest percent BI to least showing the basins with the greatest amount of estimated BI.

**Table 7-8**
**Existing Estimated BI by Sewer Basin**

| Sewer Basin | BSF (mgd) | BI (mgd) | ADF (mgd) | BI (as a percent of ADF) | BI Allowance (gpd/ac) |
|---|---|---|---|---|---|
| Capital North | 0.53 | 0.01 | 0.54 | 2.5% | 5 |
| Capital South | 0.78 | 0.06 | 0.84 | 7.3% | 31 |
| Clear Creek | 0.09 | 0.06 | 0.15 | 43.1% | 10 |
| Dry Creek North | 1.59 | 0.61 | 2.19 | 27.6% | 87 |
| Dry Creek South | 3.10 | 1.18 | 4.28 | 27.6% | 269 |
| Goodman | 0.02 | 0.00 | 0.02 | 7.3% | 41 |
| Henderson | 0.17 | 0.09 | 0.26 | 34.3% | 69 |
| Holliday | 0.86 | 0.04 | 0.90 | 4.9% | 32 |
| Lincolnway | 0.37 | 0.27 | 0.64 | 42.5% | 224 |
| North Range Business Park | 0.03 | 0.00 | 0.03 | 9.6% | 1 |
| South Cheyenne | 0.35 | 0.38 | 0.73 | 52.2% | 99 |
| The Pointe 1 | 0.03 | 0.01 | 0.04 | 27.6% | 73 |
| The Pointe 2 | 0.03 | 0.01 | 0.04 | 27.6% | 55 |
| Warren Air Force Base | 0.29 | 0.49 | 0.78 | 63.2% | 110 |

**Chart 7-1**
**Existing Estimated BSF and BI by Sewer Basin**




### Rainfall Dependent Infiltration and Inflow

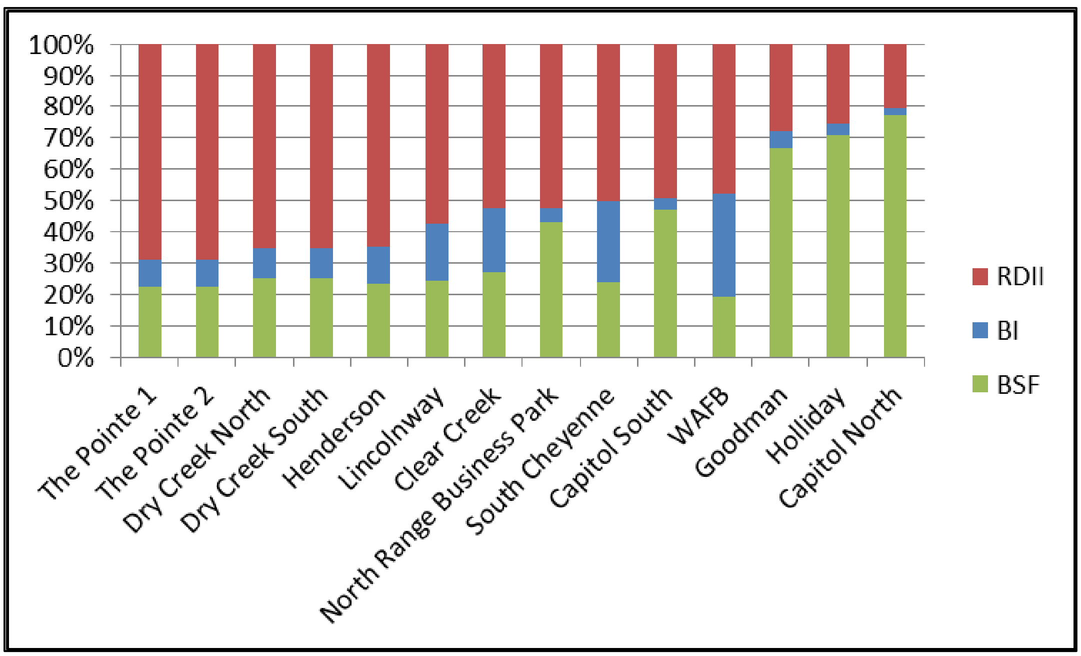
RDII allocation to the hydraulic model was also based on an area-weighted allowance in gpd/ac. The peak hour flow (PHF) and ADF from flow monitoring data were calculated from the rainfall measured on June 13th, 2010 and June 6th, 2012 for two similar storms in terms of total rainfall depth of 2.2 inches each. The 2010 storm was approximately a 4-year reoccurrence interval while the 2012 storm was approximately an 8-year reoccurrence interval. Several flow monitors were removed from the analysis due to obvious invalid data (significantly less downstream flow than upstream, invalid instantaneous peaks during dry-weather, potential manhole ID misidentification). From the PHF and ADF flows, RDII for each flow monitor was calculated and RDII as a percent of ADF was established. For areas without valid data, RDII percentages were used from the closest flow monitors or sewer basins.

The percent RDII values were averaged for each sewer basin to establish the initial BI allowances. Through the validation process described in Section 7.3.5, the RDII allowances were modified to correspond to observed flows as best as possible across the flow monitoring locations and at the WRFs. The resulting validated existing RDII allowances by sewer basin are presented in Table 7-9. Chart 7-2 shows the percentage of BSF, BI and RDII by sewer basin sorted by the greatest percent RDII to leas.

**Table 7-9**
**Existing Estimated RDII by Sewer Basin**

| Sewer Basin | ADF (mgd) | RDII (mgd) | RDII (as a percent of ADF) | RDII Allowance (gpd/ac) |
|---|---|---|---|---|
| Capital North | 0.54 | 0.14 | 26.1% | 56 |
| Capital South | 0.84 | 0.81 | 96.7% | 412 |
| Clear Creek | 0.15 | 0.17 | 110.9% | 25 |
| Dry Creek North | 2.19 | 4.15 | 189.3% | 599 |
| Dry Creek South | 4.28 | 8.11 | 189.3% | 1846 |
| Goodman | 0.02 | 0.01 | 38.7% | 217 |
| Henderson | 0.26 | 0.48 | 182.7% | 366 |
| Holliday | 0.90 | 0.31 | 34.0% | 223 |
| Lincolnway | 0.64 | 0.87 | 135.6% | 713 |
| North Range Business Park | 0.03 | 0.03 | 110.9% | 17 |
| South Cheyenne | 0.73 | 0.73 | 99.9% | 189 |
| The Pointe 1 | 0.04 | 0.10 | 222.7% | 586 |
| The Pointe 2 | 0.04 | 0.08 | 222.7% | 445 |
| Warren Air Force Base | 0.78 | 0.72 | 92.6% | 161 |

**Chart 7-2**
**Existing Estimated BSF, BI and RDII by Sewer Basin**



### 7.3.4 Load Allocation

The existing and future loads were allocated to the hydraulic model incorporating the three flow components: BSF, BI and RDII. The loads were entered in the following model fields in gallons per minute (gpm) units:

- **Existing (2012 and 2013)**
    - Base BSF – Load 1
    - Base BI – Load 2
    - Base RDII – Load 3
- **Future (2023, 2033 and 2063)**
    - Additional BSF – Load 4
    - Additional BI – Load 5
    - Additional RDII – Load 6

The sewer basin-specific BI and RDII allowances were assigned spatially to the existing and future collection system based on area-weighted contributions to each modeled manhole. This was accomplished by developing Theissen polygons for each existing and future modeled manhole to subdivide the served area to represent areas that flow to each manhole for BSF, BI and RDII. The Theissen polygons were bounded by the sewer basins to retain flows within each sewer basin. Figure 7-5 shows an example of the Theissen polygons developed in an area of the system showing how the assignment of BSF, BI and RDII, as well as the split between sewer basins, is handled in the hydraulic model.

**Figure 7-5**
**Theissen Polygons Example**


## Flow Projections

The existing (2013), near-term (2023), mid-term (2033) and long-term (2063) flows in the model were based on the flow projections from Volume 2 – Future Capacity Requirements (Volume 2). The goal was to match the flows in the model within ±10% of the flow projections for dry-weather maximum day and wet-weather peak hour. Table 7-10 and Table 7-11 present the established ADF, MDF and PHF flow projections from Volume 2 for the CCWRF and DCWRF treatment basins, respectively. Table 7-12 presents the peaking factors developed for MDF and PHF in Volume 2 used for all scenarios.

**Table 7-10**
**CCWRF Treatment Basin – Wastewater Flow Projections**

| Year | Planning Period | Average Day (ADF) Influent Flow (mgd) | Average Day (ADF) Flow to DCWRF[(1)] (mgd) | Maximum Day (MDF) Influent Flow[(2)] (mgd) | Maximum Day (MDF) Flow to DCWRF[(3)] (mgd) | Peak Hour (PHF) Influent Flow[(2)] (mgd) | Peak Hour (PHF) Flow to DCWRF[(4)] (mgd) |
|---|---|---|---|---|---|---|---|
| 2013 | Existing | 4.8 | 1.0 | 7.5 | 1.7 | 7.5 | 4.6 |
| 2023 | Near-Term | 6.0 | 1.3 | 9.5 | 1.9 | 12.0 | 3.0 |
| 2033 | Mid-Term | 7.1 | 1.5 | 11.3 | 2.2 | 12.0 | 5.8 |
| 2063 | Long-Term | 9.7 | 1.9 | 12.0 | 5.9 | 12.0 | 12.3 |

(1) ADF to DCWRF includes estimated flushing water and sludge flows from CCWRF.

(2) Flow projections over 7.5 mgd for 2013 and 12.0 mgd for 2023-2063 are adjusted down as the diversion weir in the CCWRF influent pumping station is set to divert the flows over these values to DCWRF. The differences between the CCWRF flow projections and the maximum CCWRF influent limits are added to the DCWRF flow projections.

(3) MDF to DCWRF includes estimated flushing water, sludge flows and flow diversion to DCWRF based on an existing and future CCWRF influent limit of 7.5 and 12 mgd, respectively.

(4) PHF to DCWRF includes estimated peak hour flow diversion plus the ADF flow to DCWRF based on an existing and future CCWRF influent limit of 7.5 and 12 mgd, respectively.

**Table 7-11**
**DCWRF Treatment Basin – Wastewater Flow Projections**

| Year | Planning Period | Average Day (ADF) Flow from CCWRF[(1)] (mgd) | Average Day (ADF) Influent Flow (mgd) | Maximum Day (MDF) Flow from CCWRF[(2)] (mgd) | Maximum Day (MDF) Influent Flow (mgd) | Peak Hour (PHF) Flow from CCWRF[(3)] (mgd) | Peak Hour (PHF) Influent Flow (mgd) |
|---|---|---|---|---|---|---|---|
| 2013 | Existing | 1.0 | 7.3 | 1.7 | 13.6 | 4.6 | 25.4 |
| 2023 | Near-Term | 1.3 | 8.6 | 1.9 | 15.8 | 3.0 | 27.4 |
| 2033 | Mid-Term | 1.5 | 10.2 | 2.2 | 18.9 | 5.8 | 34.9 |
| 2063 | Long-term | 1.9 | 14.7 | 5.9 | 30.7 | 12.3 | 54.4 |

(1) ADF from CCWRF includes estimated flushing water and sludge flows from CCWRF which is included in the DCWRF influent ADF flow projections.

(2) MDF from CCWRF includes estimated flushing water, sludge flows and max day flow diversion which is included in the DCWRF influent PDF flow projections.

(3) PHF from CCWRF includes estimated peak hour flow diversion plus the ADF flow from CWWRF which is included in the DCWRF influent PHF flow projections.

**Table 7-12**
**Peaking Factors**

| Treatment Basin | MDF Peaking Factor | PHF Peaking Factor |
|---|---|---|
| CCWRF | 1.60 | 1.85 |
| DCWRF | 2.30 | 3.00 |

### Validation and Design Storm Determination

For model validation during wet-weather conditions and to determine a design storm for the wastewater collection system, eight storms were selected from 2008 to 2012 with greater than 1 inch of total rainfall. The storms were analyzed to determine a storm which could be used to validate the wet-weather model. Table 7-13 summarizes the historic storm events and estimated RDII and PHF/ADF ratios at the two WRFs. The June 6th, 2012 storm (highlighted in red in the table) was chosen for wet-weather validation since it had a more balanced rainfall across the system resulting in PHF/ADF ratios close to the Volume 2 wastewater peaking factors, for a 10 year return interval. This rainfall occurred in the same year (2012) used to establish the BSF in the model from water meter data. Also, based on the review of the historic events and RDII response at the WRFs, a 10-year, 24-hr storm with a total rainfall depth of 2.39 inches was selected to represent the design storm for planning improvements. This design storm is paired with future design criteria to adequately size the improvements and allow for conveyance of RDII from larger storm events.

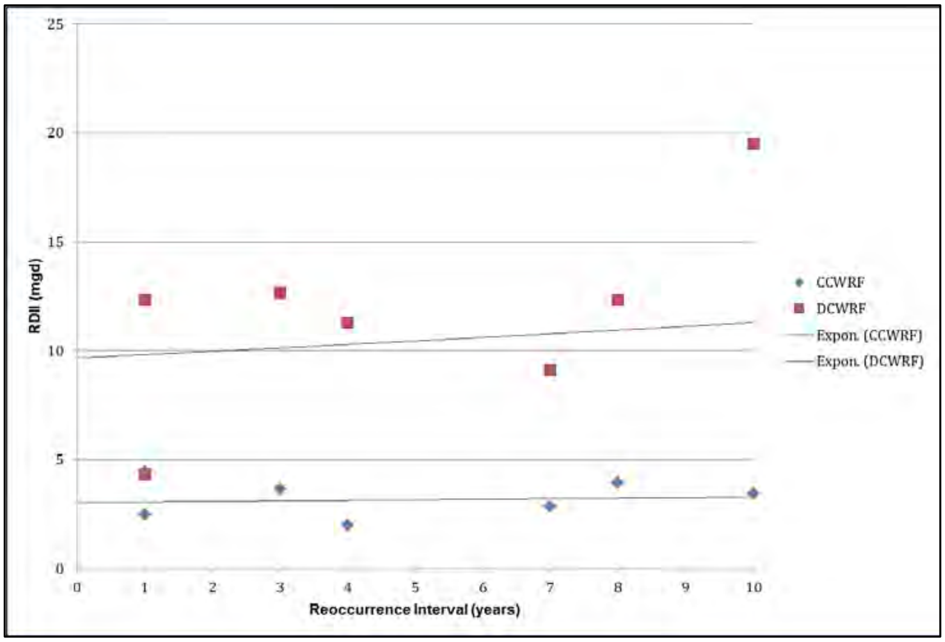
**Table 7-13**
**Historic Storm Events and Estimated RDII**

| | | | | CCWRF | | DCWRF | |
|---|---|---|---|---|---|---|---|
| Storm Date | Storm Rainfall (inches) | Storm Duration (hours) | Return Interval[1] (years) | RDII (mgd) | PHF/ADF | RDII (mgd) | PHF/ADF |
| May 17th, 2011 | 1.24 | 46 | 1 | 2.49 | 1.76 | 4.33 | 1.70 |
| May 15th, 2010 | 1.97 | 102 | 1 | 4.43 | 2.34 | 12.34 | 2.92 |
| June 19th, 2011 | 1.39 | 6 | 3 | 3.64 | 2.12 | 12.70 | 3.06 |
| June 13th, 2010 | 2.21 | 72 | 4 | 2.01 | 1.61 | 11.31 | 2.76 |
| April 22nd, 2010 | 2.62 | 43 | 7 | 2.87 | 1.87 | 9.12 | 2.42 |
| June 6th, 2012 | 2.23 | 26 | 8 | 3.93 | 2.22 | 12.36 | 3.30 |
| August 5th, 2008 | 2.42 | 26 | 10 | 3.45 | 1.96 | 19.49 | 4.63 |
| August 16th, 2008 | 3.22 | 39 | 25 | 3.68 | 2.03 | 11.35 | 3.12 |

[1] Calculated based on the storm event's total rainfall and duration and the National Oceanic and Atmospheric Administration (NOAA) Atlas II, Volume II, TP-40 and TP-49.

The estimated RDII versus return intervals for the historic storms was plotted as shown in Chart 7-3 to observe the wet-weather response at the WRFs based on the various rainfall events. The current approximately 6.5 mgd maximum influent flow at CCWRF and diversion of additional flows above that limit to DCWRF causes almost a flat RDII response to storm events at CCWRF. At DCWRF, the opposite affect is true where the diversion of flow from CCWRF increases the RDII response of any one storm event. Once the CCWRF headworks building is completed, the maximum influent flow at CCWRF will be increased to 12 mgd and the response at each of the WRFs will be more in line with typical RDII responses that increase as the return interval increases. These existing and future CCWRF limitations are accounted for in the modeling using the flow split at CCWRF to DCWRF.

**Chart 7-3**
**RDII versus Storm Event Return Interval**




## Existing Load Allocation

The existing load allocation was established for ADF, MDF and PHF using historic data as a basis for assigning flows spatially to the model.

***Average Day Flow and Maximum Day Flow***

The assignment of BSF to the model used potable water meter data as the source. An average of the metered 2012 potable water consumption from January, February and December was calculated when there is a minimum of outdoor water use. The resulting water use was assigned as the existing BSF to the Theissen polygon containing the corresponding water meter.

The assignment of BI to the model used flow monitoring and WRF influent data as the source as discussed previously. Each Theissen polygon area was assigned its corresponding sewer basin BI allowance to allocate the existing BI to the model.

The existing dry-weather flow in the model is represented by the BSF and BI flows in each Theissen polygon which resulted in a total flow to each modeled manhole. The BI flow allowances by sewer basin were adjusted to correspond to the historic 2012 ADF flows and to account for growth to correspond with the 2013 ADF flow projections. A portion of the existing ADF load allocation was represented by large users and smaller lift stations whose wastewater contribution is metered at their outfall locations as outlined below.

The South Cheyenne Water and Sanitation District (SCWSD) operates a collection system that conveys wastewater flows from their customers to the BOPU collection system in the South Cheyenne sewer basin to be treated currently at DCWRF. The SCWSD collection system was not included in the hydraulic model due to incomplete input data (diameters and inverts). However, an existing SCWSD ADF flow of 546 gpm was calculated from 2012 meter data at the outfall of their system (manhole 108MH068) and was assigned to the model accordingly. This flow includes both BSF and BI so the separate BI allowance was not added.

Frontier Refinery is a large user whose wastewater enters the Holliday sewer basin to be treated at the CCWRF. An existing Frontier Refinery ADF flow of 195 gpm was calculated from 2012 meter data at the outfall of their system (manhole 106MH002) and was assigned to the model accordingly. This flow includes both BSF and BI so the separate BI allowance was not added.

Warren Air Force Base (Warren AFB) operates a collection system that conveys wastewater flows from their customers to the BOPU collection system in the Capitol North sewer basin to be treated currently at CCWRF. The Warren AFB collection system was not included in the hydraulic model due to incomplete input data (diameters and inverts). However, an existing Warren AFB ADF flow of 246 gpm was calculated from 2012 meter data at the outfall of their system (manhole 089MH135) and was assigned to the model accordingly. This flow includes both BSF and BI so the separate BI allowance was not added.

Several small lift station flows were loaded to manholes downstream of their forcemains to simplify the model. The flows were estimated based on one pump running. They include the following lift stations and forcemains and their assigned flow at the downstream manhole:

- Army Air Heli Station Lift Station and Forcemain – 15 gpm at manhole 046MH001
- Wyoming Welcome Center Lift Station and Forcemain – 15 gpm at manhole 171MH007
- Harmony Lift Station and Forcemain – 15 gpm at manhole 118MH202

The MDF peaking factors as recorded in Table 7-12 were used to increase ADF to MDF in the model. All of the ADF (BSF and BI) flows in the model were increased based on the MDF peaking factors and adjusted slightly to correspond with the 2013 flow projections.

***Peak Hour Flow***

The assignment of RDII to the existing model used flow monitoring and WRF influent data as the source as discussed previously. Each Theissen polygon area was assigned its corresponding sewer basin RDII allowance to allocate the existing RDII to the model.

The existing wet-weather flow in the model is represented by the ADF and RDII flows in each Theissen polygon which resulted in a total flow to each modeled manhole. The RDII flow allowances by sewer basin were adjusted to correspond to the historic 2012 PHF flows and account for growth to correspond to the 2013 PHF flow projection. The 10-year, 24 hour storm was approximately equal to the RDII assigned to the 2013 peak hour wet-weather scenario of 2.7 mgd at CCWRF and 18.1 mgd at DCWRF. This was assuming that the CCWRF headworks improvements weren't in place yet as they will be finished in 2014 (refer to 10-year return RDII values on Chart 7-3 for both WRFs).

A portion of the existing RDII load allocation was represented by large users whose wastewater contribution is metered at their outfall locations and assigned to the model from the June 6th, 2012 storm event as outlined below:

- SCWSD PHF flow – 1,056 gpm at manhole 108MH068
- Frontier Refinery PHF flow – 255 gpm at manhole 106MH002
- Warren AFB PHF flow – 1,044 gpm at manhole 089MH135

These large user flows include both ADF and RDII so the separate RDII allowance was not added. The small lift station service areas are small enough that the PHF flows were kept the same as ADF.

### Future Load Allocation

The future load allocation was established for ADF, MDF and PHF using unit flow factors and BI and RDII allowances as a basis for assigning additional future flows spatially to the model.

#### *Average Day Flow and Maximum Day Flow*

The assignment of BSF to the model used the existing BSF allocation as well as additional future potable water projections as the sources. The additional future water demand projections were allocated in the model as BSF based on analysis of future developable lands and unit demand factors, the same process used in Volume 5 – Potable Water Storage and Distribution (Volume 5). The unit BSF factors were developed by spatially joining the 2012 water demands with the GIS layer of the County's Zoning areas. By dividing the total water demand by the number of acres within the total area of each zoning polygon and averaging the water demand for each zoning type, the overall BSF factors were developed to apply to the future developable land.

Table 7-14 lists the unit BSF factors for each zoning type. Figure 7-6 shows a map of the future developable areas. Each of the developable land areas was assigned a percent buildout for each planning period (near-term, mid-term and long-term) based on current and anticipated development plans.

The assignment of additional future BI to the model used a future BI assumption of 20% of future additional ADF. This percentage is reduced from the existing BI allowance average (28%) as new systems are built with newer materials with less leakage. Each Theissen polygon area was assigned its corresponding future BI allowance based on the future additional ADF to allocate the future BI to the model. For the purposes of this study, the rate of I/I reduction due to rehabilitation efforts would approximately equal the I/I increase due to pipe deterioration.

The future dry-weather flow in the model is represented by the existing and future additional BSF and BI flows in each Theissen polygon which resulted in a total flow to each modeled manhole. The BI flow allowances were adjusted slightly to correspond to the ADF flow projections for each planning period in Volume 2 as summarized in Table 7-10 and Table 7-11. The resulting flows were assigned to the established existing and future Theissen polygons in the model for each planning period scenario.

SCWSD, Frontier Refinery and Warren AFB ADF flows were assumed to stay the same since no new significant development is shown in these areas. The flows for the several small lift station flows which were loaded to existing manholes downstream of their forcemains were not changed based on the existing flows since any development in the area is assumed to be within the firm capacity of the pump station as assigned in the existing modeling loads.

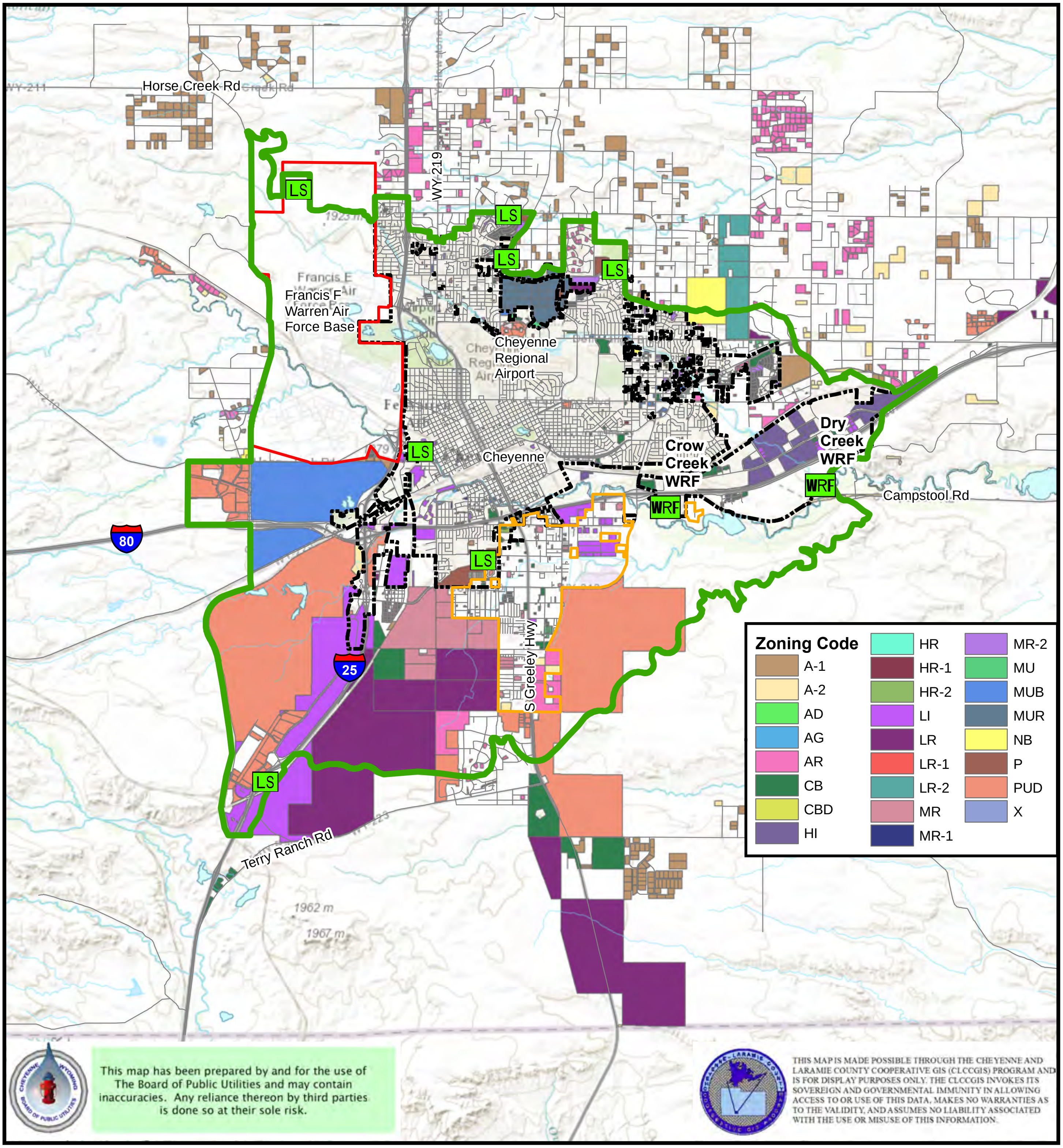
The MDF peaking factors as recorded in Table 7-12 were used to increase ADF to MDF in the model. All of the ADF (BSF and BI) flows in the model were increased based on the MDF peaking factors and adjusted slightly to correspond to the MDF flow projections for each planning period in Volume 2 as summarized in Table 7-10 and Table 7-11.

***Peak Hour Flow***

The assignment of additional future RDII to the model used a future RDII assumption of 50% of future additional ADF. This percentage is reduced from the existing RDII allowance average (59%) as new systems are built with newer materials with less I/I. Each Theissen polygon area was assigned its corresponding future RDII allowance based on the future additional ADF to allocate the future RDII to the model.

**Table 7-14**
**Zoning Types with Unit Base Sanitary Flows**

| Zoning Code | Zoning Type | Zoning Area (acres) | Percent of Total Area | Assigned Future Unit BSF (gpd/ac) |
|---|---|---|---|---|
| A-2 | Agricultural | 75,998 | 55.8% | 350 |
| A-1 | Agricultural and Rural Residential | 15,749 | 11.6% | 350 |
| AR | Agricultural Residential | 7,381 | 5.4% | 350 |
| AD | Airport District | 907 | 0.7% | N/A |
| CBD | Central Business District | 123 | 0.1% | 1400 |
| AG | City Agricultural | 158 | 0.1% | 350 |
| CB | Community Business | 2,484 | 1.8% | 850 |
| X | Military Public | 6,006 | 4.4% | N/A |
| HI | Heavy Industrial | 2,256 | 1.7% | 100 |
| HR | High Density Residential - County | 61 | 0.0% | 1,900 |
| HR-2 | High Density Residential Developing | 117 | 0.1% | 1,900 |
| HR-1 | High Density Residential Established | 223 | 0.2% | 1,900 |
| LI | Light Industrial | 3,477 | 2.6% | 350 |
| LR | Low Density Residential - County | 703 | 0.5% | 1,300 |
| LR-2 | Low Density Residential Developing | 519 | 0.4% | 1,300 |
| LR-1 | Low Density Residential Established | 668 | 0.5% | 1,300 |
| MR | Medium Density Residential - County | 1,581 | 1.2% | 1,200 |
| MR-2 | Medium Density Residential Developing | 1,386 | 1.0% | 1,200 |
| MR-1 | Medium Density Residential Established | 3,302 | 2.4% | 1,200 |
| MU | Mixed Use - County | 452 | 0.3% | 500 |
| MUB | Mixed Use Business Emphasis | 591 | 0.4% | 1,000 |
| MUR | Mixed Use Residential Emphasis | 107 | 0.1% | 1,600 |
| NB | Neighborhood Business | 211 | 0.2% | 800 |
| PUD | Planned Unit Development | 6,711 | 4.9% | 1,100 |
| P | Public | 4,908 | 3.6% | 1,500 |
| | Total | 136,079 | 100.0% | - |




**Legend**

- City of Cheyenne
- Sewer Service Area Boundary
- F.E. Warren Air Force Base
- South Cheyenne Water and Sewer District
- WRF Water Reclamation Facility
- LS Lift Station
- Roads
- Creeks
- Lakes

1 inch = 3 miles

N

HDR

Last Updated: 10/4/2013

# Figure 7-6
# Future Development Land

**Volume 7 – Wastewater Collection**

2013 Water and Wastewater Master Plans

The future PHF flow in the model is represented by the existing and future additional ADF and RDII flows in each Theissen polygon which resulted in a total flow to each modeled manhole. The RDII flow allowances were adjusted slightly to correspond to the PHF flow projections for each planning period in Volume 2 as summarized in Table 7-10 and Table 7-11. The resulting flows were assigned to the established existing and future Theissen polygons in the model for each planning period scenario.

SCWSD, Frontier Refinery and Warren AFB PHF flows were assumed to stay the same since no new significant development is shown in these areas. The flows for the several small lift station flows which were loaded to existing manholes downstream of their forcemains were not changed based on the existing flows since any development in the area is assumed to be within the firm capacity of the pump station as assigned in the existing modeling loads.

**Flow Split at Crow Creek Water Reclamation Facility**

A portion of the flow coming to the CCWRF is diverted as flushing water for conveying sludge flows from CCWRF to DCWRF. The primary and secondary sludge flows from the CCWRF treatment process are included in the CCWRF influent meter and are sent to DCWRF through the bypass pipeline along with the flushing water. The January, February and December 2012 average flushing water was calculated from provided meter data to be 125 gpm which was removed from manhole 107MH036 and added to manhole 107MH059 in the model. The January, February and December 2012 average sludge flow was calculated from provided meter data to be 403 gpm which was added to manhole 107MH059 in the model. This 2012 sludge flow is approximately 18 percent of the 2012 ADF so this percentage was used to calculate the 2013 and future scenarios ADF flow to DCWRF.

The diversion at CCWRF is also currently used to bypass flows above 7.5 mgd coming from the Crow Creek treatment basin to DCWRF during wet-weather. The assumed maximum flow to CCWRF is 7.5 mgd for the 2012 validation and 2013 existing scenarios. After the CCWRF headworks improvements are completed the diversion will occur when flows are above 12 mgd. The average flushing and sludge flows were kept the same in the future scenarios and the PHF values above 12 mgd in the 2023 through 2063 scenarios were removed from the CCWRF influent flow and added to the DCWRF influent flow through the bypass pipeline.

**Table 7-15**
**Model Flow Split at Crow Creek Water Reclamation Facility**

| Year | Planning Period | ADF to DCWRF(1) (gpm) | MDF to DCWRF(2) (gpm) | PHF to DCWRF(2) (gpm) |
|---|---|---|---|---|
| 2012 | Validation | 528 | - | 528 |
| 2013 | Existing | 725 | 1,181 | 3,225 |
| 2023 | Near-Term | 875 | 1,319 | 2,056 |
| 2033 | Mid-Term | 1,012 | 1,528 | 3,998 |
| 2063 | Long-term | 1,337 | 4,097 | 8,559 |

(1) ADF flow to DCWRF includes estimated flushing water and sludge flows from CCWRF.

(2) MDF flow to DCWRF includes estimated flushing water, sludge flows and flow diversion from CCWRF based on an existing and future CCWRF influent limit of 7.5 and 12 mgd, respectively.

(3) PHF to DCWRF includes estimated peak hour flow diversion plus ADF flow from CWWRF based on an existing and future CCWRF influent limit of 7.5 and 12 mgd, respectively.

### 7.3.5 Validation

Initial model results from the 2012 validation scenario were compared to flow monitoring and WRF influent flows to adjust BI and RDII allowances so that the total flows at the WRFs better correspond to the historical dry-weather and wet-weather flows. The model validation goal was to be within +10%/-5% of ADF and PHF at the WRFs and flow monitoring locations. The flow monitoring locations were used to determine the probable split of flows between sewer basins and BI and RDII percentages of ADF, as discussed previously. In preparation for the next master plan, future flow monitoring should focus on individual sewer basin flows for model validation and I/I determination instead of a smaller area of each sewer basin.

**Average Day Flow**

The 2012 ADF flows from the WRF influent meters and flow monitoring were used to develop and refine the BI allowances so that there was a better correlation across the system between the model and the observed flows. The process involved adjusting BI allowances per sewer basin on a percentage basis to best correspond to flows at the flow monitoring and ultimately at each of the WRF influent locations. Table 7-16 presents the results of the validated ADF flows and the volume and percent difference between the model and observed flows.

**Table 7-16**
**Dry-Weather 2012 Validation Results**

| Flow Location | Sewer Basin | Modeled ADF (mgd) | Observed ADF (mgd) | Percent Difference (%) |
|---|---|---|---|---|
| 093S0367 | Lincolnway | 0.62 | 0.64 | -3.6% |
| 103MH042 | Clear Creek | 0.10 | 0.12 | -19.6% |
| 091MH203 | Holliday | 0.13 | 0.21 | -48.5% |
| 104MH217 | Capitol South | 0.04 | 0.05 | -30.6% |
| 104MH087 | Capitol North | 1.03 | 0.20 | +135.6% |
| 106MH045 | Henderson | 0.30 | 0.36 | -17.5% |
| CCWRF | - | 3.57 | 3.23 | +9.9% |
| DCWRF | - | 5.26 | 5.38 | -2.3% |

The following observations were made after completing the dry-weather validation:

- The flow monitoring locations with flows less than 0.5 mgd were not considered accurate enough to use for validation comparison (this is discussed further in Section 7.6).
- An inherent ±10% error in flow measurement by the existing flow monitoring equipment could further make the flows difficult to match between the modeled and observed.
- The flow monitor at manhole 091MH203 is upstream of another flow monitor showing less flow. This indicates an issue with how the meter was installed and/or calibrated.
- The flow monitor at manhole 104MH087 is downstream of Warren AFB which has an ADF of 0.35 mgd which is higher than the observed ADF at this location.
- CCWRF ADF influent is a little high and DCWRF influent ADF flow is a little low in the model; however they are both within 10% of the observed flows.

### Peak Hour Flow

The 2012 PHF flows from the June 6th, 2012 storm event were used to refine RDII inputs for a better correlation across the system between the model and the observed flows. The process involved adjusting RDII allowances per sewer basin on a percentage basis to best correspond to flows at the flow monitoring and ultimately at each of the WRF influent locations. Table 7-16 presents the results of the validated PDF flows and the volume and percent difference between the model and observed flows.

**Table 7-17**
**Wet-Weather 2012 Validation Results**

| Flow Location | Sewer Basin | Modeled PHF (mgd) | Observed PHF (mgd) | Percent Difference (%) |
|---|---|---|---|---|
| 093S0367 | Lincolnway | 1.51 | 1.43 | +5.5% |
| 103MH042 | Clear Creek | 0.26 | 0.38 | -38.8% |
| 091MH203 | Holliday | 0.22 | 1.07 | -133.2% |
| 104MH217 | Capitol South | 0.06 | 1.37 | -182.1% |
| 104MH087 | Capitol North | 2.31 | 0.71 | +105.8% |
| 106MH045 | Henderson | 0.53 | 1.36 | -87.9% |
| CCWRF | - | 7.64 | 7.16 | +6.5% |
| DCWRF | - | 17.84 | 17.73 | +0.6% |

The following observations were made after completing the wet-weather validation:

- The flow monitoring locations with flows less than 0.5 mgd were not considered accurate enough to use for validation comparison (this is discussed further in Section 7.6).
- An inherent ±10% error in flow measurement by the existing flow monitoring equipment could further make the flows difficult to match between the modeled and observed.
- The flow monitor at manhole 091MH203 is upstream of another flow monitor showing less flow. This indicates an issue with how the meter was installed and/or calibrated.
- The flow monitor at manhole 104MH087 is downstream of Warren AFB which has a PDF of 1.5 mgd which is higher than the observed PHF at this location.
- CCWRF PHF influent is a high and DCWRF influent PHF flow almost matches in the model; however they are both within 10% of the observed flows.

**Validation Summary and Recommendations**

In general, the model is in a condition satisfactory for planning level analysis. The pipeline and lift station input data are all assigned based on current known system information. Pipe roughness is assumed based on the pipe age and material which is adequate for the purpose of this analysis. By continuing to collection additional information and confirm pipe inverts, materials, diameters and other model input data and adding more of the collection system the system hydraulics and load allocation in the model will be more accurate, especially in the upstream extents of the system.

The flow monitoring data was not collected at locations at the downstream end of the sewer basins so it made it more difficult to develop BI and RDII allowances. In addition, bad data including abnormal peak flows and flows that didn't add up from flow monitoring location to location could have to do with installation and calibration of the flow monitors. Prior to future master planning efforts, a complete sewer basin-specific I/I study should be conducted to prepare for wastewater collection system model development and calibration.

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## 7.4 Collection System Analysis

The collection system analysis examined existing and future performance of the mains and interceptors using the validated hydraulic model. Only the modeled existing and future pipes were included in the capacity analysis.

### 7.4.1 Modeling Scenarios

Steady state hydraulic analyses were completed for existing (2013), near-term (2023), mid-term year (2033) and long-term (2063) flow conditions. These analyses considered maximum day and peak hour flow conditions. Table 7-18 describes the modeling scenarios conducted and the sequence within which they were performed. The results of the model scenarios in regards to the collection system analysis are described in greater detail in the following sections.

**Table 7-18**
**Model Scenarios**

| Description | Flow | Purpose |
|---|---|---|
| Existing (2013) Maximum Day Flow | 2013 (BSF + BI) x MDF Peaking Factor | Evaluate existing system performance under MDF conditions |
| Existing (2013) Peak Hour Flow | 2013 BSF + BI + RDII | Evaluate existing system performance under PHF conditions |
| Near-Term (2023) Maximum Day Flow | 2023 (BSF + BI) x MDF Peaking Factor | Evaluate system performance and develop CIP under near-term MDF conditions |
| Near-term (2023) Peak Hour Flow | 2023 BSF + BI + RDII | Evaluate system performance and develop CIP under near-term PHF conditions |
| Mid-term (2033) Maximum Day Flow | 2033 (BSF + BI) x MDF Peaking Factor | Evaluate system performance and develop CIP under mid-term MDF conditions |
| Mid-term (2033) Peak Hour Flow | 2033 BSF + BI + RDII | Evaluate system performance and develop CIP under mid-term PHF conditions |
| Long-term (2063) Maximum Day Flow | 2063 (BSF + BI) x MDF Peaking Factor | Evaluate system performance and develop CIP under long-term MDF conditions |
| Long-term (2063) Peak Hour Flow | 2063 BSF + BI + RDII | Evaluate system performance and develop CIP under long-term PHF conditions |

The resulting modeled WRF influent flows after the load allocation process was complete are shown in Table 7-19 for each scenario compared to the flow projections from Volume 2. The goal was to correspond within 10% the WRF influent flows in the model to the flow projections.

**Table 7-19**
**Modeled WRF Influent Flows**

| | CCWRF | | | DCWRF | | |
|---|---|---|---|---|---|---|
| Scenario | Modeled Flow (mgd) | Projected Flow (mgd) | Percent Difference (%) | Modeled Flow (mgd) | Projected Flow (mgd) | Percent Difference (%) |
| Existing (2013) MDF | 7.6 | 7.5 | +1.3% | 13.8 | 13.6 | +1.5% |
| Existing (2013) PHF | 7.7 | 7.5 | +2.6% | 26.9 | 25.4 | +5.7% |
| Near-Term (2023) MDF | 9.7 | 9.5 | +2.1% | 16 | 15.8 | +1.3% |
| Near-term (2023) PHF | 11.9 | 12 | -0.8% | 26.8 | 27.4 | -2.2% |
| Mid-term (2033) MDF | 11.7 | 12 | -2.5% | 19.7 | 18.9 | +4.1% |
| Mid-term (2033) PHF | 11.9 | 11.3 | +5.2% | 33.7 | 34.9 | -3.5% |
| Long-term (2063) MDF | 12 | 12 | +0.0% | 31.2 | 30.7 | +1.6% |
| Long-term (2063) PHF | 12.1 | 12 | +0.8% | 54.7 | 54.4 | +0.5% |

### 7.4.2 Analysis Criteria

To accomplish the analysis, capacity-limited pipe identification criteria are necessary. These criteria also aid in the development of system improvements to verify that the capacity limitation has been resolved or the future pipes are adequately sized to handle estimated future flows within the long-term planning period. Capacity-limited pipe identification criteria are based on flow conditions within pipes and surcharge conditions within manholes. Avoiding sanitary sewer overflows (SSOs) by maintaining adequate collection system capacity is fundamental. In accordance with Wyoming Department of Environmental Quality (WDEQ) Water Quality Rules and Regulations Chapter 11, Section 9 (c) (i) (B), collection systems shall be sized for 200 percent of maximum daily flow or more. This would equate to a 50% full pipe flow (q/Q) during MDF conditions. This design criterion from WDEQ that was applied to MDF conditions in the model to locate potential future capacity-limited areas but not trigger improvement needs.

InfoSewer doesn't calculate backwater conditions in pipes for q/Q values in steady-state simulation mode; therefore, capacity limitations shown in the following sections represent individual pipe segment results. However, backwater effects from downstream segments were examined in the improvements scenario by looking at the adjusted flow depth which accounts for backwater conditions. The recommended improvements were reviewed to ensure that their sizing properly removed backwater affects in upstream sections.

**Existing Performance**

The capacity-limited pipe identification criteria established for this study to evaluate existing system performance is comprised of the following:

- Predicted SSO risk for all flow conditions – within 3 feet of manhole rim
- Predicted pipe capacity for MDF conditions – q/Q of 50 percent
- Predicted pipe capacity for PHF conditions – q/Q of 80 percent

If the existing SSO and PHF performance criteria could not be met as demonstrated by the model, improvements were identified and, through an iterative trial-and-error process, implemented until the capacity criteria could be satisfied with a minimum of pipe and lift station additions.

**Future Sizing**

The sizing of pipe improvements and extensions for this study is based on the following criteria:

- Predicted pipe capacity for MDF conditions
    - Pipe diameter less than 18 inches - q/Q of 50 percent
    - Pipe diameter equal to or greater than 18 inches - q/Q of 50 percent
- Predicted pipe capacity for PHF conditions
    - Pipe diameter less than 18 inches - q/Q of 65 percent
    - Pipe diameter equal to or greater than 18 inches - q/Q of 78 percent

### 7.4.3 Maximum Day Flow Results

The maximum day scenarios were run in the model and compared to the MDF analysis criteria to determine where predicted capacity limitations existed in each planning period. The MDF results were used for general performance observations and to size future pipes along with PHF conditions. The PHF results were used to trigger improvement needs.

### Existing (2013)

Figure 7-7 shows the existing MDF capacity limitations for both manholes with predicted SSO risks and pipe length with predicted percentage of full pipe flow capacity. Table 7-20 presents the MDF results, breaking down the existing system performance by sewer basin.

**Table 7-20**
**Existing (2013) Maximum Day Flow Capacity Limitations**

| Sewer Basin | Manholes with SSO Risk | Pipe Length with q/Q of | | | | | Total Pipe Length |
|---|---|---|---|---|---|---|---|
| | | 0-50% | 50-75% | 75-100% | 100-120% | 120%+ | |
| Capital North | 1 | 77,295 | 323 | 332 | 410 | 619 | 78,979 |
| Capital South | 0 | 71,529 | 504 | 0 | 63 | 503 | 72,598 |
| Clear Creek | 0 | 55,691 | 0 | 0 | 0 | 0 | 55,691 |
| Dry Creek North | 0 | 155,265 | 6,197 | 2,046 | 1,003 | 2,295 | 166,806 |
| Dry Creek South | 0 | 98,449 | 6,106 | 325 | 123 | 887 | 105,889 |
| Goodman | 0 | 2,130 | 0 | 0 | 0 | 13 | 2,143 |
| Henderson | 0 | 32,411 | 1,637 | 1,140 | 0 | 432 | 35,619 |
| Holliday | 0 | 31,861 | 0 | 539 | 0 | 26 | 32,427 |
| Lincolnway | 0 | 16,520 | 1,685 | 107 | 0 | 148 | 18,460 |
| North Range Business Park | 0 | 27,011 | 0 | 0 | 0 | 0 | 27,011 |
| The Pointe 1 | 0 | 9,876 | 0 | 0 | 0 | 0 | 9,876 |
| The Pointe 2 | 0 | 15,451 | 0 | 0 | 0 | 0 | 15,451 |
| Total | 1 | 593,491 | 16,451 | 4,489 | 1,598 | 4,922 | 620,951 |

**Near-term (2023)**

Figure 7-8 shows the near-term MDF capacity limitations for both manholes with predicted SSO risks and pipe length with predicted percentage of full pipe flow capacity. Table 7-21 presents the MDF results, breaking down the near-term system performance by sewer basin.

**Table 7-21**
**Near-term (2023) Maximum Day Flow Capacity Limitations**

| Sewer Basin | Manholes with SSO Risk | Pipe Length with q/Q of | | | | | Total Pipe Length |
|---|---|---|---|---|---|---|---|
| | | 0-50% | 50-75% | 75-100% | 100-120% | 120%+ | |
| Capital North | 1 | 77,295 | 323 | 332 | 410 | 619 | 78,979 |
| Capital South | 0 | 69,081 | 2,951 | 0 | 0 | 566 | 72,598 |
| Clear Creek | 0 | 54,997 | 694 | 0 | 0 | 0 | 55,691 |
| Dry Creek North | 0 | 153,885 | 6,522 | 2,463 | 1,303 | 2,633 | 166,806 |
| Dry Creek South | 0 | 94,500 | 10,055 | 325 | 123 | 887 | 105,889 |
| Goodman | 0 | 2,130 | 0 | 0 | 0 | 13 | 2,143 |
| Henderson | 0 | 30,549 | 3,499 | 1,076 | 64 | 432 | 35,619 |
| Holliday | 0 | 28,968 | 2,893 | 0 | 539 | 26 | 32,427 |
| Lincolnway | 0 | 16,520 | 1,685 | 107 | 0 | 148 | 18,460 |
| North Range Business Park | 0 | 27,011 | 0 | 0 | 0 | 0 | 27,011 |
| The Pointe 1 | 0 | 9,832 | 44 | 0 | 0 | 0 | 9,876 |
| The Pointe 2 | 0 | 15,378 | 73 | 0 | 0 | 0 | 15,451 |
| Total | 1 | 580,147 | 28,740 | 4,304 | 2,438 | 5,323 | 620,951 |

### Mid-term (2033)

Figure 7-9 shows the mid-term MDF capacity limitations for both manholes with predicted SSO risks and pipe length with predicted percentage of full pipe flow capacity. Table 7-22 presents the MDF results, breaking down the mid-term system performance by sewer basin.

**Table 7-22**
**Mid-term (2033) Maximum Day Flow Capacity Limitations**

| Sewer Basin | Manholes with SSO Risk | Pipe Length with q/Q of | | | | | Total Pipe Length |
|---|---|---|---|---|---|---|---|
| | | 0-50% | 50-75% | 75-100% | 100-120% | 120%+ | |
| Capital North | 1 | 77,295 | 323 | 332 | 410 | 619 | 78,979 |
| Capital South | 0 | 61,444 | 6,871 | 3,359 | 0 | 566 | 72,239 |
| Clear Creek | 3 | 46,511 | 3,841 | 4,605 | 0 | 341 | 55,298 |
| Dry Creek North | 0 | 149,344 | 8,519 | 4,081 | 1,629 | 3,233 | 166,806 |
| Dry Creek South | 0 | 82,483 | 19,488 | 2,616 | 416 | 887 | 105,889 |
| Goodman | 0 | 2,130 | 0 | 0 | 0 | 13 | 2,143 |
| Henderson | 0 | 29,952 | 3,301 | 1,872 | 0 | 496 | 35,619 |
| Holliday | 0 | 28,793 | 822 | 2,247 | 0 | 565 | 32,427 |
| Lincolnway | 0 | 16,520 | 1,685 | 107 | 0 | 148 | 18,460 |
| North Range Business Park | 0 | 26,702 | 309 | 0 | 0 | 0 | 27,011 |
| The Pointe 1 | 0 | 9,698 | 179 | 0 | 0 | 0 | 9,876 |
| The Pointe 2 | 0 | 15,316 | 62 | 73 | 0 | 0 | 15,451 |
| Total | 4 | 546,189 | 45,398 | 19,291 | 2,454 | 6,867 | 620,199 |

### Long-term (2063)

Figure 7-10 shows the long-term MDF capacity limitations for both manholes with predicted SSO risks and pipe length with predicted percentage of full pipe flow capacity. Table 7-23 presents the MDF results, breaking down the long -term system performance by sewer basin.

**Table 7-23**
**Long-term (2063) Maximum Day Flow Capacity Limitations**

| Sewer Basin | Manholes with SSO Risk | Pipe Length with q/Q of | | | | | Total Pipe Length |
|---|---|---|---|---|---|---|---|
| | | 0-50% | 50-75% | 75-100% | 100-120% | 120%+ | |
| Capital North | 1 | 77,295 | 323 | 332 | 410 | 619 | 78,979 |
| Capital South | 0 | 57,739 | 2,191 | 7,440 | 945 | 4,283 | 72,598 |
| Clear Creek | 11 | 28,890 | 11,199 | 8,861 | 458 | 5,950 | 55,358 |
| Dry Creek North | 0 | 144,360 | 9,391 | 6,745 | 2,100 | 4,088 | 166,683 |
| Dry Creek South | 9 | 72,635 | 11,023 | 9,607 | 2,977 | 8,960 | 105,202 |
| Goodman | 0 | 2,130 | 0 | 0 | 0 | 13 | 2,143 |
| Henderson | 0 | 29,309 | 1,628 | 3,392 | 795 | 496 | 35,619 |
| Holliday | 0 | 27,155 | 1,638 | 175 | 2,316 | 1,142 | 32,427 |
| Lincolnway | 0 | 16,520 | 1,685 | 107 | 0 | 148 | 18,460 |
| North Range Business Park | 0 | 19,345 | 7,357 | 0 | 309 | 0 | 27,011 |
| The Pointe 1 | 0 | 8,996 | 837 | 44 | 0 | 0 | 9,876 |
| The Pointe 2 | 0 | 15,316 | 62 | 0 | 73 | 0 | 15,451 |
| Total | 21 | 499,690 | 47,334 | 36,703 | 10,382 | 25,697 | 619,807 |

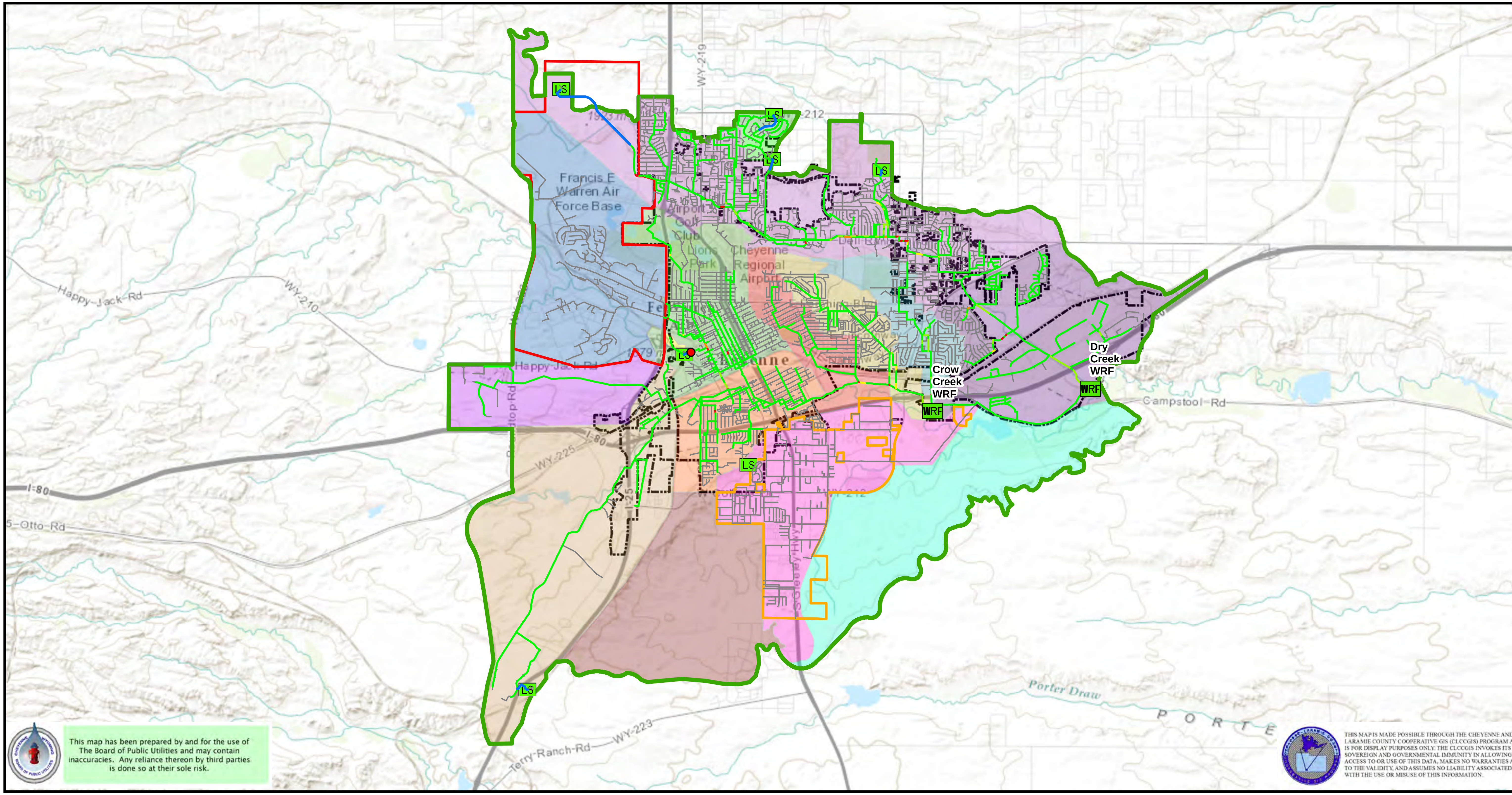
### Summary of Maximum Day Flow Analysis Observations

- With the existing flow conditions, there are only isolated surcharging pipes due to flat slopes; these locations should be verified in the field if any improvements are necessary or if they are results of incorrect model input data. There is one predicted SSO near the Goodman lift station that should be investigated. Otherwise, no capacity improvements should be necessary in the near-term.
- With the near-term flow conditions, there are only isolated surcharging pipes due to flat slopes. There is one predicted SSO near the Goodman lift station that should be investigated. Otherwise, no capacity improvements should be necessary in the near-term.
- With the mid-term flow conditions, there are isolated surcharging pipes due to flat slopes. The primary DCWRF and CCWRF interceptors as well as the Clear Creek

interceptor are starting to show capacity limitations in isolated areas but with no predicted SSO risks. The DCWRF interceptors may be able to better utilize the parallel interceptors to prolong the need for improvements. Some improvements may be necessary to alleviate these capacity limitations depending on growth and observed flows in these areas.

- With the long-term flow conditions, there are isolated surcharging pipes due to flat slopes. The primary CCWRF and Clear Creek interceptors are showing significant capacity limitations and predicted SSOs. The primary DCWRF interceptor is showing about the same capacity limitations as in the mid-term. The CCWRF to DCWRF bypass is showing significant capacity limitations and predicted SSOs. Improvements are likely necessary to alleviate these capacity limitations depending on growth and observed flows in these areas.

Single pipe segments that exceeded the analysis criteria were not described in the previous observations since they may be due to input data issues rather than actual capacity limitations. They do appear on the preceding result tables and following figures for consideration.




**Legend**

- WRF Water Reclamation Facility
- LS Existing Lift Station
- Existing Forcemain
- Non-modeled Main

**Manhole Results**

- Predicted SSO
- Predicted SSO Risk

**Pipe Results (q/Q)**

- 0 - 50%
- 50 - 75%
- 75 - 100%
- 100 - 120%
- > 120%

**Existing Sewer Basins**

- Allison Draw East
- Allison Draw South
- Capitol North
- Capitol South
- Clear Creek
- Dry Creek North
- Dry Creek South
- Goodman
- Henderson
- Holliday
- Lincolnway
- North Range Business Park
- South Cheyenne
- The Pointe 1
- The Pointe 2
- Warren Air Force Base

- City of Cheyenne
- Sewer Service Area Boundary
- F.E. Warren Air Force Base
- South Cheyenne

1 inch = 2 miles

N

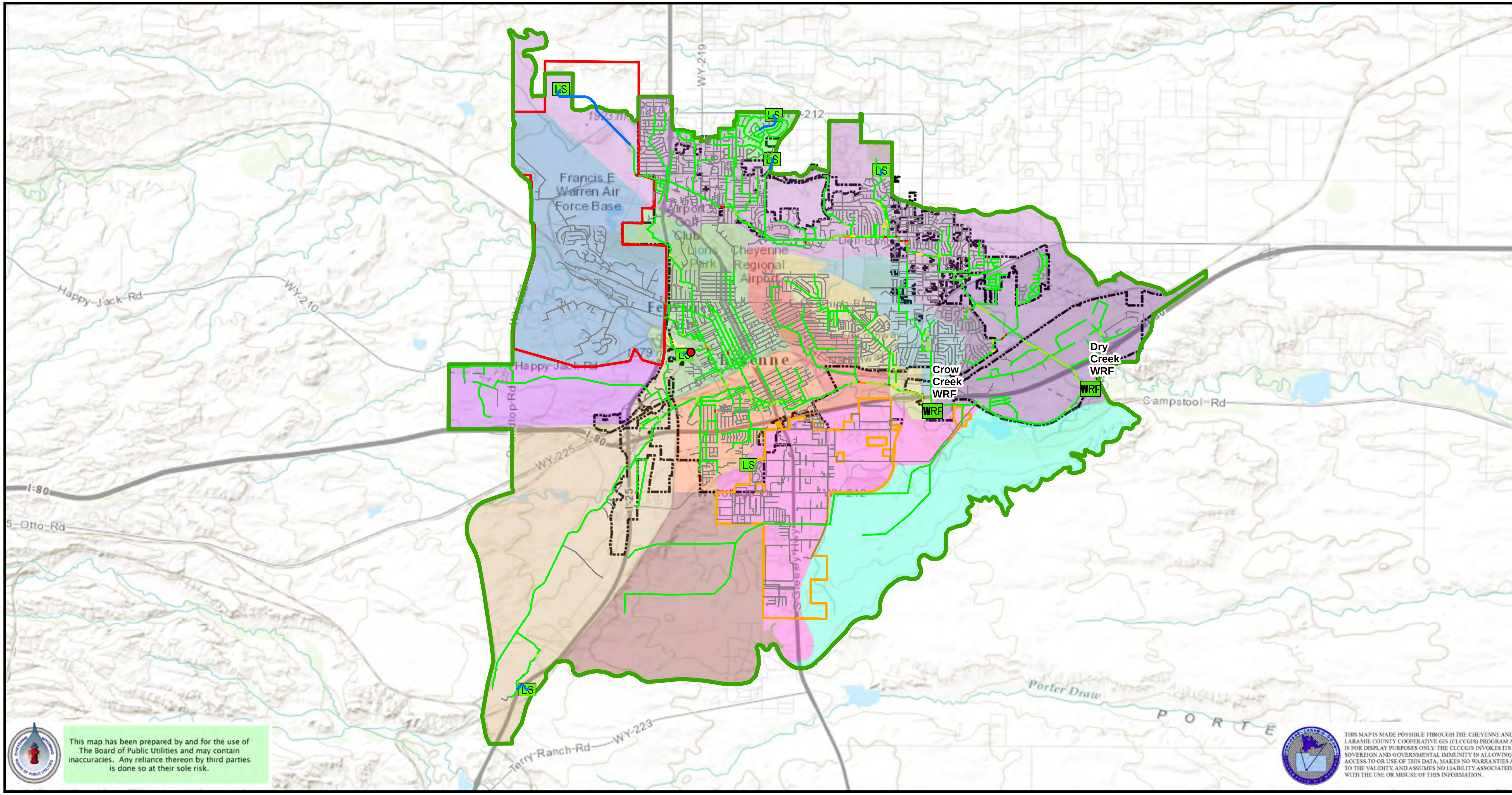
HDR

Last Updated: 10/4/2013

# Figure 7-7
# Existing (2013) Maximum Day Flow Results

**Volume 7 - Wastewater Collection**

2013 Water and Wastewater Master Plans




**Legend**

WRF Water Reclamation Facility
LS Existing Lift Station
Existing Forcemain
Non-modeled Main

**Manhole Results**
Predicted SSO
Predicted SSO Risk

**Pipe Results (q/Q)**
0 - 50%
50 - 75%
75 - 100%
100 - 120%
> 120%

**Existing Sewer Basins**
Allison Draw East
Allison Draw South
Capitol North
Capitol South
Clear Creek
Dry Creek North
Dry Creek South
Goodman
Henderson
Holliday
Lincolnway
North Range Business Park
South Cheyenne
The Pointe 1
The Pointe 2
Warren Air Force Base

City of Cheyenne
Sewer Service Area Boundary
F.E. Warren Air Force Base
South Cheyenne

1 inch = 2 miles

N

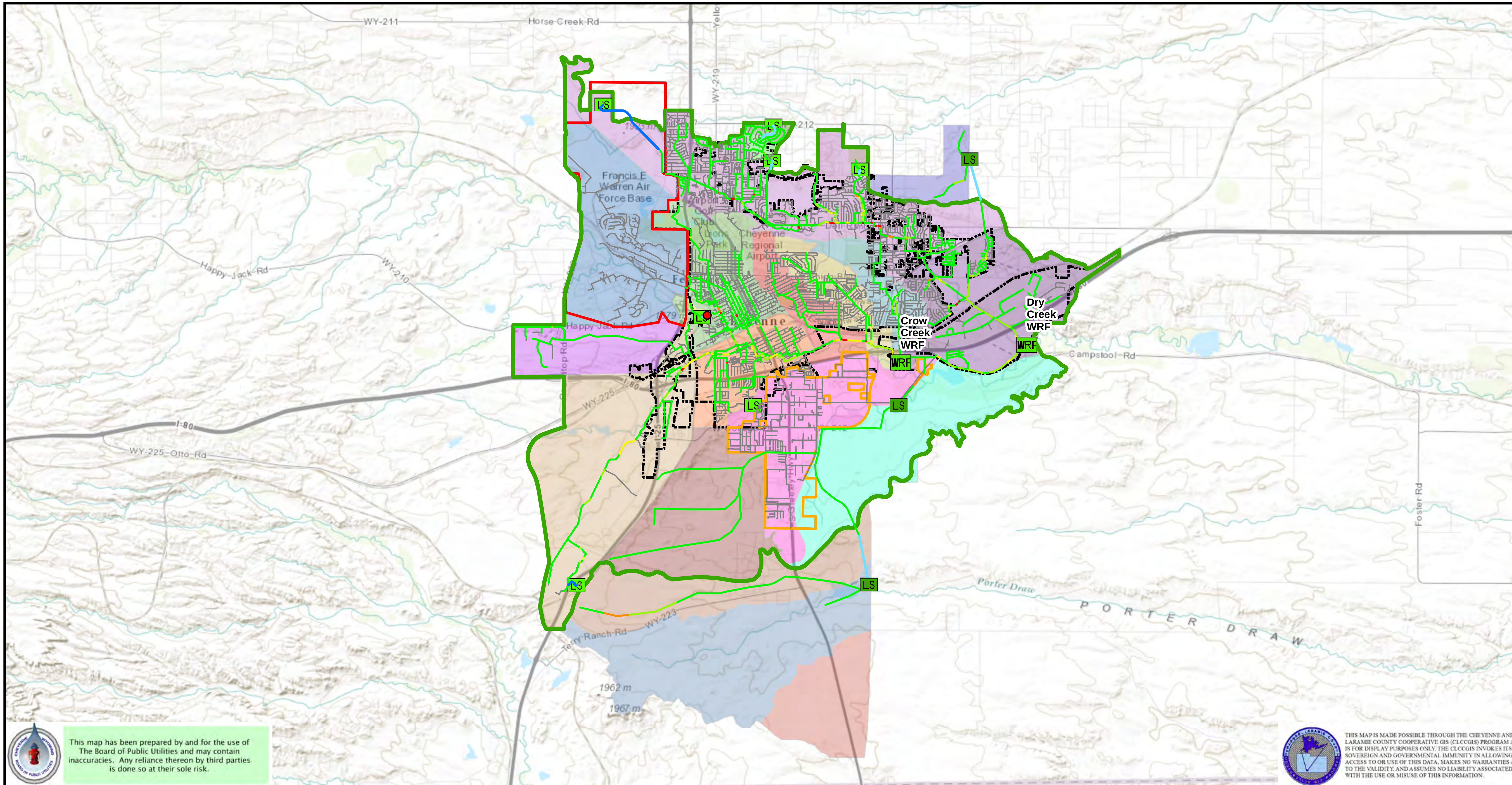
HDR

Last Updated: 10/4/2013

# Figure 7-8
# Near-term (2023) Maximum Day Flow Results

Volume 7 - Wastewater Collection

2013 Water and Wastewater Master Plans




## Legend

- WRF — Water Reclamation Facility
- LS — Existing Lift Station
- LS — Future Lift Station
- Existing Forcemain
- Future Forcemain
- Non-modeled Main

**Manhole Results**

- Predicted SSO
- Predicted SSO Risk

**Pipe Results (q/Q)**

- 0 - 50%
- 50 - 75%
- 75 - 100%
- 100 - 120%
- > 120%

**Future Sewer Basins**

- Allison Draw East
- Allison Draw South
- Capitol North
- Capitol South
- Childs Draw
- Clear Creek
- Dry Creek North
- Dry Creek South
- Goodman
- Henderson
- Holliday
- Lincolnway
- Little Simpson Creek
- North Range Business Park
- Porter Draw North
- Porter Draw South
- South Cheyenne
- The Pointe 1
- The Pointe 2
- Warren Air Force Base

- City of Cheyenne
- Sewer Service Area Boundary
- F.E. Warren Air Force Base
- South Cheyenne

1 inch = 2.5 miles

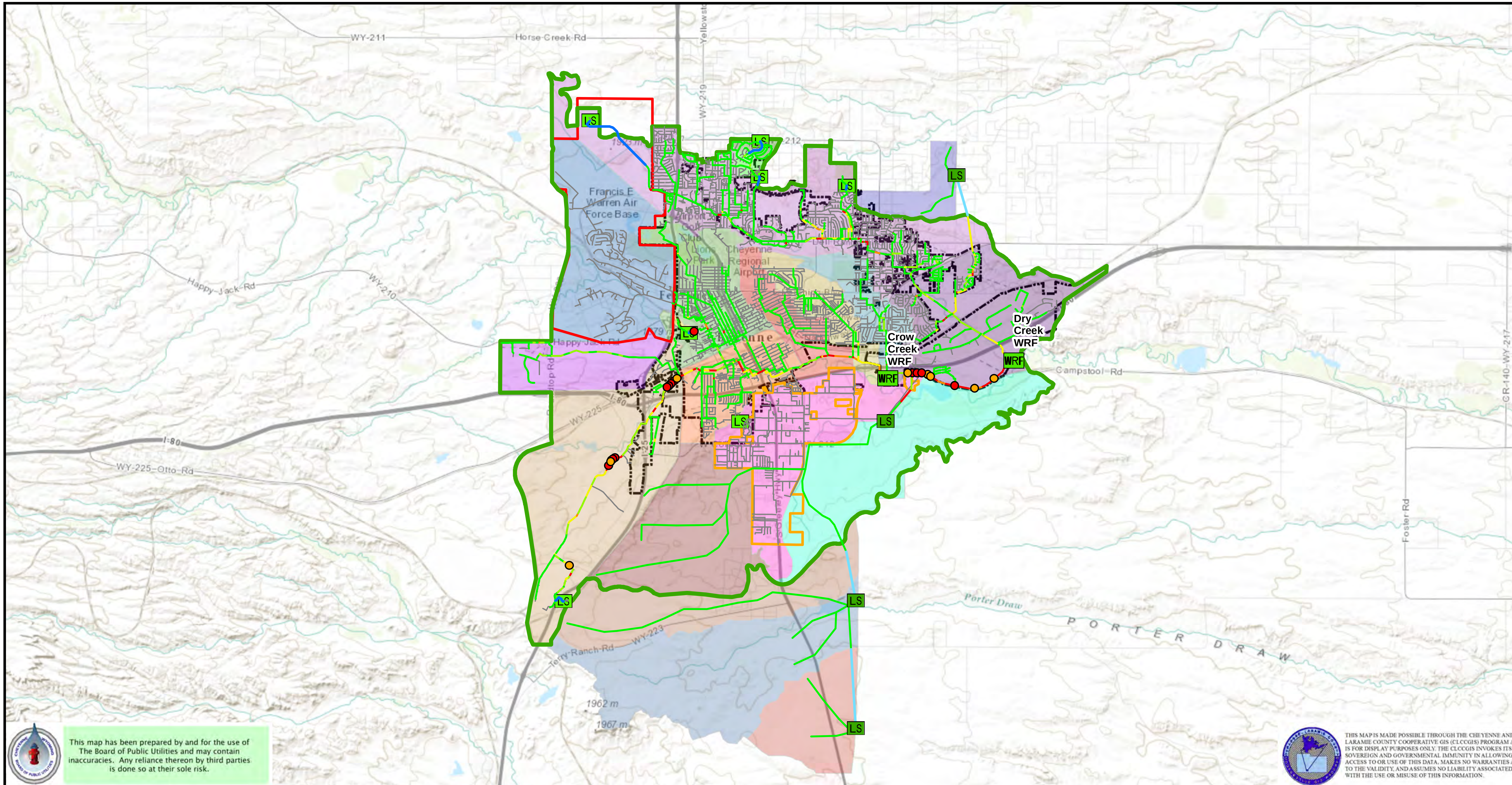
N

Last Updated: 10/4/2013

# Figure 7-9
# Mid-term (2033) Maximum Day Flow Results

**Volume 7 - Wastewater Collection**

2013 Water and Wastewater Master Plans




**Legend**

WRF Water Reclamation Facility
LS Existing Lift Station
LS Future Lift Station
Existing Forcemain
Future Forcemain
Non-modeled Main

**Manhole Results**
- Predicted SSO
- Predicted SSO Risk

**Pipe Results (q/Q)**
- 0 - 50%
- 50 - 75%
- 75 - 100%
- 100 - 120%
- > 120%

**Future Sewer Basins**
- Allison Draw East
- Allison Draw South
- Capitol North
- Capitol South
- Childs Draw
- Clear Creek
- Dry Creek North
- Dry Creek South
- Goodman
- Henderson
- Holliday
- Lincolnway
- Little Simpson Creek
- North Range Business Park
- Porter Draw North
- Porter Draw South
- South Cheyenne
- The Pointe 1
- The Pointe 2
- Warren Air Force Base

- City of Cheyenne
- Sewer Service Area Boundary
- F.E. Warren Air Force Base
- South Cheyenne

1 inch = 2.5 miles

N

HDR

Last Updated: 10/4/2013

# Figure 7-10
## Long-term (2063) Maximum Day Flow Results

Volume 7 - Wastewater Collection

2013 Water and Wastewater Master Plans

### 7.4.4 Peak Hour Flow Results

The peak hour scenarios were run in the model and compared to the PHF analysis criteria to determine where predicted capacity limitations exist in each planning period. The PHF results were used to trigger improvement needs and to size future pipes along with MDF conditions.

**Existing (2013)**

Figure 7-11 shows the existing PHF capacity limitations for both manholes with predicted SSO risks and pipe length with predicted percentage of full pipe flow capacity. Table 7-24 presents the PHF results, breaking down the existing system performance by sewer basin.

**Table 7-24**
**Existing (2013) Peak Hour Flow Capacity Limitations**

| Sewer Basin | Manholes with SSO Risk | Pipe Length with q/Q of | | | | | Total Pipe Length |
|---|---|---|---|---|---|---|---|
| | | 0-50% | 50-75% | 75-100% | 100-120% | 120%+ | |
| Capital North | 1 | 73,373 | 4,111 | 49 | 271 | 1,176 | 78,979 |
| Capital South | 0 | 70,485 | 1,164 | 383 | 0 | 566 | 72,598 |
| Clear Creek | 0 | 55,691 | 0 | 0 | 0 | 0 | 55,691 |
| Dry Creek North | 0 | 142,973 | 13,386 | 4,333 | 1,615 | 4,498 | 166,806 |
| Dry Creek South | 0 | 70,491 | 18,321 | 9,351 | 2,731 | 4,697 | 105,591 |
| Goodman | 0 | 2,130 | 0 | 0 | 0 | 13 | 2,143 |
| Henderson | 0 | 28,987 | 4,841 | 220 | 813 | 759 | 35,619 |
| Holliday | 0 | 28,968 | 2,893 | 0 | 539 | 26 | 32,427 |
| Lincolnway | 0 | 11,432 | 3,966 | 2,126 | 681 | 255 | 18,460 |
| North Range Business Park | 0 | 27,011 | 0 | 0 | 0 | 0 | 27,011 |
| The Pointe 1 | 0 | 9,832 | 44 | 0 | 0 | 0 | 9,876 |
| The Pointe 2 | 0 | 15,378 | 73 | 0 | 0 | 0 | 15,451 |
| Total | 1 | 536,753 | 48,798 | 16,462 | 6,650 | 11,989 | 620,653 |

### Near-term (2023)

Figure 7-12 shows the near-term PHF capacity limitations for both manholes with predicted SSO risks and pipe segments with predicted percentage of full pipe flow capacity. Table 7-25 presents the PHF results, breaking down the near-term system performance by sewer basin.

**Table 7-25**
**Near-term (2023) Peak Hour Flow Capacity Limitations**

| Sewer Basin | Manholes with SSO Risk | Pipe Length with q/Q of | | | | | Total Pipe Length |
|---|---|---|---|---|---|---|---|
| | | 0-50% | 50-75% | 75-100% | 100-120% | 120%+ | |
| Capital North | 1 | 73,373 | 4,111 | 49 | 271 | 1,176 | 78,979 |
| Capital South | 0 | 61,918 | 8,019 | 1,891 | 0 | 566 | 72,394 |
| Clear Creek | 0 | 50,746 | 4,605 | 341 | 0 | 0 | 55,691 |
| Dry Creek North | 0 | 140,416 | 14,840 | 4,838 | 2,213 | 4,498 | 166,806 |
| Dry Creek South | 0 | 70,889 | 17,004 | 9,138 | 3,303 | 5,063 | 105,397 |
| Goodman | 0 | 2,130 | 0 | 0 | 0 | 13 | 2,143 |
| Henderson | 0 | 28,390 | 4,642 | 1,015 | 749 | 823 | 35,619 |
| Holliday | 0 | 28,793 | 822 | 2,247 | 0 | 565 | 32,427 |
| Lincolnway | 0 | 11,432 | 3,966 | 2,126 | 681 | 255 | 18,460 |
| North Range Business Park | 0 | 26,702 | 309 | 0 | 0 | 0 | 27,011 |
| The Pointe 1 | 0 | 9,698 | 135 | 44 | 0 | 0 | 9,876 |
| The Pointe 2 | 0 | 15,316 | 62 | 73 | 0 | 0 | 15,451 |
| Total | 1 | 519,803 | 58,515 | 21,762 | 7,217 | 12,959 | 620,255 |

### Mid-term (2033)

Figure 7-13 shows the mid-term PHF capacity limitations for both manholes with predicted SSO risks and pipe segments with predicted percentage of full pipe flow capacity. Table 7-26 presents the PHF results, breaking down the mid-term system performance by sewer basin.

**Table 7-26**
**Mid-term (2033) Peak Hour Flow Capacity Limitations**

| Sewer Basin | Manholes with SSO Risk | Pipe Length with q/Q of | | | | | Total Pipe Length |
|---|---|---|---|---|---|---|---|
| | | 0-50% | 50-75% | 75-100% | 100-120% | 120%+ | |
| Capital North | 1 | 73,373 | 4,111 | 49 | 271 | 1,176 | 78,979 |
| Capital South | 0 | 57,527 | 6,766 | 4,022 | 3,130 | 1,153 | 72,598 |
| Clear Creek | 5 | 40,094 | 9,648 | 1,004 | 2,491 | 2,455 | 55,691 |
| Dry Creek North | 0 | 136,282 | 13,969 | 7,033 | 2,756 | 6,173 | 166,213 |
| Dry Creek South | 0 | 60,434 | 16,087 | 12,958 | 7,447 | 8,410 | 105,335 |
| Goodman | 0 | 2,130 | 0 | 0 | 0 | 13 | 2,143 |
| Henderson | 0 | 27,623 | 3,423 | 2,082 | 1,544 | 823 | 35,495 |
| Holliday | 0 | 28,239 | 554 | 822 | 2,247 | 565 | 32,427 |
| Lincolnway | 0 | 11,432 | 3,966 | 2,126 | 681 | 255 | 18,460 |
| North Range Business Park | 0 | 25,437 | 1,265 | 309 | 0 | 0 | 27,011 |
| The Pointe 1 | 0 | 8,618 | 1,215 | 44 | 0 | 0 | 9,876 |
| The Pointe 2 | 0 | 15,316 | 0 | 62 | 0 | 73 | 15,451 |
| Total | 6 | 486,504 | 61,004 | 30,510 | 20,566 | 21,096 | 619,680 |

**Long-term (2063)**

Figure 7-14 shows the mid-term PHF capacity limitations for both manholes with predicted SSO risks and pipe segments with predicted percentage of full pipe flow capacity. Table 7-27 presents the PHF results, breaking down the mid-term system performance by sewer basin.

**Table 7-27**
**Long-term (2063) Peak Hour Flow Capacity Limitations**

| Sewer Basin | Manholes with SSO Risk | Pipe Length with q/Q of | | | | | Total Pipe Length |
|---|---|---|---|---|---|---|---|
| | | 0-50% | 50-75% | 75-100% | 100-120% | 120%+ | |
| Capital North | 1 | 73,033 | 4,451 | 49 | 271 | 1,176 | 78,979 |
| Capital South | 18 | 55,898 | 1,961 | 1,127 | 3,244 | 10,369 | 72,598 |
| Clear Creek | 59 | 25,002 | 4,642 | 8,170 | 6,064 | 11,237 | 55,115 |
| Dry Creek North | 17 | 123,337 | 17,754 | 9,921 | 5,049 | 10,467 | 166,529 |
| Dry Creek South | 68 | 54,238 | 11,374 | 5,832 | 7,593 | 26,141 | 105,179 |
| Goodman | 0 | 2,130 | 0 | 0 | 0 | 13 | 2,143 |
| Henderson | 4 | 26,736 | 2,762 | 1,006 | 1,203 | 3,480 | 35,187 |
| Holliday | 6 | 25,192 | 2,392 | 1,208 | 0 | 3,634 | 32,427 |
| Lincolnway | 0 | 11,208 | 4,190 | 2,126 | 681 | 255 | 18,460 |
| North Range Business Park | 0 | 16,045 | 6,012 | 4,335 | 310 | 309 | 27,011 |
| The Pointe 1 | 0 | 6,912 | 2,000 | 837 | 0 | 44 | 9,792 |
| The Pointe 2 | 0 | 15,316 | 0 | 0 | 0 | 135 | 15,451 |
| Total | 173 | 435,048 | 57,537 | 34,612 | 24,415 | 67,260 | 618,871 |

**Summary of Peak Hour Flow Analysis Observations**

- With the existing flow conditions, there are isolated surcharging pipes due to flat slopes; these locations should be verified in the field if any improvements are necessary or if they are results of incorrect model input data. There is one predicted SSO near the Goodman lift station that should be investigated. The primary DCWRF interceptors are starting to show capacity limitations in isolated areas but with no predicted SSO risks. The DCWRF interceptors may be able to better utilize the parallel interceptors to prolong the need for improvements. A portion of the Archer area is showing at capacity due to shallow pipe slopes. Otherwise, no capacity improvements should be necessary in the near-term.
- With the near-term flow conditions, there are isolated surcharging pipes due to flat slopes. There is one predicted SSO near the Goodman lift station that should be

investigated. The primary DCWRF interceptors are starting to show capacity limitations in isolated areas but with no predicted SSO risks. The DCWRF interceptors may be able to better utilize the parallel interceptors to prolong the need for improvements. A portion of the Archer area is showing at capacity due to shallow pipe slopes. Otherwise, no capacity improvements should be necessary in the near-term.

- With the mid-term flow conditions, there are isolated surcharging pipes due to flat slopes. The primary DCWRF and CCWRF interceptors as well as the Clear Creek interceptor are starting to show capacity limitations in isolated areas and with a few predicted SSO risks. The DCWRF interceptors may be able to better utilize the parallel interceptors to prolong the need for improvements. A portion of the Archer area is showing at capacity due to shallow pipe slopes. Some improvements may be necessary to alleviate these capacity limitations depending on growth and observed flows in these areas.
- With the long-term flow conditions, there are isolated surcharging pipes due to flat slopes. The primary CCWRF, DCWRF and Clear Creek interceptors are showing very significant capacity limitations and many predicted SSOs. The CCWRF to DCWRF bypass is showing very significant capacity limitations and many predicted SSOs. A portion of the Archer area is showing at capacity due to shallow pipe slopes. The mains downstream of the future Childs Draw lift station are showing capacity limitations and predicted SSOs. Improvements are likely necessary to alleviate these capacity limitations depending on growth and observed flows in these areas.

Single pipe segments that exceeded the analysis criteria were not described in the previous observations since they may be due to input data issues rather than actual capacity limitations. They do appear on the preceding result tables and following figures for consideration.

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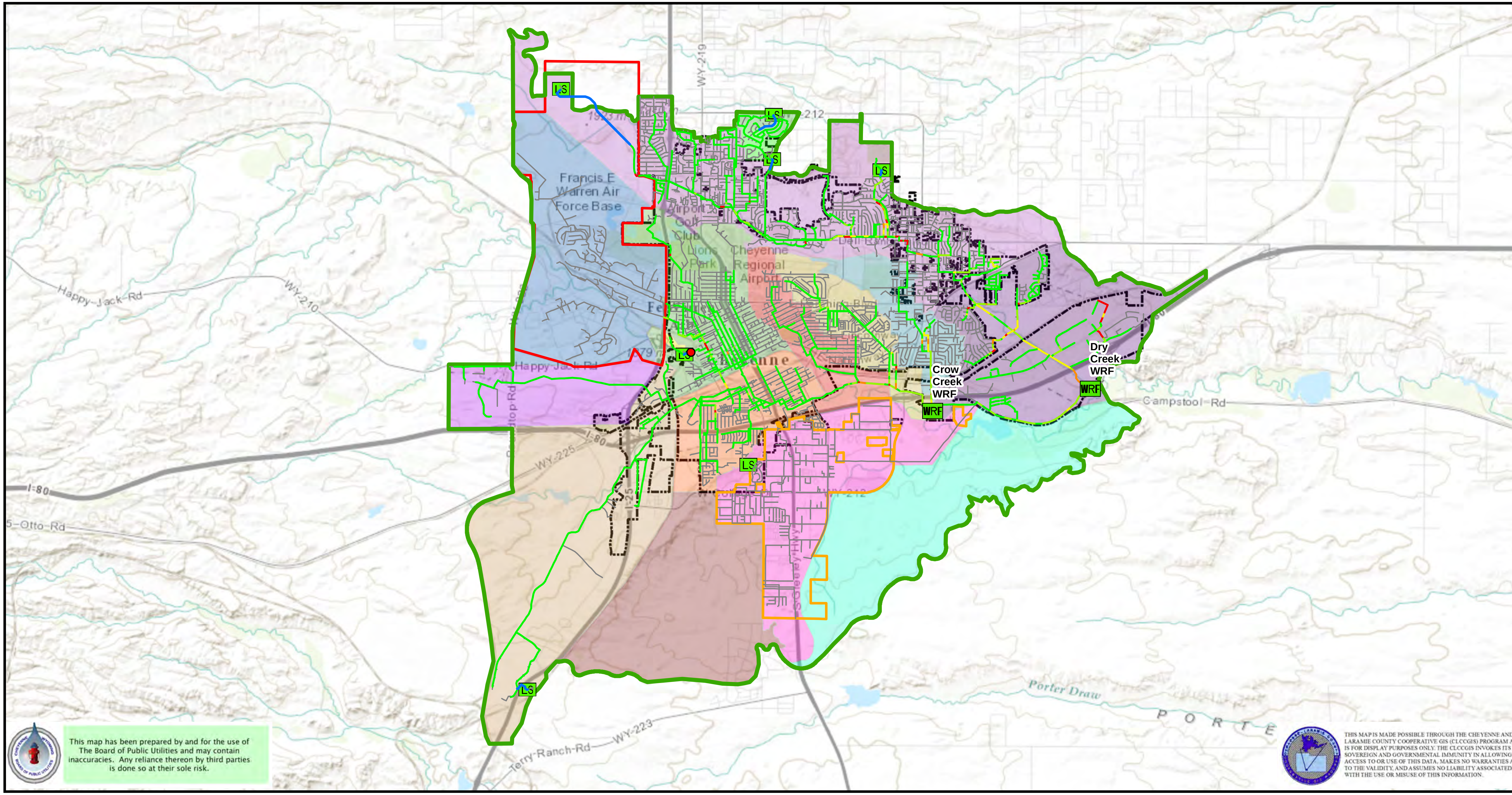



**Legend**

- WRF Water Reclamation Facility
- LS Existing Lift Station
- Existing Forcemain
- Non-modeled Main

**Manhole Results**

- Predicted SSO
- Predicted SSO Risk

**Pipe Results (q/Q)**

- 0 - 50%
- 50 - 75%
- 75 - 100%
- 100 - 120%
- > 120%

**Existing Sewer Basins**

- Allison Draw East
- Allison Draw South
- Capitol North
- Capitol South
- Clear Creek
- Dry Creek North
- Dry Creek South
- Goodman
- Henderson
- Holliday
- Lincolnway
- North Range Business Park
- South Cheyenne
- The Pointe 1
- The Pointe 2
- Warren Air Force Base

- City of Cheyenne
- Sewer Service Area Boundary
- F.E. Warren Air Force Base
- South Cheyenne

1 inch = 2 miles

N

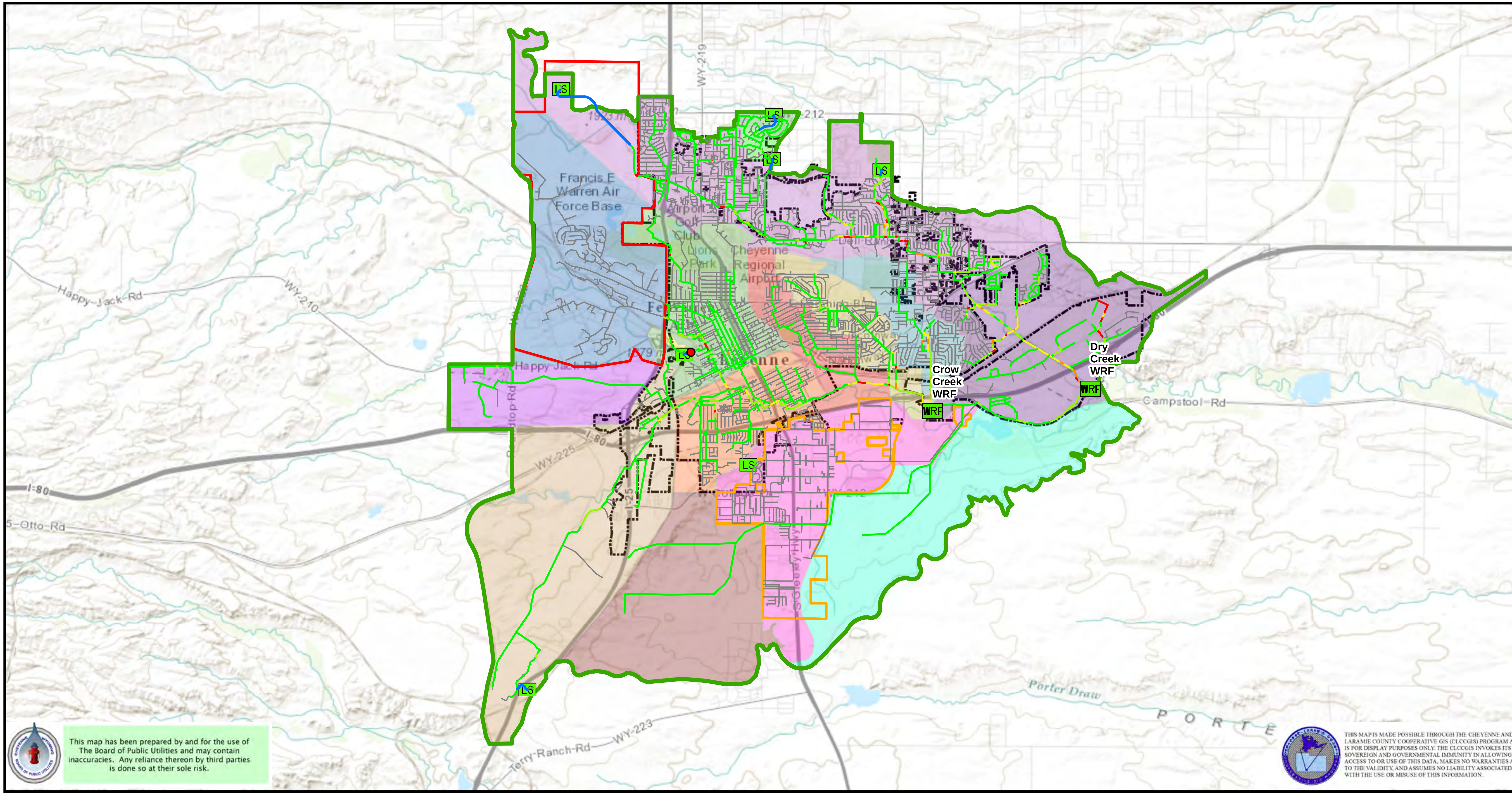
HDR

Last Updated: 10/4/2013

# Figure 7-11
# Existing (2013) Peak Hour Flow Results

Volume 7 - Wastewater Collection

2013 Water and Wastewater Master Plans




**Legend**

- WRF Water Reclamation Facility
- LS Existing Lift Station
- Existing Forcemain
- Non-modeled Main

**Manhole Results**

- Predicted SSO
- Predicted SSO Risk

**Pipe Results (q/Q)**

- 0 - 50%
- 50 - 75%
- 75 - 100%
- 100 - 120%
- > 120%

**Existing Sewer Basins**

- Allison Draw East
- Allison Draw South
- Capitol North
- Capitol South
- Clear Creek
- Dry Creek North
- Dry Creek South
- Goodman
- Henderson
- Holliday
- Lincolnway
- North Range Business Park
- South Cheyenne
- The Pointe 1
- The Pointe 2
- Warren Air Force Base

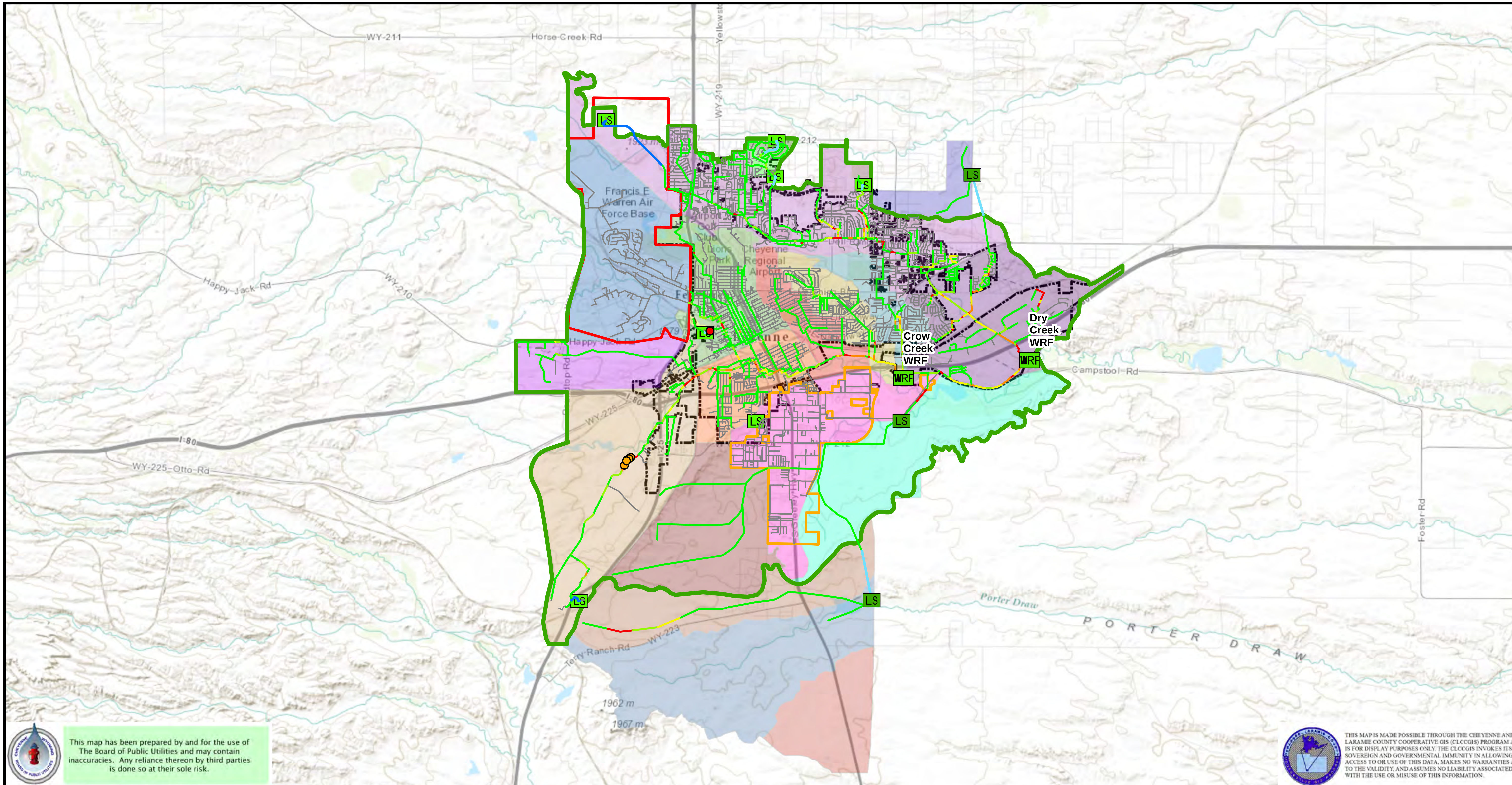
- City of Cheyenne
- Sewer Service Area Boundary
- F.E. Warren Air Force Base
- South Cheyenne

1 inch = 2 miles

N

Last Updated: 10/4/2013

**Figure 7-12**
**Near-term (2023) Peak Hour Flow Results**
**Volume 7 - Wastewater Collection**
2013 Water and Wastewater Master Plans




## Legend

- WRF Water Reclamation Facility
- LS Existing Lift Station
- LS Future Lift Station
- Existing Forcemain
- Future Forcemain
- Non-modeled Main

**Manhole Results**

- Predicted SSO
- Predicted SSO Risk

**Pipe Results (q/Q)**

- 0 - 50%
- 50 - 75%
- 75 - 100%
- 100 - 120%
- > 120%

**Future Sewer Basins**

- Allison Draw East
- Allison Draw South
- Capitol North
- Capitol South
- Childs Draw
- Clear Creek
- Dry Creek North
- Dry Creek South
- Goodman
- Henderson
- Holliday
- Lincolnway
- Little Simpson Creek
- North Range Business Park
- Porter Draw North
- Porter Draw South
- South Cheyenne
- The Pointe 1
- The Pointe 2
- Warren Air Force Base

- City of Cheyenne
- Sewer Service Area Boundary
- F.E. Warren Air Force Base
- South Cheyenne

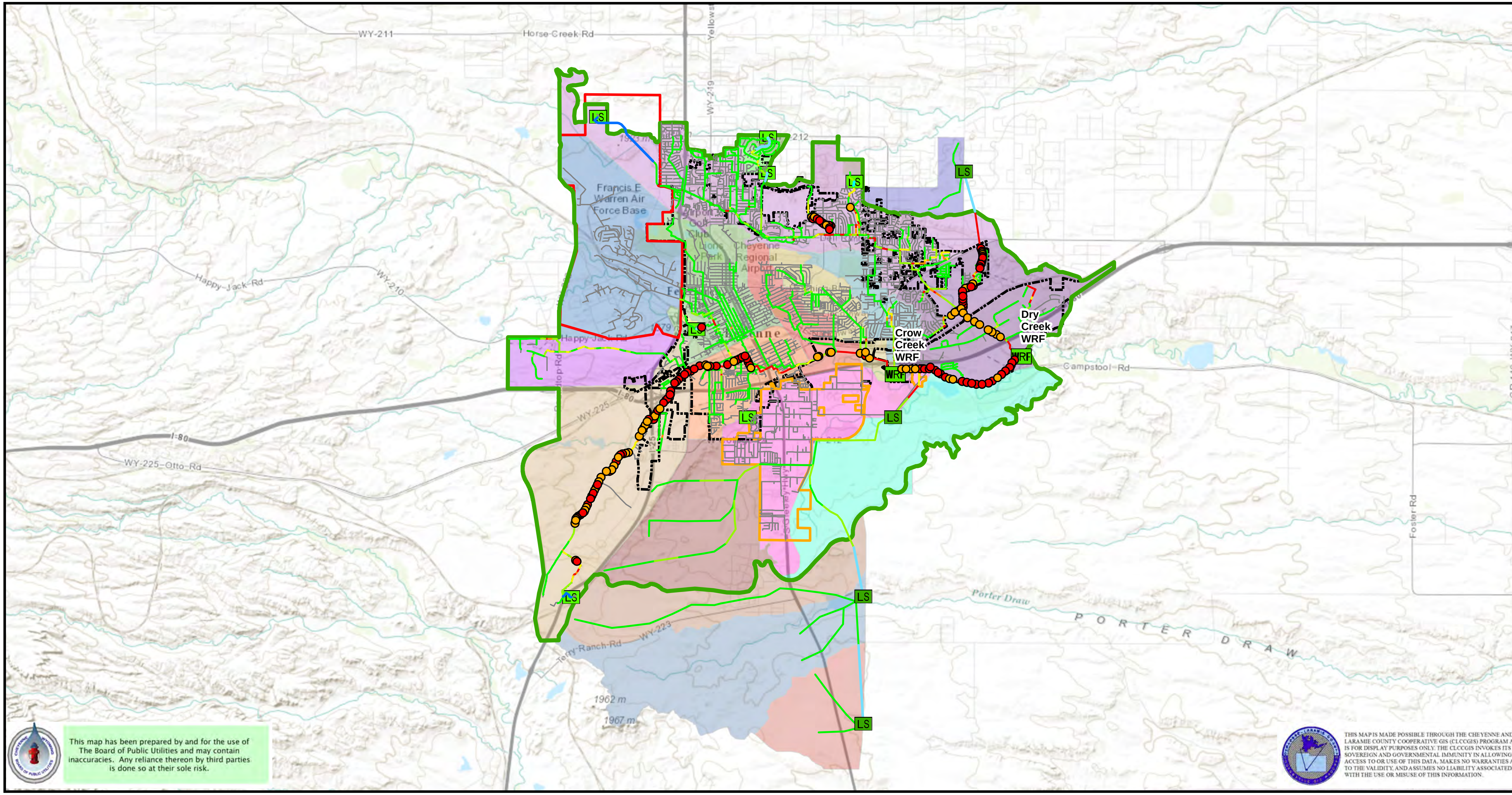
1 inch = 2.5 miles

N

**Figure 7-13**
**Mid-term (2033) Peak Hour Flow Results**
**Volume 7 - Wastewater Collection**

2013 Water and Wastewater Master Plans

Last Updated: 10/4/2013




**Legend**

- WRF Water Reclamation Facility
- LS Existing Lift Station
- LS Future Lift Station
- Existing Forcemain
- Future Forcemain
- Non-modeled Main

**Manhole Results**

- Predicted SSO
- Predicted SSO Risk

**Pipe Results (q/Q)**

- 0 - 50%
- 50 - 75%
- 75 - 100%
- 100 - 120%
- > 120%

**Future Sewer Basins**

- Allison Draw East
- Allison Draw South
- Capitol North
- Capitol South
- Childs Draw
- Clear Creek
- Dry Creek North
- Dry Creek South
- Goodman
- Henderson
- Holliday
- Lincolnway
- Little Simpson Creek
- North Range Business Park
- Porter Draw North
- Porter Draw South
- South Cheyenne
- The Pointe 1
- The Pointe 2
- Warren Air Force Base

- City of Cheyenne
- Sewer Service Area Boundary
- F.E. Warren Air Force Base
- South Cheyenne

1 inch = 2.5 miles

N

HDR

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# Figure 7-14
# Long-term (2063) Peak Hour Flow Results

### 7.4.5 Flat and Retrograde Mains and Interceptors

Wastewater mains and interceptors with very flat or retrograde slopes were found throughout the system and generally appear as conduits at or over capacity even under existing conditions. In many cases, these mains are only a pipe segment or two long. These lines should be a focus for preventive maintenance since they are more prone to deposition of debris and silt, which can cause blockages and/or reduced flow capacity. Figure 7-15 shows the pipes in the existing system model that were identified as very flat or retrograde. These lines should be closely monitored and corrective action taken. Relief or replacement sewer lines may be warranted, should surcharging cause problems such as SSOs and/or flooded basements. If the future additional flows were not above 120% q/Q, then no improvements were recommended.

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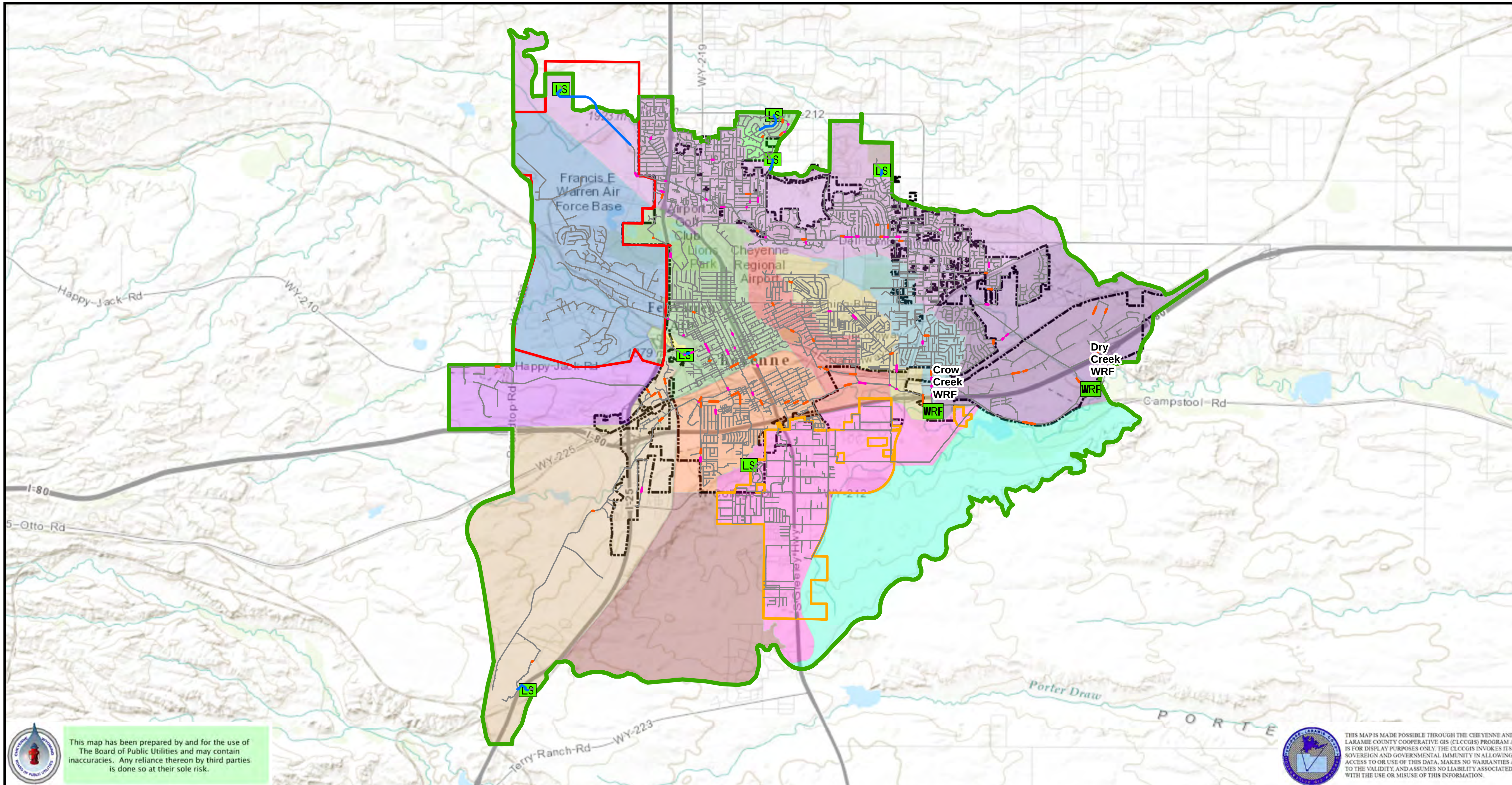


**Legend**

WRF Water Reclamation Facility
LS Existing Lift Station
Existing Forcemain
Non-modeled Main

**Slope Description**
Retrograde
Flat
Shallow

**Existing Sewer Basins**
Allison Draw East
Allison Draw South
Capitol North
Capitol South
Clear Creek
Dry Creek North
Dry Creek South
Goodman
Henderson
Holliday
Lincolnway
North Range Business Park
South Cheyenne
The Pointe 1
The Pointe 2
Warren Air Force Base

City of Cheyenne
Sewer Service Area Boundary
F.E. Warren Air Force Base
South Cheyenne

1 inch = 2 miles
N

HDR

# Figure 7-15
# Existing Flat or Retrograde Mains and Interceptors

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Last Updated: 10/4/2013

2013 Water and Wastewater Master Plans

## 7.5 Lift Station and Forcemain Capacity Analysis

The lift station and forcemain capacity analysis examined existing and future performance of the lift stations firm capacities and forcemain velocities using the validated hydraulic model. Only the modeled existing and future lift stations and forcemains were included in the capacity analysis.

### 7.5.1 Evaluation Criteria

The lift station evaluation capacity evaluation is based on conveying PHF with the largest pump out of service. WDEQ requires a minimum forcemain velocity of 2.5 ft/s. Force mains are recommended for replacement or paralleling when peak flow velocities exceed 5 ft/s on a consistent basis (under ADF conditions) or 10 ft/s during PHF.

### 7.5.2 Capacity Analysis

Existing and future lift station and forcemain capacities were analyzed for each of the planning periods based on the model results.

**Existing Lift Stations**

Table 7-28 through Table 7-31 document the existing lift station capacity analysis and any capacity surpluses or deficiencies for The Pointe 1, The Pointe 2, North Park and Goodman lift stations. The existing smaller City and private lift stations including the Wyoming Welcome Center, Army Air Heli Station and Harmony lift stations are assumed to be sized correctly to service their contributing areas as future development is not expected in these areas.

**Table 7-28**
**Lift Station Capacity Analysis for The Pointe 1 (Existing)**

| | Year | | | |
|---|---|---|---|---|
| | 2013 | 2023 | 2033 | 2063 |
| Projected Flows [(1)] | | | | |
| Average Day Flow (gpm) | 78 | 107 | 124 | 203 |
| Maximum Day Flow (gpm) | 147 | 215 | 249 | 374 |
| Peak Hour Flow (gpm) | 262 | 289 | 342 | 466 |
| Evaluation of Existing Capacity | | | | |
| Available Existing Capacity (gpm) [(2)] | 625 | 625 | 625 | 625 |
| Capacity Surplus/(Deficiency) (gpm) [(3)] | 363 | 336 | 283 | 159 |
| Forcemain Diameter (inches) | 6 | 6 | 6 | 6 |
| Forcemain PHF Velocity (ft/s) | 3.0 | 3.3 | 3.9 | 5.3 |

(1) Projected flows taken from model results

(2) Available capacity assumes the largest pump is offline.

(3) Capacity surplus/deficiency is the amount of available existing capacity greater than peak hour flow.

**Table 7-29**
**Lift Station Capacity Analysis for The Pointe 2 (Existing)**

| | Year | | | |
|---|---|---|---|---|
| | 2013 | 2023 | 2033 | 2063 |
| Projected Flows [(1)] | | | | |
| Average Day Flow (gpm) | 35 | 53 | 64 | 115 |
| Maximum Day Flow (gpm) | 67 | 109 | 131 | 210 |
| Peak Hour Flow (gpm) | 106 | 140 | 173 | 251 |
| Evaluation of Existing Capacity | | | | |
| Available Existing Capacity (gpm) [(2)] | 250 | 250 | 250 | 250 |
| Capacity Surplus/(Deficiency) (gpm) [(3)] | 144 | 110 | 77 | -1 |
| Forcemain Diameter (inches) | 6 | 6 | 6 | 6 |
| Forcemain PHF Velocity (ft/s) | 1.2 | 1.6 | 2.0 | 2.9 |

(1) Projected flows taken from model results

(2) Available capacity assumes the largest pump is offline.

(3) Capacity surplus/deficiency is the amount of available existing capacity greater than peak hour flow.

**Table 7-30**
**Lift Station Capacity Analysis for North Park (Existing)**

| | Year | | | |
|---|---|---|---|---|
| | 2013 | 2023 | 2033 | 2063 |
| Projected Flows [(1)] | | | | |
| Average Day Flow (gpm) | 37 | 37 | 47 | 89 |
| Maximum Day Flow (gpm) | 72 | 72 | 92 | 163 |
| Peak Hour Flow (gpm) | 193 | 193 | 215 | 286 |
| Evaluation of Existing Capacity | | | | |
| Available Existing Capacity (gpm) [(2)] | 100 | 100 | 100 | 100 |
| Capacity Surplus/(Deficiency) (gpm) [(3)] | -93 | -93 | -115 | -186 |
| Forcemain Diameter (inches) | 4 | 4 | 4 | 4 |
| Forcemain PHF Velocity (ft/s) | 4.9 | 4.9 | 5.5 | 7.3 |

(1) Projected flows taken from model results

(2) Available capacity assumes the largest pump is offline.

(3) Capacity surplus/deficiency is the amount of available existing capacity greater than peak hour flow.

**Table 7-31**
**Lift Station Capacity Analysis for Goodman (Existing)**

| | Year | | | |
|---|---|---|---|---|
| | 2013 | 2023 | 2033 | 2063 |
| Projected Flows [(1)] | | | | |
| Average Day Flow (gpm) | 18 | 18 | 18 | 18 |
| Maximum Day Flow (gpm) | 28 | 28 | 28 | 28 |
| Peak Hour Flow (gpm) | 26 | 26 | 26 | 26 |
| Evaluation of Existing Capacity | | | | |
| Available Existing Capacity (gpm) [(2)] | 150 | 150 | 150 | 150 |
| Capacity Surplus/(Deficiency) (gpm) [(3)] | 124 | 124 | 124 | 124 |
| Forcemain Diameter (inches) | 6 | 6 | 6 | 6 |
| Forcemain PHF Velocity (ft/s) | 0.3 | 0.3 | 0.3 | 0.3 |

(1) Projected flows taken from model results

(2) Available capacity assumes the largest pump is offline.

(3) Capacity surplus/deficiency is the amount of available existing capacity greater than peak hour flow.

### Future Lift Stations

Table 7-32 through Table 7-34 document the future lift station capacity analysis and any capacity surpluses or deficiencies for Porter Draw, Childs Draw and Little Simpson Creek lift stations.

**Table 7-32**
**Lift Station Capacity Analysis for Porter Draw (Future)**

| | Year | | | |
|---|---|---|---|---|
| | 2013 | 2023 | 2033 | 2063 |
| Projected Flows (1) | | | | |
| Average Day Flow (gpm) | - | | 219 | 1,669 |
| Maximum Day Flow (gpm) | - | - | 483 | 2,003 |
| Peak Hour Flow (gpm) | - | - | 511 | 3,076 |
| Evaluation of Existing Capacity | | | | |
| Available Capacity (gpm) (2) | - | - | 1,000 | 3,200 |
| Capacity Surplus/(Deficiency) (gpm) (3) | - | - | 489 | 124 |
| Forcemain Diameter (inches) | - | - | 8 | 15(4) |
| Forcemain PHF Velocity (ft/s) | - | - | 3.3 | 5.6 |

(1) Projected flows taken from model results

(2) Available capacity assumes the largest pump is offline.

(3) Capacity surplus/deficiency is the amount of available existing capacity greater than peak hour flow.

(4) Based on an equivalent diameter of parallel 8-inch and 12-inch forcemains.

**Table 7-33**
**Lift Station Capacity Analysis for Childs Draw (Future)**

| | Year | | | |
|---|---|---|---|---|
| | 2013 | 2023 | 2033 | 2063 |
| Projected Flows (1) | | | | |
| Average Day Flow (gpm) | - | - | 129 | 527 |
| Maximum Day Flow (gpm) | - | - | 284 | 949 |
| Peak Hour Flow (gpm) | - | - | 301 | 971 |
| Evaluation of Existing Capacity | | | | |
| Available Capacity (gpm) (2) | - | - | 1,000 | 1,000 |
| Capacity Surplus/(Deficiency) (gpm) (3) | - | - | 699 | 29 |
| Forcemain Diameter (inches) | - | - | 8 | 8 |
| Forcemain PHF Velocity (ft/s) | - | - | 1.9 | 6.2 |

(1) Projected flows taken from model results

(2) Available capacity assumes the largest pump is offline.

(3) Capacity surplus/deficiency is the amount of available existing capacity greater than peak hour flow.

**Table 7-34**
**Lift Station Capacity Analysis for Little Simpson Creek (Future)**

| | Year | | | |
|---|---|---|---|---|
| | 2013 | 2023 | 2033 | 2063 |
| Projected Flows (1) | | | | |
| Average Day Flow (gpm) | - | - | - | 378 |
| Maximum Day Flow (gpm) | - | - | | 454 |
| Peak Hour Flow (gpm) | - | - | - | 697 |
| Evaluation of Existing Capacity | | | | |
| Available Capacity (gpm) (2) | - | - | - | 750 |
| Capacity Surplus/(Deficiency) (gpm) (3) | - | - | - | 53 |
| Forcemain Diameter (inches) | - | - | - | 8 |
| Forcemain PHF Velocity (ft/s) | - | - | - | 4.5 |

(1) Projected flows taken from model results

(2) Available capacity assumes the largest pump is offline.

(3) Capacity surplus/deficiency is the amount of available existing capacity greater than peak hour flow.

### 7.5.3 Recommended Lift Station Improvements

The following lift station improvements are recommended:

- The only existing lift station that may reach its existing capacity is North Park. Depending on development in the North Park lift station's contributing area, an additional 200 gpm of firm capacity should be added in the near- to mid-term. If the pump station is upgraded then a parallel forcemain should be evaluated for redundancy and to help reduce PHF velocities in the existing 4-inch forcemain.
- Future Porter Draw Lift Station should be built in the mid-term planning period as development and the collection system moves to the south with a mid-term firm capacity of 1,000 gpm and an 8 inch forcemain and long-term firm capacity of 3,200 gpm and a parallel 12 inch forcemain.
- Future Childs Draw Lift Station should be built in the mid-term planning period as development and the collection system moves to the north with a firm capacity of 1,000 gpm and an 8 inch forcemain.
- Future Little Simpson Creek Lift Station should be built in the long-term planning period as development and the collection system moves further to the south with a firm capacity of 750 gpm and an 8 inch forcemain.

Since wetwell storage, which can offset PHF capacity requirements of the pumps station and forcemain, was not included in the lift station capacity analysis, a wetwell storage analysis is recommended prior to any existing or future lift station improvements.

## 7.6 Flow Metering and Monitoring

Based on recommendations from the 1995 Wastewater Master Plan, BOPU began collecting I/I data. Using Marsh-McBirney Flodars, collection system flow rates were monitored every 15 minutes at a total of 22 different locations during the spring/summer peak wet-weather season from 1995 to 1997. The monitoring sites were selected to collect I/I information on each major sewer basin within the collection system. In order to collect more accurate rainfall data, BOPU also established six rain gauge locations throughout the City. These gauges were monitored by computers at each location and collected data every 15 minutes during a rainfall event. Data collected during this study was evaluated to identify basin-specific I/I rates which were used in the 2003 Wastewater Master Plan.

Since the 1995 Wastewater Master Plan, BOPU has made significant efforts to reduce sources of I/I by disconnecting roof drains, inspecting and relining pipes in high I/I areas and other repairs. Although there have been few SSOs in the last ten years, this Volume denotes isolated areas that have been identified by the hydraulic model as being near capacity in the existing system. The model also identifies line segments that will need additional capacity to handle future loads. Flow monitoring helps confirm these potential capacity-limited areas in the field.

Annual or semi-annual flow monitoring provides the following benefits:

- Completing accurate model calibration of dry-weather and wet-weather conditions including more in-depth I/I analysis.
- Confirming model predicted capacity-limited areas and monitoring for flow trigger points to determine improvements are needed.
- Increasing planning accuracy.
- Developing historical trending of collection system performance.
- Creating flow characterization by drainage and sewer basin.
- Evaluating the on-going I/I performance of each sewer basin after rehabilitation.
- Diagnosing maintenance and rehabilitation needs for the collection system.
- Assisting improvement projects with up-to-date flow data.
- Analyzing capacity of new connections to collection system.
- Estimating by-pass pumping requirements.
- Increasing operational awareness of the movement of flow through the system during storm events.
- Improving diversion structure operations during high flow periods.

- Early warning system in capacity-sensitive areas.

### 7.6.1 Existing Metering and Monitoring Locations

Flows from Warren AFB, SCWSD and Frontier Refinery are monitored continuously for billing purposes and to determine their impact on the BOPU collection system. The major lift stations have flow meters on them including Goodman, North Park, The Pointe 1, The Pointe 2 and the Wyoming Welcome Center. There are influent meters at CCWRF and DCWRF. The CCWRF influent meter is downstream of the diversion to DCWRF. Over the past few years, various temporary flow monitoring locations have been used to locate areas of significant I/I with the sewer basins (refer to Figure 7-3 for some of these locations).

### 7.6.2 Recommended Metering and Monitoring Locations

To increase the usefulness of the metering and flow monitoring locations for locating I/I, model calibration and planning and design uses, the following locations are recommended for permanent/semi-permanent and temporary installations. Figure 7-16 shows these recommended flow metering and monitoring locations.

**Permanent or Semi-permanent Locations**

- Future lift stations
- Significant industrial / commercial users
- CCWRF to DCWRF diversion (flushing water plus peak flow diversion)
- CCWRF to DCWRF diversion (flushing water plus peak flow diversion plus sludge flows upstream of the SCWSD connection)
- Two influent lines at DCWRF
- Downstream sewer basin interceptors (existing and future)

**Temporary Locations**

- Areas of known or suspected high I/I (not shown on figure)
- Downstream of smaller lift stations where they discharge into the gravity mains

### 7.6.3 Flow Monitoring Equipment

Currently, BOPU uses Marsh-McBirney Flodars with an ultrasonic level sensor to conduct temporary flow monitoring. This is adequate for the use of the flow monitoring data collected during the wet-weather season but only if they are installed properly and calibrated. The quality of the temporary flow monitoring data over the past few years was questioned due to greater downstream than upstream flows, invalid dry-weather peaks and apparent loss of accuracy at lower flows.

Multiple sensor flow monitoring equipment is recommended to provide a higher level of flow monitoring accuracy and further redundancy of flow measurement that would be associated with a permanent installation. An accuracy of ± 5 percent is acceptable for these flow monitoring sites; however, ± 2 percent is preferred.

For the permanent or semi-permanent flow monitoring sites, four flow monitors were evaluated. Flow monitoring equipment is installed either within the pipe at low-turbulent flow locations or within the manhole above water level. Models may measure flow by depth, velocity, combination, or configurations involving all these types for redundancy.

Pressure and ultrasonic transducers are the two most common types of flow depth measurement technologies. A pressure transducer is a low-profile wetted sensor that must be mounted directly in the flow stream; typically on an expandable stainless steel band within the pipe upstream of the manhole invert. A pressure transducer may either be a stand-alone device or encapsulated into a single module along with a velocity sensor. Pressure transducers measure the pressure differential of the water column above the water-tight sensor in terms of gauge pressure (psig) less the current atmospheric pressure (psig water minus psi atmospheric). The resultant signal is converted from pressure units to inches of water or other unit of level measurement within the control panel logic. Pressure transducers, for the most part, are unaffected by debris on top of the sensor, since most debris is not dense enough or deep enough to be significantly different from the weight of the water column above the sensor. The major advantages of a pressure transducer are that hydrogen sulfide gas corrosion of the sensor is a non-issue and, within practical limits, there are no “dead band” constraints that limit the maximum level of water that can be measured.

Ultrasonic transducers are either downwards looking or upwards looking. The downwards looking variety uses an echo-back and signal timing to determine the water level. This is a well established technology and rarely requires recalibration. The upwards looking variety is a wetted sensor installed on the bottom of the conduit. The echo-back signal is directed upward at the overlying water surface. High turbulence and high aeration levels can cause errors in reading accuracy.

For velocity measurement there are four primary technologies; continuous wave Doppler, digital cross correlation, pulse-Doppler and surface radar.

Continuous wave Doppler shoots a beam upstream of the sensor and the velocity is derived from the frequency shift of returned echoes reflected by air bubbles or particles in the flow stream. This is a lower cost velocity meter.

At approximately double the cost of the continuous wave Doppler system, digital cross correlation uses an ultrasonic sensor to emit a short acoustic pulse at an angle to the flow vector. This impulse is reflected by particles or bubbles in the medium. The sensor switches to receiving mode immediately after emitting an impulse and then receives the reflected echo as a characteristic pattern. The echo patterns from the first scan are stored digitally. In the second scan another ultrasonic impulse is emitted and the received echo patterns are again stored. This method provides several advantages. This velocity technique produces highly accurate measurements (≤ 2% error), even in difficult hydraulic regimes and no calibrations are required. The sensor performs a velocity profile during every measurement cycle. This sensor does not require a symmetrical alignment in the pipe; the sensor can be offset to move out of potential silt at the bottom of the pipe.

A pulse-Doppler velocity sensor contains four ceramics that emit short pulses along a narrow acoustic beam. Each acoustic beam measures velocity at multiple points, known as bins, in the water column. The distribution of velocity measurements is then used to determine the flow pattern over the cross-section of flow. This creates a velocity profile. The bins range in size from 2” to 12”. There are multiple velocity readings taken to derive the average velocity. This technology can read a true zero velocity. The disadvantage to this technology is that the sensor must be placed in the centerline bottom of the pipe, which means that the sensor may experience siltation interferences. The sensor has a minimum water level “dead band” of approximately 12”, allowing this technology to be used in larger pipes or channels. Pulse-Doppler sensors are comparable in price to digital cross-correlation sensors.

Surface radar velocity meters are ideally installed in a dry, non-contact setting, which would suggest lesser O&M requirements. The radar sensor sits in the manhole at the level of the crown of the pipe. The beam broadcasts upstream to the surface of the water. This technology requires a relatively uniform, laminar flow, simply because the water surface is the reflective medium. The radar technology reportedly can handle velocities ranging from 0.75 fps to 20 fps. When attempting to read surface velocities less than 0.75 fps, the water surface is actually too smooth and does not return a signal. Surface radar will not read when surcharged.

Flow monitors compete to be adaptable to various conditions. Consequently many models can incorporate different sensors to fit the preferred style of measurement. Many also allow for multiple sensors for redundancy. Flow monitors are the easiest type of meter to customize.

Table 7-35 presents the four recommended alternatives for permanent or semi-permanent flow monitoring equipment. The existing Marsh-McBirney Flodars could continue to be used for temporary installations for identification of smaller I/I areas and other uses, as long as they are properly installed and calibrated.

**Table 7-35**
**Recommended Flow Monitoring Equipment**

| Product | Sensor Type | Power Connection | Surcharge Compatible | Data Transmission | Rain Gauge Option | Years Company in Service / Years Product in Service | Price (Equipment Only) |
|---|---|---|---|---|---|---|---|
| Hach – Flo-Dar with FloStation | Ultrasonic, velocity, magnetic | Permanent, battery or solar panel | Yes | Cellular modem, radio | Yes | 66 / 10 | $15,930 |
| ADS – FlowShark | Ultrasonic, pressure, surface velocity, wave velocity | Permanent or battery | Yes | Cellular modem, radio | Yes (stand alone) | 38 / 3 | $6,120 |
| Mace – FloPro Xci | Ultrasonic, area velocity | Permanent | Yes | Radio, SCADA, WebComm | No | 45 / 5 | $5,280 |
| Teledyne – Isco Signature with LaserFlow | Ultrasonic, area velocity, pressure | Permanent (separate battery option) | Yes | Cellular modem, radio | Yes | 55 / 2 | $13,580 |

### 7.6.4 Flow Monitoring Implementation and Studies

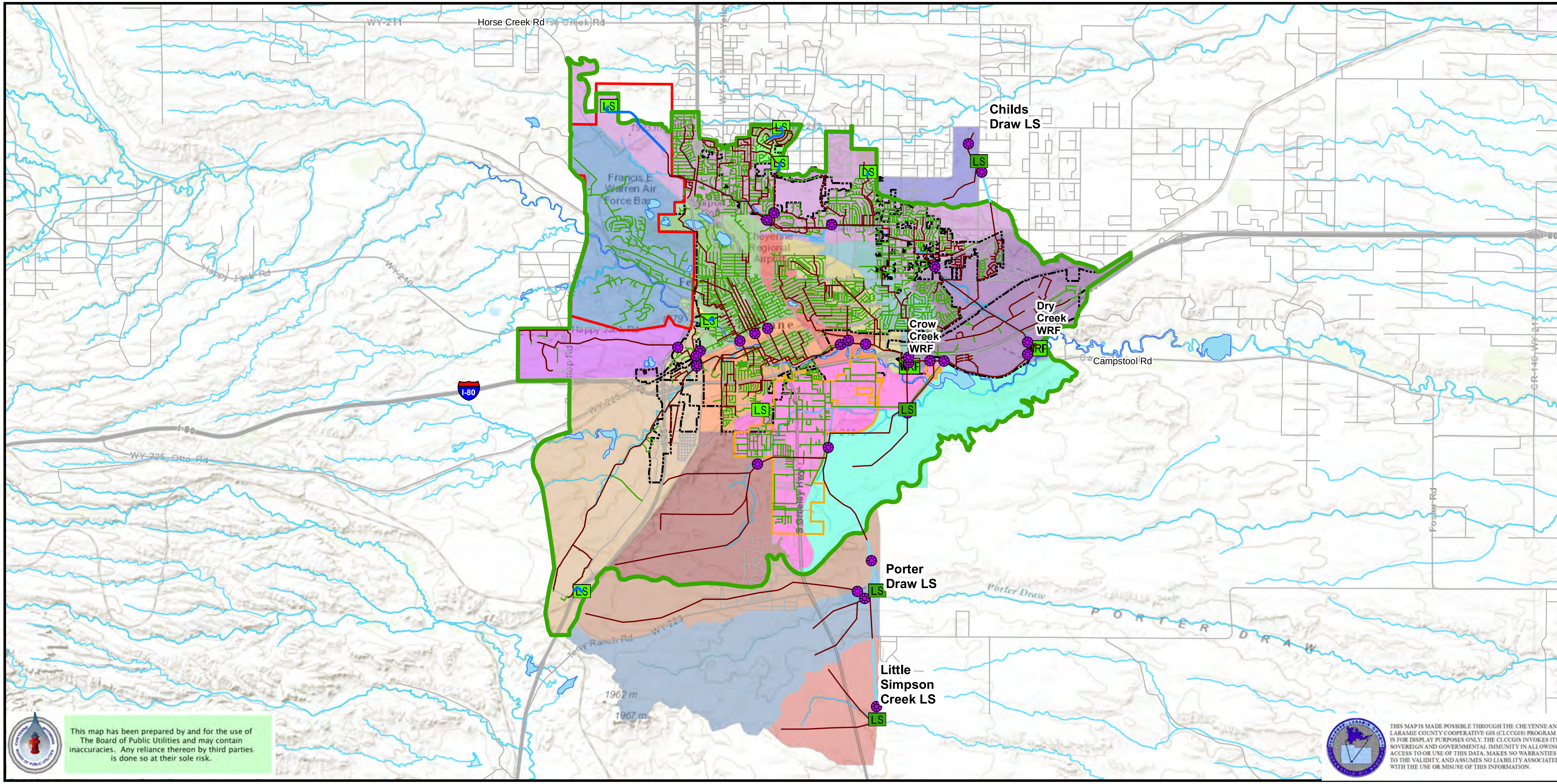
The permanent or semi-permanent flow monitoring sites will use existing manholes and power sources to reduce capital costs and maintenance. Each site must have adequate flow hydraulics within the manhole to be considered a candidate for accurate flow monitoring. Site surveys should be completed to verify the adequacy of each of the selected sites for permanent flow monitoring. Upstream or downstream manholes should be used if the initial recommended site is not adequate. Power sources should be considered as well in selecting the final sites. Existing capacity-limited areas from model results are considered for higher priority sites in the near-term.

Reducing maintenance to biannual service is desired for new flow monitoring sites. Due to the more complex nature of the flow monitors, the maintenance schedule could at times exceed biannual service. Calibration of flow monitors would be essential in the early spring prior to the wet-weather season in spring/summer. Throughout the remainder of the year, calibration requirements should be minimal.

Due to this desired maintenance schedule, onsite data collection has been ruled out, wireless transmission is preferred. Wireless data collection can be used for early detection of problems allowing targeted maintenance visits to be made to the flow monitor sites. Multiple sensors are preferred for redundancy in case of single sensor downtime to avoid data loss. Equipment and set up should reduce the probability of sediment accumulations and ragging. Batteries may be used as back-up power sources in times of power outage.

The existing flow monitors owned by BOPU could be used to cross-check new flow monitor performance. Relative accuracy of the metering equipment would have to be considered in this comparison.

BOPU could either purchase, install, calibrate and maintain their flow monitoring equipment or hire a consultant to complete the flow monitoring for them. If BOPU does not purchase their own equipment, flow monitoring studies by consultants every 5 years in between master plans for observing the performance of I/I reduction efforts is recommended. The year before future wastewater master plans are scheduled to begin, extensive sewer basin-specific flow monitoring by consultants should be conducted for BI/RDII allowance development and model validation/calibration.




## Legend

- City of Cheyenne
- F.E. Warren Air Force Base
- Sewer Service Area Boundary
- South Cheyenne
- WRF Water Reclamation Facility
- LS Existing Lift Station
- LS Future Lift Station
- Recommended Flow Monitoring Locations
- Existing Forcemain
- Future Forcemain
- Existing Main
- Future Main
- Creeks
- Roads
- Lakes

**Future Sewer Basins**

- Allison Draw East
- Allison Draw South
- Capitol North
- Capitol South
- Childs Draw
- Clear Creek
- Dry Creek North
- Dry Creek South
- Goodman
- Henderson
- Holliday
- Lincolnway
- Little Simpson Creek
- North Range Business Park
- Porter Draw North
- Porter Draw South
- South Cheyenne
- The Pointe 1
- The Pointe 2
- Warren Air Force Base

1 inch = 2.5 miles

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## Figure 7-16
## Recommended Flow Monitoring Locations

## 7.7 Assessment and Rehabilitation

An initial means and method for assessing and prioritizing the replacement or upgrading of existing mains within the collection system is presented in this section. This assessment method follows the same format as the distribution system assessment method found in Volume 5. The collection system assessment method is based on an industry-accepted practice of determining likelihood of failure (LoF) and consequence of failure (CoF) to determine critical assets for rehabilitation or replacement. Asset attributes and performance parameters have been established and organized into LoF or CoF factors and each is assigned a relative category multiplier from 1 to 5 to weight the different factors by their relative affect on failure.

A scoring system has been set up for each factor to determine which asset attributes or performance parameters receive which score. The higher the total score across all attributes and parameters, the more critical the asset is for replacement or rehabilitation. The means and methods presented within this section should be re-evaluated at least every wastewater master plan cycle to review data availability and scoring of the attributes and parameters based on updated main break and condition data.

### 7.7.1 Assessment Means

The first part of the collection system assessment process is developing asset attributes and performance parameters that will participate in the assessment method. Asset attributes and performance parameters have been categorized into two phases:

- Phase 1 – Enough accurate data is available to include in assessment; immediate implementation into scoring method; continue collecting and refining data from source.
- Phase 2 – Not enough or no data available to include in the assessment; delayed implementation into scoring method; start or continue collecting data from source.

Appendix 7-B contains a list of all asset attributes and performance parameters that are recommended for inclusion in the collection system assessment means.

All asset attributes and performance parameters much be tied back to a pipe asset by a pipe facility ID in GIS for scoring. Several performance parameters need to be converted from point data to the pipe; for example, main defects are collected as points that need to be tied back to a polyline pipe asset; these types of parameters are noted.

**Asset Attributes**

Asset attributes include information about the particular asset or its condition. Example asset attributes include diameter, material, or bedding type. The full list of asset attributes included in the Phase 1 and Phase 2 assessment means are included in Appendix 7-B. This information is obtained either through field inspection/testing, as-builts, or previously compiled GIS data. All asset attributes are LoF factors.

**Performance Parameters**

Performance parameters are typically non-material in nature and have a historical context based on how particular classes of assets have performed in the past under various conditions. Example performance parameters include main defects, main criticality, or hydrogen sulfide measurements. The full list of performance parameters is included in the Phase 1 and Phase 2 assessment means are included in Appendix 7-B. This information is obtained either through field observation, hydraulic model, system performance tracking or previously compiled GIS data. Performance parameters can be either LoF or CoF factors.

### 7.7.2 Assessment Method

The assessment method takes the assessment means information collected from various sources and calculates a pipe condition score based on a weighted scoring matrix. Once the assets are scored, a process to review the results and select pipe segments for rehabilitation needs to be implemented. A recommended data structure to contain the collection system assessment information from the various data sources can be found in Appendix 7-B.

**Scoring**

Each asset attribute and performance parameter was assigned values or ranges of values for scoring. Each value or range of values was assigned a score from 1 to 5 with higher scores assigned to those affecting LoF or CoF at a greater level based on an observed or perceived level. A relative category multiplier from 1 to 5 is assigned to east asset attribute and performance parameter to weight the different factors by their relative affect on failure. Therefore, the maximum score for each scored category is multiples of 5 from 5 to 25. Appendix 7-B includes the initial scoring matrix to use while developing the collection system assessment and rehabilitation selection process.

**Rehabilitation Selection Process**

A rehabilitation selection process will take the asset attributes and performance parameters from the sources of data combined with the scoring method to calculate total scores for each pipe segment. Geoprocessing and python tools can be built to perform these functions once the data is compiled into one geodatabase. Any recently improved pipes should be filtered out of the results to ensure the process does not select inadvertently select recently rehabilitated pipe. The process results should be sorted by pipe score from high to low and pipe diameter from low to high. An initial rehabilitation list can be created by selecting approximately 2 to 3 miles of pipe segments with the highest scores and lowest diameters.

The next step of the rehabilitation selection process, user-based selection, prioritization and grouping of rehabilitation segments, can be a manual GIS process or a semi-automated process within a customized GIS-based web browser dashboard. The manual GIS process could be an interim solution until a dashboard is developed or purchased. The user-based selection, prioritization and grouping of rehabilitation segments should allow for external information to be included in the assessment to capture known problem areas or opportunity improvement areas that may have not shown at the top of the list in the scoring results.

External information could include specific field data of mains needing immediate replacement or City-related street improvements such as overlays or reconstruction when there is an opportunity to replace pipe when the streets are already torn up. In addition, supplemental information for prioritizing and grouping of rehabilitation projects should be made available to the user. Supplemental information could include aerial photography, pipe attributes (material, age, diameter, etc.), main defect locations, main defects per 100 miles by pipe attribute type, estimated remaining life based on inspection defect data, hydraulic model results data (flow, velocity) and root, grease, or silt accumulation data from inspection programs. Renewal technology (open cut, CIPP, etc.) alternatives should be presented for selection for each rehabilitation project.

Finally, cost estimating information should be included in the assessment process to tally the total rehabilitation costs to maximum replacement projects while remaining within the planned annual rehabilitation program budget. Appendix 7-B depicts the general process to select pipe rehabilitation segments based on the assessment method.

**Collection System Assessment and Rehabilitation Planning Tools**

Several software companies have developed various collection system assessment and rehabilitation planning tools including the following examples:

- InfoMaster Sewer / CapPlan Sewer (Innovyze)
- Water Utility Capital Improvement Planning (ESRI)
- Check Up Program for Small Systems (EPA)
- CARE-S (National Civil Engineering Laboratory)
- Riva DS (Riva Modeling)
- Baseform (AWARE-P)

These software tools could be used in conjunction with a customized rehabilitation selection tool or as the assessment method itself incorporating the assessment means and the scoring matrix presented above.

**Defect Data**

Defect data from CCTV inspections should continue to be collected to support scoring matrix updates, predict vulnerable areas and estimate remaining asset life. GIS can be used to manually or automatically associate defects to a pipe facility ID for use in the assessment method. All historical data should be kept even after a repair or replacement is completed as it provides more data for analysis of similar pipe segments. The defect data should be used to calculate and trend yearly defects per 100 miles for performance tracking and effectiveness of pipe rehabilitation. Section 7.8.4 discusses a recommended condition inspection collection program in more detail.

**Assessment Updates**

The collection system assessment means should be updated annually prior to selecting the next year's rehabilitation projects. During the recommended annual update the following items should be updated in the collection system assessment database:

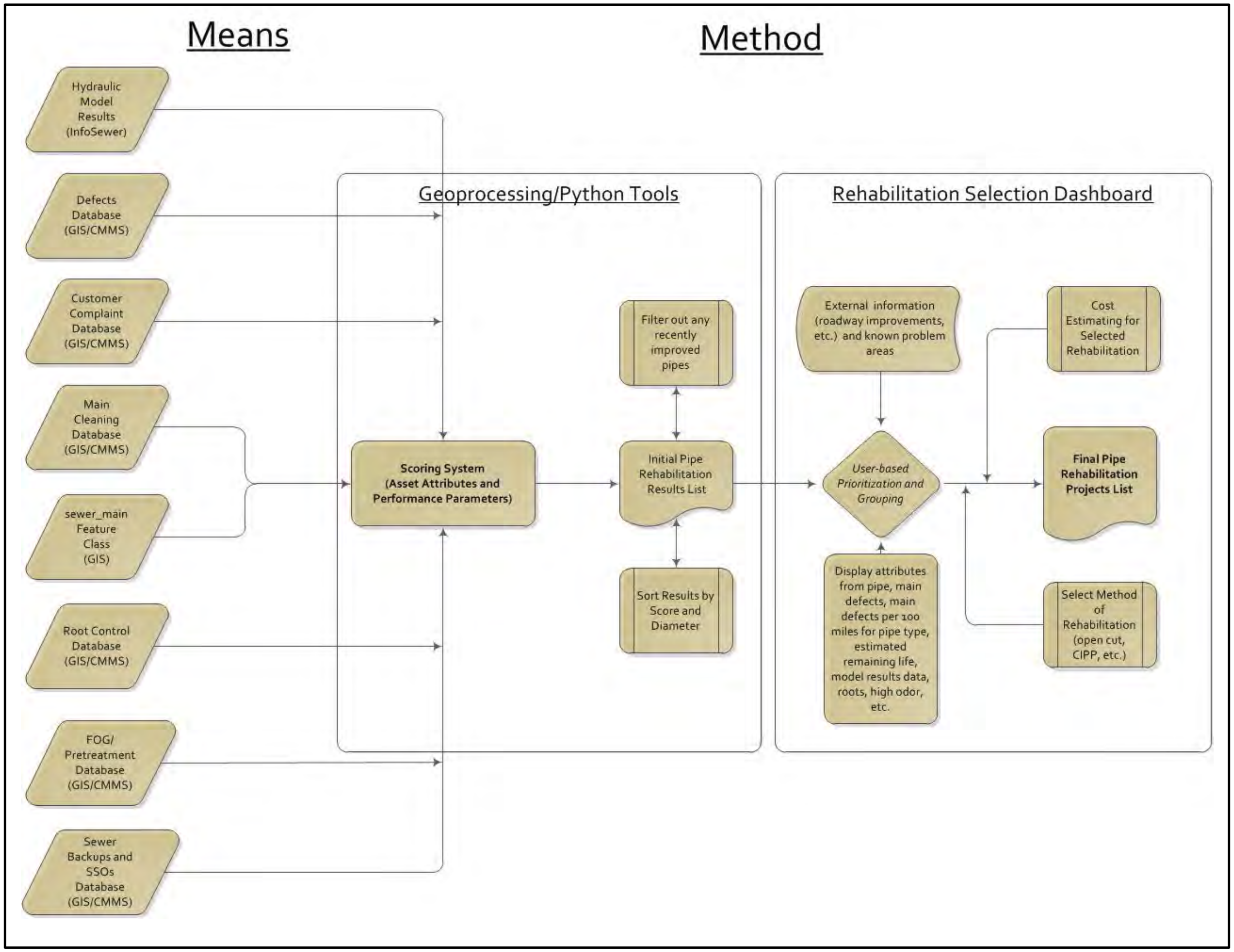
- Main and interceptor attributes from the master GIS database.
- Hydraulic model based on the previous years' flow and any operational and infrastructure changes.
- Defect data from the condition inspection database.
- Jetting data from the main cleaning database.
- Root data from the root control database.
- FOG data from the commercial/industrial pre-treatment database.
- Customer odor complaints from the complaints tracking database.
- Sewer backups and SSOs from the sewer backup tracking database.

Once the assessment means information is compiled into the collection system assessment database the scoring and rehabilitation selection process can be updated.

### 7.7.3 Collection System Assessment Implementation

The collection system assessment means should be implemented in the next two years for Phase 1 asset attributes and performance parameters. Phase 2 asset attributes and performance parameters should be implemented in 5-10 years when enough data is collected to support inclusion those scoring categories. The assessment method should be integrated with any future computerized maintenance management system (CMMS) to hold as much of the source information as possible. This integration will cut down on the number of data sources necessary to update and export to run the collection system assessment. A GIS based user-selection process can be used in the near-term until a dashboard or other rehabilitation planning software is implemented.

## Figure 7-17
## Assessment Scoring and Rehabilitation Selection Process



### 7.7.4 Recent Rehabilitation Progress

BOPU has already been actively rehabilitating their collection system in the last 10 years including replacing, lining or upsizing wastewater mains. Over the past 10 years from 2003 to 2012, a total of 14.3 miles of wastewater collection mains (average of 1.4 miles per year) have been replaced, lined, or upsized. These rehabilitation and replacement projects completed from 2003 to 2012 are presented in Figure 7-18.

### 7.7.5 Rehabilitation Recommendations

The pipe replacement, lining and upsizing program for collection system mains should be continued. PVC should be used as the primary pipe replacement material. BOPU should continue work to reduce I/I in the system through rehabilitation. Hydraulic modeling should be conducted for each replacement to determine the impact on capacity in the local area and to properly size the improvement.

Recently, BOPU and other utilities have found that there is a substantial volume of I/I entering collection utilities from the service laterals. BOPU should consider rehabilitating the first few feet up into the service lateral and use a “top hat” or “top seal” system to repair the connection at laterals into the sewer main to further reduce I/I and maximize the effectiveness of rehabilitation projects. The total estimated cost for lateral rehabilitation including installation of the “top hat” is approximately $5,000 per lateral in 2013 dollars. Communication with effected customers should be made to ensure they are aware of any potential affects before and after lateral rehabilitation. Only experienced contracted should be used for lateral rehabilitation to reduce the risk of affecting customer services.

Continue to replace, line, or upsize a minimum of 1.5 miles of pipe per year for the near-term (2013-2017) which would equate to approximately a 261 year rehabilitation cycle of the entire system based on a current total length of 392 miles of pipe.

From 2018 onwards, increase the pipeline rehabilitation rate to a minimum of 2.5 miles per year, which equates to an approximate 157 year rehabilitation cycle based on the current length of pipe. The rehabilitation cycle will increase as pipe is added to the system; however newer pipe should have a longer life than the existing pipe due to improvements in pipe material and installation as long as quality materials and installation inspection is completed to ensure design and construction standards are being followed. Therefore, a final near-term (2018-2023) and mid-term (2024-2033) rehabilitation rate of 2.5 miles per year is recommended.

BOPU’s yearly cost for the rehabilitation program has been approximately $2,000,000 for an average of 2 miles per year of replaced, lined, or upsized pipes. Therefore, a starting capital improvement project cost of $1,500,000 per 1.5 miles ($189/ft) of pipe rehabilitated is recommended with an annual escalation of 3.5%. The unit cost of $189/ft in 2013 dollars for sewer main rehabilitation is line with rehabilitation costs found at similar utilities. This equates to a capital expenditure of $16.7 million in the near-term (2014-2023) and $24.0 million in the mid-term (2024-2033).

Currently, planned rehabilitation and replacement projects from 2013 to 2021 are presented in Figure 7-19. These projects represent only 9 miles of pipe rehabilitation in the next 8 years, from 2013 to 2021 (1.1 miles/year). Additional rehabilitation to meet 1.5 miles per year through 2017 and 2.5 miles per year starting in 2018 onward should be planned.

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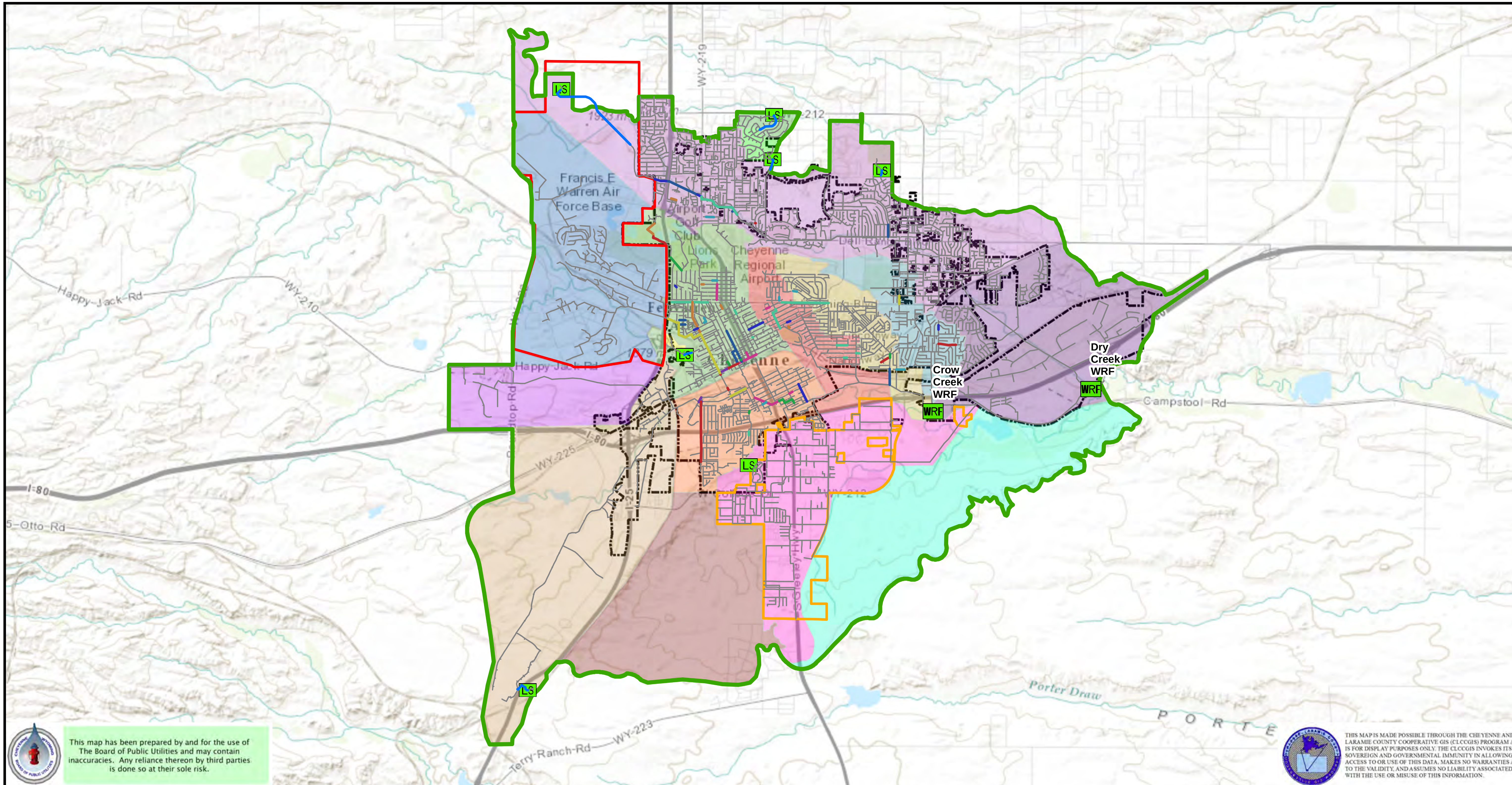


**Legend**

WRF Water Reclamation Facility
LS Lift Station
Forcemain
Non-modeled Main

**Rehabilited Mains (Year)**

2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

**Existing Sewer Basins**

Allison Draw East
Allison Draw South
Capitol North
Capitol South
Clear Creek
Dry Creek North
Dry Creek South
Goodman
Henderson
Holliday
Lincolnway
North Range Business Park
South Cheyenne
The Pointe 1
The Pointe 2
Warren Air Force Base

City of Cheyenne
Sewer Service Area Boundary
F.E. Warren Air Force Base
South Cheyenne

1 inch = 2 miles

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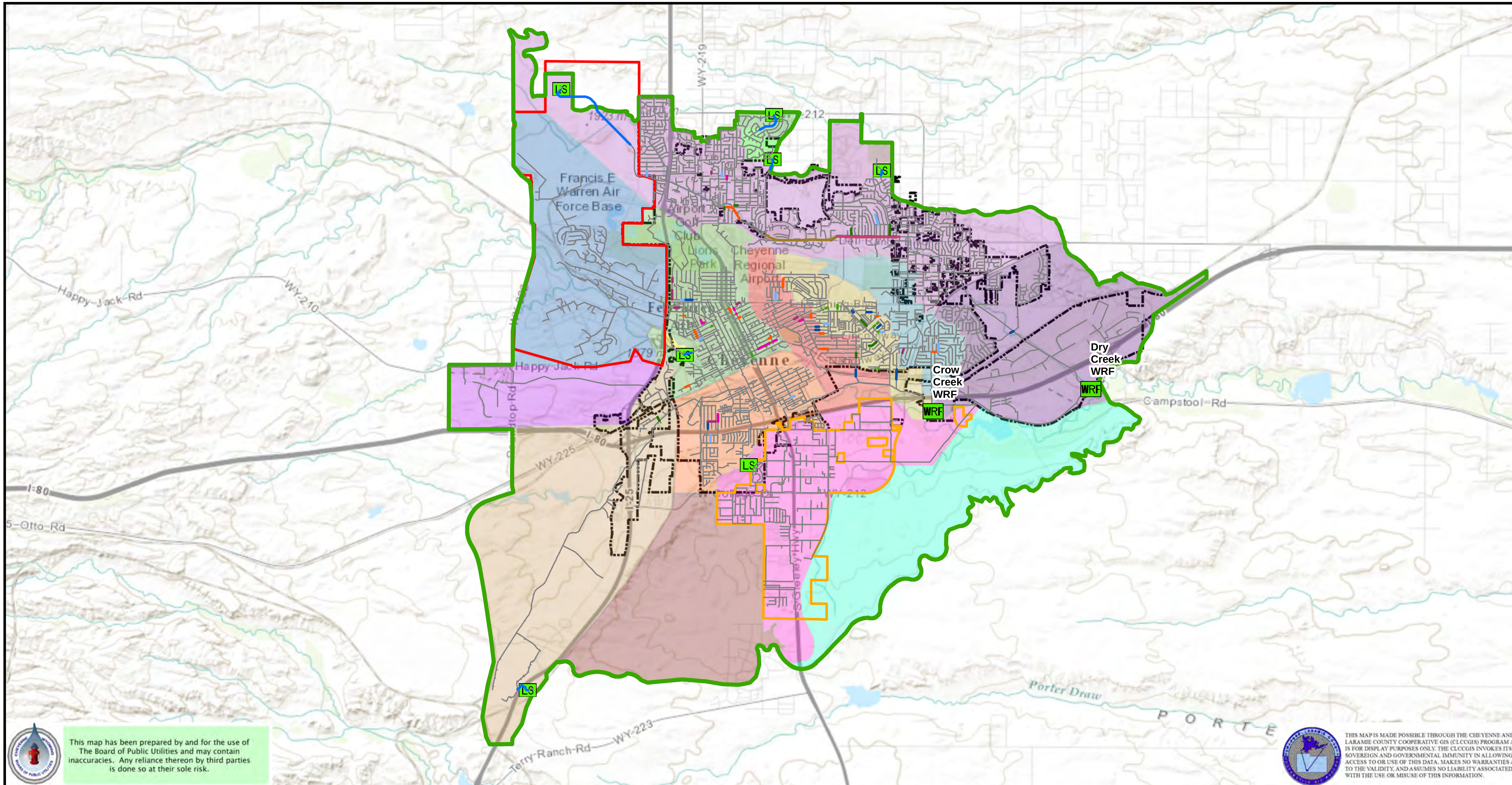
Last Updated: 10/4/2013

**Figure 7-18**
**Recently Rehabilitated Mains (2003-2012)**
**Volume 7 - Wastewater Collection**
2013 Water and Wastewater Master Plans




**Legend**

- WRF Water Reclamation Facility
- LS Lift Station
- Forcemain
- Non-modeled Main

**Near-term Main Rehabilitation (Year)**

- In Progress
- 2014
- 2015
- 2016
- 2017
- 2018
- 2019
- 2020
- 2021

**Existing Sewer Basins**

- Allison Draw East
- Allison Draw South
- Capitol North
- Capitol South
- Clear Creek
- Dry Creek North
- Dry Creek South
- Goodman
- Henderson
- Holliday
- Lincolnway
- North Range Business Park
- South Cheyenne
- The Pointe 1
- The Pointe 2
- Warren Air Force Base

- City of Cheyenne
- Sewer Service Area Boundary
- F.E. Warren Air Force Base
- South Cheyenne

1 inch = 2 miles

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Last Updated: 10/4/2013

**Figure 7-19**
**Near-term Mains to be Rehabilitated (2013-2021)**
**Volume 7 - Wastewater Collection**
2013 Water and Wastewater Master Plans

## 7.8 Preventative Maintenance

This section recommends implementation of a preventative maintenance plan including levels of service, asset management, preventative maintenance practices, and field data collection for enhancing and tracking performance of the wastewater collection system.

### 7.8.1 Level of Service

There are two key facets to asset management – defining the level of service (LOS) the system will strive to provide its customers over the long term and determining the most efficient and economical way to deliver that service (the least cost approach). Therefore, determining and detailing the LOS goals that the system will provide is a key first step in the overall asset management plan development process. The asset management program will determine the least cost approach for meeting those established LOS goals.

A LOS agreement defines the way in which the utility owners, managers, and operators want the system to perform over the long term. An established LOS allows utilities to track performance of their systems over a number of years to determine effectiveness of preventative maintenance, customer service, and regulatory compliance. An LOS agreement can be kept for internal uses or externally shared with the public on an annual or semi-annual basis.

Examples of performance indicators that can be included in the LOS agreement include, but are not limited to the following (more in-depth examples are provided in Appendix 7-C):

- Number of defects per mile that are acceptable.
- Length of time from report of a defect until repair.
- Amount of notification (and method) prior to a scheduled shut down.
- Amount of notification (and method) prior to a non -scheduled but nonemergency shutdown.
- Quantity of unplanned interruptions in service verses planned interruptions.
- System dry- and wet-weather I/I maintained at less than X% and X% overall, respectively.
- Maximum system flow will be X gpd.
- Rates will be raised annually to avoid rate shock in the system.
- Rates will be reviewed annually.
- No service outage will be longer than X hours total.
- Maximum customer complaints will be X total annually.
- Customers will be notified of planned system outages at least X hours or X days before the interruption.
- Customers will be notified at least X minutes prior to shut down for an emergency condition, unless life threatening conditions cause a need for immediate shut down.
- Response time to customer complaints and service requests.

- SSO occurrences throughout the system will be zero.

The performance indicators in the LOS agreement should be established with baseline values initially and updated at least annually to determine the effectiveness and any refinements needed to the asset management and preventative maintenance programs.

### 7.8.2 Asset Management

Asset management is a framework being widely adopted as a means to pursue and achieve sustainable infrastructure. An Enterprise Assessment Management (EAM) program is made up of asset inventory or registry and asset management plan to determine the least cost approach to delivering the agreement established. The asset inventory is an always up-to-date and accurate record of:

- What and where all of the assets the utility owns and maintains are.
- What condition they are in.
- What their estimated remaining useful life is.
- What their estimated value and replacement cost is.

While the asset management plan generally includes:

- Asset maintenance management approach, procedures and records.
- Emergency maintenance response information.
- Critical and vulnerable assets with resulting special maintenance procedures.
- Assets that are in need of rehabilitation, repair, or replacement due to their current condition.

EAM provides utilities the following benefits[1]:

- Increases knowledge of your system, which will allow you to make better financial decisions. This is useful information when considering options to address various system challenges such as meeting regulatory requirements or upgrading system security.
- Reduces system “down-time” and the number of emergency repairs, since you will have planned for the replacement and rehabilitation of your assets.
- Prioritizes rehabilitation and replacement needs and providing time to research cost-effective alternatives.
- Shows investors and the public that you are using their money effectively and efficiently, which may make them more likely to increase investment or tolerate rate increases.

[1] http://simple.werf.org/Books/Contents/How-Can-Asset-Management-Help-Me-

- Gives you greater access to financial assistance. Some funding sources give applicants extra credit (higher priority ratings) for having an asset management plan or a capital improvement plan.

Chart 7-4 shows the general asset management plan approach in flowchart form.

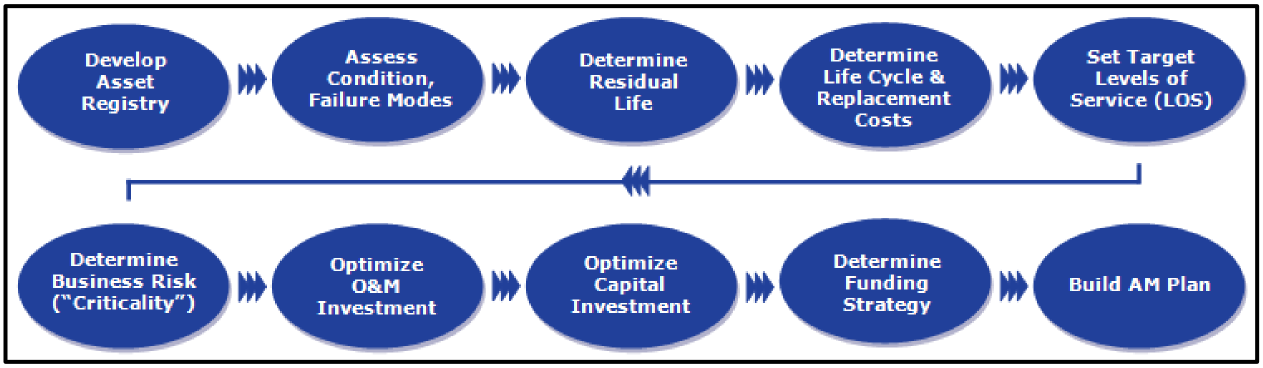


**Chart 7-4**
**Asset Management Plan Development Flowchart**

The Sustainable Infrastructure Management Program Learning Environment (SIMPLE) framework created by Water Research Foundation and Water Environment Research Foundation can help determine asset management gaps and needs for BOPU. The SIMPLE website has an intuitive and user-friendly set of on-line process and practice guidelines, templates and decision support tools that will:

- Simplify the development of consistent Asset Management Plans
- Provide effective Implementation Guidelines for agencies to assess and drive meaningful improvements in asset management.

### Computerized Maintenance Management System

Adjustments to the utility infrastructure during utility maintenance activities must be collected and cataloged so that the information is recallable and useable within BOPU's overall information management system. Maintenance activities represent one of the largest day-to-day changes to BOPU's utility infrastructure and without a system to collect and store this information uniformly and consistently the utility data in the GIS and other asset management databases no longer represent the utility infrastructure in the field. BOPU should implement a Computerized Maintenance Management System (CMMS) to track these daily activities to maintain BOPU's infrastructure assets.

The CMMS would allow BOPU to not only track the changes to the GIS data representing the utility systems but also effectively schedule maintenance and track all effort and costs associated with these activities. The CMMS provides BOPU with the ability to capture labor, equipment and material costs for all maintenance activities and use this information to plan for future activities and analyze past maintenance practices.

The CMMS is a tool by which BOPU is able to not only respond to immediate maintenance issues but also develop preventative and ongoing maintenance plans to ensure that the utility systems are operating at an optimum level of service. Additionally, the CMMS can be expanded into other aspects of BOPU's utilities such as distribution system, vehicle, meter, and treatment maintenance operations which will provide better data access, scheduling and maintenance across many different BOPU systems.

Along with GIS, CMMS would be a major part of on-going success of the EAM program. Therefore, a GIS-based CMMS solution is recommended such as:

- Cityworks
- Accela
- Infor/Hansen
- Lucidity
- Oracle
- Maximo
- VueWorks
- Cartegraph
- MaintStar
- Elements XS
- GeoStack
- Cityview
- Agile Assets

Other important components or modules that can be found in common CMMS packages are:

- Facilities (for tracking assets not found in the GIS)
- Customer Request Portal (customer input)
- Service Request (customer response)
- Work Odors (labor, material, and equipment planning)
- Parts Inventory
- Resource Manager (labor, material, and equipment planning)

- Fleet (Vehicle) Maintenance
- Asset Registry
- Asset Condition
- Asset Risk
- Asset Valuation
- Budget Forecasting
- Capital Improvement Plan Management
- Permits and Inspections
- Analytics

The selected CMMS system should be able to be fully integrated into the future customer information system (CIS) and utility billing system. A beneficial feature of some of the CMMS systems is mobile access using iPads, iPhones, or similar mobile devices that allows in the field updates to maintenance databases. This can be a powerful tool for maximizing work order response and efficiency and minimizing loss of information between the field and the office.

### 7.8.3 Existing Collection System Maintenance Program

Currently, BOPU completes an area maintenance program that targets known problem areas; this program should be formalized and expanded into a complete program. The maintenance efforts in conjunction with adequate system capacity have been successful in keeping SSOs to a minimum over the years. There are still sewer backups into basements but those have been traced mainly to fats, oils, and grease (FOG) issues. Customer education on what FOG is and how to reduce it has been shown to be an effective method in reducing sewer backups.

Priorities for cleaning and maintenance are determined based on experience with problem areas. BOPU completes condition assessment of the sewer interceptors and mains using a CCTV truck and Granite XP sewer inspection management software. Defects are recorded in National Association of Sewer Service Companies (NASSCO) format immediately while on the truck and transferred manually to GIS. Depending on the results of the CCTV, point repairs or rehabilitation projects are scheduled in to the annual and cleaning is scheduled, as necessary. BOPU cleans approximately 30 percent of the identified area maintenance pipes annually, with problem areas cleaned more frequently up to every 3 months. BOPU uses jet, vacuum, and rod equipment to clean the system. BOPU currently contracts out for root control in problem areas which completes an entire cycle about every 10 years and has just started the second cycle.

An industrial pre-treatment program currently exists within BOPU. The industrial pretreatment program is currently documented through an Excel spreadsheet with location, type of business, address, contact, and type of treatment. An industrial waste questionnaire in PDF format is sent out through the engineering department during the permit process for any new industrial or commercial users. A pretreatment permit is needed 180 days prior to discharge. Excel spreadsheets are also used to schedule industrial user inspections. Depending on the industrial user, inspections are completed annually or semi-annually. Some of the sampling is done internally for the program, however most is outsourced.

Discharge of raw sewage is not a significant problem for the BOPU. Nevertheless, a preventative maintenance program gives the BOPU the opportunity to evaluate their existing O&M program and improve procedures for emergency response and maintenance. The most common complaint is basement backups, to which the BOPU tries to provide an immediate response. When a backup occurs, the BOPU does a risk management assessment, investigates the complaint, jets the line, does a video inspection and reports the results.

### 7.8.4 Preventative Maintenance Best Practices

Preventative maintenance is essential to prolonging infrastructure life and meeting the LOS goals established for the collection system. The following preventative maintenance practices are recommended along with a method to plan and track their completion (sorted in recommended implementation order):

- Condition Inspection (CCTV)
- FOG and Industrial Pre-treatment Program
- SSO / Sewer Backup Response
- Main Cleaning
- Root Control
- Customer Complaint Tracking

Depending on the CMMS software implemented, some or all of these preventative maintenance practices may be able to be planned and tracked in the CMMS using mobile applications. Another option is to use ArcGIS Online Configuration for Water Utilities & Water Utility Apps which allows utility organizations to maximize their use with out-of-the-box configurations for desktop and mobile mapping, data collection, and inspection/maintenance tracking solutions. These apps can be customized and expanded on to create BOPU-specific preventative maintenance applications. In addition, there are several other vendors who offer tailored solutions to collect this information such as Cartegraph, Fulcrum, or Sedaru. Some of the apps including ArcGIS Online require data connections at all times to function correctly while some allow intermittent data connections and sync at reconnection; this could cause issues if there are areas of the system with unreliable data connections. If out-of-the-box mobile apps are used, care should be taken to ensure they will be compatible with the future CMMS and other BOPU systems (CIS, assessment method, system monitoring, etc.) as necessary.

### Condition Inspection (CCTV)

Currently CCTV is used to inspect critical or known problem areas, this practice is recommended to be expanded system-wide. Inspection and cleaning efforts are combined, mains are cleaned if inspection shows it's needed and the main is put on prioritized cleaning list In addition, condition analysis should be included in master planning process once an entire inspection cycle is completed to enhance the use of this data and plan 10 year worth of rehabilitation. Condition inspection (CCTV) program should be completed once every 5 years for interceptors (1/5 of interceptors per year) and once every 10 years for mains (1/10 of mains per year). Targeted CCTV inspection should be continued as needed. The data from the CCTV truck should be automatically uploaded monthly to the GIS database and checked against known pipe material, size, and related information to enhance GIS accuracy and maintain current condition of the mains in GIS for analysis. Along with defects, locations of observed I/I should be tracked and mitigated when possible.

### FOG and Industrial Pre-Treatment Program

The fats, oils and greases (FOG) education and industrial pre-treatment program should be continued and integrated into a CMMS. FOG observed in the system should be tracked to its source for mitigation, if possible, and the affected mains put on the prioritized cleaning list. The industrial pre-treatment program should be made completely electronic including the inspection, permitting and billing processes.

### SSO / Sewer Backup Response

A SSO response plan is in place; the Overflow Response Plan details procedures to follow to report and clean up a SSO. Converting the Overflow Repsonse Plan to an electronic data collection app based on GIS is recommended to capture key information from the SSO or sewer backup. The data collected by the app would help determine causes such as capacity limitations or FOG and help reduce future occurrences. The locations of SSOs or sewer backups could be tracked over time for grouping or trends for targeted preventative maintenance or public education on the effects of FOG entering the sewer system.

### Main Cleaning

Main cleaning is completed on generally a three year cycle. Mains are not cleaned if no observed issues from CCTV inspection. Some areas continue to be clean over time while others need to be cleaned up to every 3 months. Finding the upstream sources of debris or FOG for segments with frequent cleaning schedule and follow-up with the FOG and industrial pre-treatment program to enforce limitation of discharge of FOG and other blockage causing materials to the sewer is recommended.

Main cleaning program should be completed in conjunction with condition inspection program depending on CCTV results once every 5 years for interceptors (1/5 of interceptors per year) and once every 10 years for mains (1/10 of mains per year). Targeted main cleaning should be continued as needed. Main cleaning should be tracked within GIS along with results of cleaning, cleaning cycle and next scheduled cleaning date.

**Root Control**

Root control is essential from reducing blockages and resulting SSOs. The root control program should be completed once every 5 years in known problem areas from CCTV inspection (1/5 of problem areas per year).

**Customer Complaint Tracking**

Tracking customer complaints from odor, sewer backups, or related issues should be conducted. Complaint tracking should be formalized and analyzed spatially for patterns and trends to support the cleaning and condition inspection programs. Long-term data could be analyzed for the potential need for active odor control system in problematic areas of the system.

### 7.8.5 Preventative Maintenance Implementation

A detailed preventative maintenance plan and complete implementation of that plan is recommended for the collection system. Preventative maintenance practices are proven to support system sustainability, increase remaining life of assets and reduce I/I and SSOs. Currently, BOPU completes an area maintenance program that targets known problem areas; this program should be formalized and expanded into a complete program.

At a minimum the following components are recommended for implementation within the next 3 years:

- Enterprise asset management (EAM) and computerized maintenance management system (CMMS).
- Field data collection for increased accuracy and completeness of GIS data.
- Condition inspection (CCTV) program to be completed once every 5 years for interceptors (1/5 of interceptors per year) and once every 10 years for mains (1/10 of mains per year). Targeted CCTV inspection continued as needed.
- Main cleaning program to be completed in conjunction with condition inspection program depending on CCTV results once every 5 years for interceptors (1/5 of interceptors per year) and once every 10 years for mains (1/10 of mains per year). Targeted main cleaning continued as needed.
- Root control program to be completed once every 5 years in known problem areas from CCTV (1/5 of problem areas per year).
- On-going FOG and industrial pretreatment program.

- Customer complaint (odor) tracking program to support the cleaning and condition inspection programs.
- Sewer backup and SSO response program and tracking.

Levels of service goals for performance indicators such as defects per 100 miles of pipe and customer complaints should be established and tracked to determine the improvement of system performance over time. Appendix 7-C contains examples of common wastewater system performance indicators that are used for tracking level of service.

Volume 10 includes more details on the system hardware and software requirements to support a preventative maintenance plan including CMMS, EAM and mobile requirements. A full time equivalent, a preventative maintenance coordinator, with previous asset management and GIS experience is recommended to lead and implement the collection and distribution preventative maintenance program utilizing O&M staff for field work. Depending on the size of a utility, it is typical of a full implementation of EAM and CMMS to have two to three full-time equivalent personnel to implement preventative maintenance plan between water and sewer utilities, a department coordinator and a technician or two. With the size of Cheyenne's utility systems, at least one full-time equivalent is highly recommended to ensure the programs success. This staff member would fit under O&M division or the engineering division as a parallel department to GIS. A utility-wide organizational and staffing evaluation is recommended that would help determine the division, duties and roles for any CMMS staff in relation to the rest of the organization.

**Recommended Implementation Phase 1**

5-year Plan

Level of Service – Year 1

Develop Level of Service agreement

Develop performance indicators

Data Collection Implementation – Years 1 and 2

Condition inspection (CCTV)

FOG and industrial pre-treatment program

SSO / sewer backup response

Main cleaning

Root control

Customer complaint tracking

Interface/Dashboard for Distribution Assessment Method – Year 3

Asset Management System Implementation – Years 3 through 5

Remaining life analysis

Defect analysis

Valuation analysis

**Recommended Implementation Phase 2**

10-year Plan

Performance Indicator Tracking – Annually from Year 2 on

Data Collection Tracking, Analysis, and Process Refinement – Annually from Year 2 on

Collection Assessment Method Update – Annually from Year 3 on

Asset Management Integration with CIS - Year 5

### 7.8.6 Field Data Collection

Capturing information while in the field when pipe and manholes are already dug up will help in verifying GIS data while preforming preventative and emergency maintenance such as, condition inspection, FOG and industrial pre-treatment inspection, SSO / sewer backup response, main cleaning and root control, main and manhole replacement and rehabilitation maximizes time and efforts in the field for continual improvement of the data that BOPU relies on daily. All attributes for the assets in the GIS geodatabase should be made available for verification and editing if needed. Monthly edits from the field should be merged back into the master GIS geodatabase.

A few of the GIS field data collection apps currently available for iOS (iPad/iPhone) are:

- ArcGIS Online (only online data compatible)
- Cartography (online/offline data compatible)
- Fulcrum App (online/offline data compatible)
- GIS Cloud (online/offline data compatible)
- GIS Roam / iGeoTrak (online/offline data compatible)
- GIS Kit and GIS Pro (online/offline data compatible)
- Trimble Connect (online/offline data compatible)

## 7.9 Improvement Recommendations

This section presents the improvement recommendations from the collection system and lift station analyses including:

- Infrastructure improvements to support system growth and rehabilitation.
- Flow monitoring improvements to support system operations and future planning and design efforts.
- Collection system assessment method implementation to support system rehabilitation.
- Preventative maintenance practices to support system sustainability and increased remaining asset life.

The improvement projects are all assigned a capital improvement ID with the following format, Planning Period-System-Project Number:

- Planning Period-
    - 2013 – In Progress/Completed
    - NT – Near-term (2014-2023)
    - MT – Mid-term (2024-2033)
    - LT – Long-term (2034-2063)
- System-
    - CS – Collection System
- Project Number
    - Sequential number for each project

### 7.9.1 Infrastructure Improvements

Infrastructure improvements including mains, interceptors, lift stations and force mains are recommended for each of the planning periods to support system growth and rehabilitation. The infrastructure improvements are shown on Figure 7-20 identified by their capital improvement ID.

Areas of the existing system where peak flows exceeded 80 percent of pipe capacity or where there were predicted SSO risks were evaluated to determine the extent and severity of overloading. Localized problems due to a single segment of flat slope or undersized line do not usually require rehabilitation. In general, relief lines are not recommended until a line is modeled to be 120 percent of capacity, unless surcharging problems have been reported in the area.

Relief sewer lines and new extension lines should be sized more conservatively to provide some reserve capacity to accommodate changes in land-use patterns and tributary areas that cannot be forecasted until the improvements are made. Accordingly, in this study the following sewer line sizing criteria were used:

- Pipe diameter less than 18 inches - q/Q of 0.65 during PHF conditions
- Pipe diameter equal to or greater than 18 inches - q/Q of 0.78 during PHF conditions

### Future Interceptors

Interceptor mains are those 18-inches and larger that convey wastewater from larger areas of the sewer basins. The following interceptor main projects are recommended to convey wastewater generally west to east through the system sorted by year installed.

***Near-term (2014-2023)***

**Improvement Name: South Cheyenne Sewer Collection Main – Phase I**

**Improvement ID:** NT-CS-7

**Year:** 2014-2015

**Description:** Interceptors conveying wastewater from southern area of the collection system including the South Cheyenne, Allison Draw South, Allison Draw East, Porter Draw North, Porter Draw South and Little Simpson Creek sewer basins. As an alternative to the 36- and 42-inch interceptors, a 24-inch interceptor could be built in the near-term and a parallel 24-inch interceptor could be built in the mid-term to handle future flows from growth to the south.

**Scope:** 12,210 ft of 36-inch and 6,000 ft of 42-inch interceptor

**Purpose:** To convey wastewater from the southern area of the collection to serve existing and future areas of development.

**Improvement Name: South Cheyenne Sewer Collection Main – Phase II**

**Improvement ID:** NT-CS-9

**Year:** 2017-2018

**Description:** Interceptors conveying wastewater from southern area of the collection system including the South Cheyenne, Allison Draw South, Allison Draw East, Porter Draw North, Porter Draw South and Little Simpson Creek sewer basins.

**Scope:** 4,000 ft of 18-inch, 5,120 ft of 27-inch and 6,048 ft of 36-inch interceptor

**Purpose:** To convey wastewater from the southern area of the collection to serve existing and future areas of development.

***Mid-term (2024-2033)***

**Improvement Name: Southern Sewer Interceptor Extensions by 2033**

**Improvement ID:** MT-CS-8

**Year:** 2024-2033

**Description:** Interceptors conveying wastewater from southern area of the collection system including the South Cheyenne, Allison Draw South, Allison Draw East, Porter Draw North, Porter Draw South and Little Simpson Creek sewer basins.

**Scope:** 10,070 ft of 18-inch and 2,000 ft of 21-inch interceptor

**Purpose:** To convey wastewater from the southern area of the collection system to serve existing and future areas of development.

***Long-term (2034-2063)***

Currently no long-term interceptor projects are recommended

### Future Mains

Mains are those pipelines less than 18-inches in diameter that collect wastewater from customers to the interceptor. The following main projects are recommended for to collect wastewater from customers, provide relief or replacement due to the City or Wyoming Department of Transportation (WYDOT) projects sorted by year installed.

***Current (2013)***

**Improvement Name: Snyder Avenue from 24th to Pershing - City Project**

**Improvement ID:** 2013-CS-1

**Year:** 2013

**Description:** Main CIPP lining along Snyder Avenue from W 28th Ave to Pershing Blvd. This is a City coordinated project funded by BOPU and is currently under construction.

**Scope:** 2,112 ft of 15-inch

**Purpose:** To rehabilitate main coordinated with a street project.

***Near-term (2014-2023)***

**Improvement Name: Logan Avenue from Nationway to Pershing – City Project**

**Improvement ID:** NT-CS-5

**Year:** 2014

**Description:** CIPP lining of 10-inch and 12-inch main along Logan Avenue from Nationway to 19th St. This is a City coordinated project funded by BOPU.

**Scope:** 3,100 ft of 10-inch and 12-inch

**Purpose:** To rehabilitate main coordinated with a street project.

**Improvement Name: 19th Street from Snyder to Morrie – City Project**

**Improvement ID:** NT-CS-6

**Year:** 2015-2016

**Description:** Replacement of 8-inch main along 19th Street from Snyder Avenue to Morrie Avenue. This is a City coordinated project funded by BOPU.

**Scope:** 8,582 ft of 8-inch

**Purpose:** To rehabilitate main coordinated with a street project.

**Improvement Name: Southern Sewer Main Extensions by 2023**

**Improvement ID:** NT-CS-10

**Year:** 2019-2021

**Description:** Mains conveying wastewater from southern area of the collection system including the South Cheyenne, Allison Draw South, Allison Draw East, Porter Draw North, Porter Draw South and Little Simpson Creek sewer basins.

**Scope:** 9,350 ft of 8-inch, 10,600 ft of 12-inch, 6,400 ft of 15-inch

**Purpose:** To convey wastewater from the southern area of the collection to serve existing and future areas of development.

***Mid-term (2024-2033)***

**Improvement Name: Southern Sewer Main Extensions by 2033**

**Improvement ID:** MT-CS-9

**Year:** 2024-2033

**Description:** Mains conveying wastewater from southern area of the collection system including the South Cheyenne, Allison Draw South, Allison Draw East, Porter Draw North, Porter Draw South and Little Simpson Creek sewer basins.

**Scope:** 13,370 ft of 8-inch, 22,560 ft of 12-inch and 16,000 ft of 15-inch main

**Purpose:** To convey wastewater from the southern area of the collection system to serve existing and future areas of development.

**Improvement Name: Northern Sewer Main Extensions by 2033**

**Improvement ID:** MT-CS-10

**Year:** 2024-2033

**Description:** Mains conveying wastewater from northern area of the collection system including the Childs Draw sewer basin.

**Scope:** 1,0120 ft of 8-inch, 1,690 ft of 12-inch, 3,240 ft of 15-inch and 240 ft of 18-inch main

**Purpose:** To convey wastewater from the northern area of the collection system to serve existing and future areas of development.

***Long-term (2034-2063)***

**Improvement Name: Southern Sewer Main Extensions by 2063**

**Improvement ID:** LT-CS-8

**Year:** 2034-2063

**Description:** Mains conveying wastewater from southern area of the collection system including the Porter Draw North, Porter Draw South and Little Simpson Creek sewer basins.

**Scope:** 15,500 ft of 8-inch, 89,30 ft of 12-inch and 5,090 ft of 15-inch main

**Purpose:** To convey wastewater from the northern area of the collection system to serve existing and future areas of development.

**Improvement Name: Northern Sewer Main Extensions by 2063**

**Improvement ID:** LT-CS-9

**Year:** 2034-2063

**Description:** Mains conveying wastewater from northern area of the collection system including the Childs Draw sewer basin.

**Scope:** 3,400 ft of 8-inch main

**Purpose:** To convey wastewater from the southern area of the collection system to serve existing and future areas of development.

### Existing Replacement Interceptors and Mains

***Near-term (2014-2023)***

**Improvement Name: Dry Creek North Near-term Replacement 1**

**Improvement ID:** NT-CS-14

**Year:** 2014-2023

**Description:** Replacement of sewer main conveying wastewater along Mountain Road to Sheridan Street and Interceptor conveying water along Sheridan Street in the Dry Creek North sewer basin. This line serves portions of the Cole property.

**Scope:** 510 ft of 12-inch sewer main (along Mountain Road) and 1,675 ft of 18-inch interceptor (along Sheridan Street)

**Purpose:** To convey wastewater along Mountain Road and along Sheridan Street in the northern area of the collection system to serve existing and future areas of development.

**Improvement Name: Dry Creek North Near-term Replacement 2**

**Improvement ID:** NT-CS-15

**Year:** 2014-2023

**Description:** Replacement of sewer main conveying wastewater along Hilltop Avenue to Sheridan Street and Interceptor conveying water along Sheridan Street in the Dry Creek North sewer basin.

**Scope:** 3,146 ft of 12-inch sewer main (along Hilltop Avenue) and 751 of 18-inch interceptor (along Sheridan Street)

**Purpose:** To convey wastewater along Hilltop Avenue and along Sheridan Street in the northern area of the collection system to serve existing and future areas of development.

**Improvement Name: Dry Creek South Near-term Replacement 1**

**Improvement ID:** NT-CS-16

**Year:** 2014-2023

**Description:** Replacement of sewer main conveying wastewater in the Dry Creek South sewer basin.

**Scope:** 4,238 ft of 12-inch and 300 ft of 15-inch sewer main

**Purpose:** To convey wastewater in the Dry Creek South area of the collection system to serve existing and future areas of development.

**Improvement Name: Dry Creek South Near-term Replacement 2**

**Improvement ID:** NT-CS-17

**Year:** 2014-2023

**Description:** Replacement of interceptors conveying wastewater from the northern area of the collection system including the Dry Creek North and Dry Creek South sewer basins

**Scope:** 394 ft of 36-inch, 725 ft of 42-inch and 1,110 ft of 48-inch Interceptor

**Purpose:** To convey wastewater from the northern area of the collection system to serve existing and future areas of development.

**Improvement Name: Lincolnway Near-term Replacement 1**

**Improvement ID:** NT-CS-18

**Year:** 2014-2023

**Description:** Replacement of interceptor conveying wastewater in the Lincolnway sewer basin.

**Scope:** 2,740 ft of 27-inch interceptor

**Purpose:** To convey wastewater in the Lincolnway basin area of the collection system to serve existing and future areas of development.

**Improvement Name: Henderson Near-term Replacement 1**

**Improvement ID:** NT-CS-19

**Year:** 2014-2023

**Description:** Replacement of sewer main conveying wastewater in the Henderson sewer basin.

**Scope:** 1,945 ft of 15-inch sewer main

**Purpose:** To convey wastewater in the Henderson basin area of the collection system to serve existing and future areas of development

***Mid-term (2024-2033)***

**Improvement Name: Dry Creek North Mid-term Replacement 1**

**Improvement ID:** MT-CS-11

**Year:** 2024-2033

**Description:** Replacement of sewer main along King Arthur Way to Mountain Road and along Mountain Road in the Dry Creek North sewer basin. This line serves portions of the Cole property.

**Scope:** 1,730 feet of 12-inch sewer main

**Purpose:** To convey wastewater along King Arthur Way and along Mountain Road in the northern area of the collection system to service existing and future areas of development.

**Improvement Name: Dry Creek South Mid-term Replacement 1**

**Improvement ID:** MT-CS-12

**Year:** 2024-2033

**Description:** Replacement of sewer main in the Dry Creek South sewer basin to serve future flows from future developments in the Child's Draw sewer basin.

**Scope:** 2,670 ft of 12-inch and 3,815 ft of 15-inch sewer main

**Purpose:** To convey wastewater from the Childs Draw and Dry Creek South area of the collection system to serve future areas of development.

**Improvement Name: Dry Creek South Mid-term Replacement 2**

**Improvement ID:** MT-CS-13

**Year:** 2024-2033

**Description:** Replacement of interceptors conveying wastewater from the northern area of the collection system including the Dry Creek North and Dry Creek South sewer basins

**Scope:** 2,500 ft of 36-inch Interceptor

**Purpose:** To convey wastewater from the northern area of the collection to serve existing and future areas of development.

**Improvement Name: Dry Creek South Mid-term Replacement 3**

**Improvement ID:** MT-CS-14

**Year:** 2024-2033

**Description:** Replacement of interceptors conveying wastewater from southern area of the collection system including overflow from Crow Creek WRF.

**Scope:** 5,140 ft of 48-inch and 260 ft of 60-inch interceptor

**Purpose:** To convey wastewater from the southern area of the collection system to serve existing and future areas of development.

**Improvement Name: Holliday Mid-term Replacement 1**

**Improvement ID:** MT-CS-15

**Year:** 2024-2033

**Description:** Replacement of interceptors conveying wastewater from the southern area of the collection system including Henderson, Holliday, Capitol South, Capitol North, Goodman, WAFB, North Range Business Park and Clear Creek sewer basins

**Scope:** 8,180 ft of 42-inch interceptor

**Purpose:** To convey wastewater from the southern area of the collection system to serve existing and future areas of development.

**Improvement Name: Capitol South Mid-term Replacement 1**

**Improvement ID:** MT-CS-16

**Year:** 2024-2033

**Description:** Replacement of interceptors conveying wastewater from the southern area of the collection system including Capitol South, Capitol North, Goodman, WAFB, North Range Business Park and Clear Creek sewer basins

**Scope:** 4,560 ft of 36-inch interceptor

**Purpose:** To convey wastewater from the southern area of the collection system to serve existing and future areas of development.

***Long-term (2034-2063)***

**Improvement Name: Dry Creek North Long-term Replacement 1**

**Improvement ID:** MT-CS-10

**Year:** 2034-2063

**Description:** Replacement of sewer main along King Arthur Way in the Dry Creek North sewer basin. This line serves portions of the Cole property.

**Scope:** 1,450 feet of 12-inch sewer main

**Purpose:** To convey wastewater along King Arthur Way in the northern area of the collection system to serve existing and future areas of development.

**Improvement Name: Dry Creek North Long-term Replacement 2**

**Improvement ID:** MT-CS-11

**Year:** 2034-2063

**Description:** Replacement of sewer main in the Dry Creek South sewer basin to serve future flows from future developments in the Child's Draw sewer basin.

**Scope:** 2,045 ft of 12-inch sewer main

**Purpose:** To convey wastewater from the Childs Draw and Dry Creek South area of the collection system to serve future areas of development.

**Improvement Name: Dry Creek South Long-term Replacement 1**

**Improvement ID:** MT-CS-12

**Year:** 2034-2063

**Description:** Replacement of interceptors conveying wastewater from the northern area of the collection system including the Dry Creek North and Dry Creek South sewer basins

**Scope:** 3,155 ft of 36-inch Interceptor

**Purpose:** To convey wastewater from the northern area of the collection to serve existing and future areas of development.

**Improvement Name: Dry Creek South Long-term Replacement 2**

**Improvement ID:** MT-CS-13

**Year:** 2034-2063

**Description:** Replacement of interceptors conveying wastewater from southern area of the collection system including the overflow from Crow Creek WRF.

**Scope:** 445 ft of 36-inch, 1,185 ft of 42-inch and 5,850 ft of 48-inch interceptor

**Purpose:** To convey wastewater from the southern area of the collection system to serve existing and future areas of development.

**Improvement Name: Capitol South Long-term Replacement 1**

**Improvement ID:** MT-CS-14

**Year:** 2034-2063

**Description:** Replacement of interceptors conveying wastewater from the southern area of the collection system including Capitol South, Capitol North, Goodman, WAFB, North Range Business Park and Clear Creek sewer basins

**Scope:** 1,465 ft of 27-inch, 510 ft of 30-inch and 8,420 ft of 36-inch interceptor

**Purpose:** To convey wastewater from the southern area of the collection system to serve existing and future areas of development.

**Improvement Name: Clear Creek Long-term Replacement 1**

**Improvement ID:** MT-CS-15

**Year:** 2034-2063

**Description:** Replacement of sewer mains and interceptors conveying wastewater from the southern area of the collection system in the Clear Creek sewer basin

**Scope:** 1,951 ft of 12-inch sewer main and 3,172 ft of 18-inch, 2,508 ft of 21-inch, 10,735 ft of 24-inch and 1,835 ft of 27-inch interceptor

**Purpose:** To convey wastewater from the southern area of the collection system to serve existing and future areas of development.

**Improvement Name: Clear Creek Long-term Replacement 2**

**Improvement ID:** MT-CS-16

**Year:** 2034-2063

**Description:** Replacement of sewer mains conveying wastewater from the southern area of the collection system in the Clear Creek sewer basin

**Scope:** 4,613 ft of 12-inch sewer main

**Purpose:** To convey wastewater from the southern area of the collection system to serve existing and future areas of development.

### Manholes

The number of individual manholes required for the interceptors and mains were not developed. However, WDEQ suggests the following spacing for manholes based on the following pipe diameters:

- 15 inches or less – every 400 ft
- 15-30 inches – every 500 ft
- 31 inches or greater – every 600 ft

A minimum manhole diameter of 4 ft should be used and quality internal coatings should be applied to new manholes to extend manhole life before rehabilitation is required.

### Lift Stations

Lift station improvements will help support growth and increased load in the system. The existing lift stations can meet current (2013) loads but North Park Lift Station should be evaluated further in the near-terms for its ability to meet all future flows with firm capacity. Pump upgrades may be necessary after the evaluation; however, no capital improvements are currently recommended as there are two pumps in the lift station that can cover peak hour flow through the mid-term planning period.

**Improvement Name: SCWSD to CCWRF Lift Station and Forcemain**

**Improvement ID:** NT-CS-8

**Year:** 2014-2015

**Description:** As a near-term alternative of pumping back flow from DCWRF to CCWRF and an additional near-term gravity interceptor from South Cheyenne to DCWRF, add a lift station and forcemain near the middle of the SCWSD gravity interceptor to pump flow to CCWRF. Eventually, an additional gravity interceptor will be required from the southern service area to DCWRF.

**Scope:** 1,500 gpm firm capacity lift station with a 12-inch forcemain.

**Purpose:** To provide additional Class B effluent for recycled water supply.

***Mid-term (2024-2033)***

**Improvement Name: Porter Draw Lift Station and Forcemains**

**Improvement ID:** MT-CS-5/LT-CS-5

**Year:** 2024-2063

**Description:** A lift station to provide service to the Porter Draw sewer basin with two phases.

**Scope:** 1,000 gpm (mid-term) and 3,200 gpm (long-term) firm capacity lift station with an 8-inch (mid-term) and 12-inch (long-term) 5,200 ft forcemains.

**Purpose:** To provide wastewater service to the Porter Draw drainage area south of the City.

**Improvement Name: Childs Draw Lift Station and Forcemain**

**Improvement ID:** MT-CS-6

**Year:** 2024-2033

**Description:** A lift station to provide service to the Childs Draw sewer basin.

**Scope:** 1,000 gpm firm capacity lift station with an 8-inch 4,070 ft forcemain.

**Purpose:** To provide wastewater service to the Childs Draw drainage area north of the City.

***Long-term (2034-2063)***

**Improvement Name: Little Simpson Creek Lift Station and Forcemain**

**Improvement ID:** LT-CS-6

**Year:** 2034-2063

**Description:** A lift station to provide service to the Little Simpson Creek sewer basin.

**Scope:** 750 gpm firm capacity lift station with an 8-inch 8,300 ft forcemain.

**Purpose:** To provide wastewater service to the Little Simpson Creek drainage area south of the City.

### Other Capital Improvements

Other capital improvement and facilities planned include the following items.

#### Improvement Name: Reimburse Oversized Sewer Mains

**Improvement IDs:** NT-CS-3 / MT-CS-3 / LT-CS-3

**Year:** 2014-2063

**Description:** A fund to provide re-imbursement to developers for oversized sewer mains due to BOPU direction for providing additional capacity in their collection systems.

**Purpose:** To provide available funds to pay back developers for oversized sewer mains to improve system reliability and provide capacity to future growth areas.

#### Improvement Name: Special Sewer Projects

**Improvement IDs:** NT-CS-4 / MT-CS-4 / LT-CS-4

**Year:** 2014-2063

**Description:** Special unforeseen collection projects that come up such as major collection system repairs, manhole, wetwell, or lift station rehabilitation and replacement or rehabilitation of mains coordinated with street projects.

**Purpose:** To provide available funds for special sewer projects as described above.

## 7.9.2 Flow Metering and Monitoring

System flow metering and monitoring is recommended to support system operations and future planning efforts. By flow data over time, trends can be developed and reviewed upon which operations and capacity improvements can be made to improve system performance and optimize use of existing capacity. By understanding system operations using data, a more sustainable system can be obtained by removing unnecessary stresses and maximizing hydraulic benefits provided by the flexibility of existing facilities.

Existing flow data collected from the system should be take advantage of through annual analysis and use in hydraulic modeling. Additional flow monitoring equipment and communications infrastructure should be installed to collect data from existing and future flow metering facilities. Recommended system flow monitoring locations are presented in Figure 7-16. Volume 10 captures the cost of permanent flow monitoring in the system. Additionally, approximately $450,000 should be budgeted in the near-term planning period to implement an I/I study (2022) by a flow monitoring consultant to examine performance of pipe rehabilitation by sewer basin as well as complete extensive flow monitoring by consultants to prepare for the next wastewater master plan. Future capital projects such as major interceptors and lift stations should include flow monitoring as part of the design and construction of the improvement. Several locations around the WRFs are recommended for increased ability to track flows through the CCWRF and DCWRF bypass line (refer to Section 7.6.2).

An operations dashboard and analysis platform is recommended for implementation in the near-term to use this information for day-to-day operations and longer-term optimization of the collection system.

**Improvement Name: System Flow Metering and Monitoring**

**Improvement IDs:** NT-CS-12 / MT-CS-7 / LT-CS-7

**Year:** 2014-2063

**Description:** Installation of system metering and monitoring equipment and SCADA infrastructure to collect flow data at select locations in the system.

**Purpose:** To provide system performance data for day-to-day operations and analysis of capacity and optimization opportunities.

### 7.9.3 Collection System Assessment and Rehabilitation

Continued assessment and rehabilitation is vital to the sustainability of the collection system. The collection system assessment method described in Section 7.7 should be implemented in the next two years to support data-based system rehabilitation. This assessment method will aid the yearly selection of rehabilitation pipe segments based on both probability of failure and consequence of failure factors.

The collection main rehabilitation program begun 10 years ago should be continued. Continue lining and upsizing collection mains and coating manholes as needed to prolong the life of collection system infrastructure and reduce I/I. BOPU should consider rehabilitating the first few feet up into the service lateral and use a “top hat” or “top seal” system to repair the connection at laterals into the sewer main to further reduce I/I and maximize the effectiveness of rehabilitation projects.

The target for main rehabilitation is recommended to be 1.5 miles per year from 2014 to 2017 and then increased to 2.5 miles per year from 2018 onwards. At 2.5 miles per year, the entire existing system replacement cycle would be approximately 160 years. Future system improvements should last longer due to increased quality of materials and installation; however, the replacement rate should be evaluated to be increased again during the next wastewater master plan. Identified near-term rehabilitation projects from 2013 to 2018 are shown on Figure 7-19. Additional pipe segments should be added to each of the years as necessary to reach the main rehabilitation targets. Two targeted rehabilitations outside of the primary rehabilitation program since they are larger rehabilitation projects are North Crow Creek Interceptor and Dry Creek Interceptor Rehabilitations.

**Improvement Name: Collection Main Rehabilitation Program (Rehab/Replace/Upsize)**

**Improvement IDs:** NT-CS-1 / MT-CS-1 / LT-CS-1

**Year:** 2014-2063

**Description:** Replacement, upsizing or lining of collection mains.

**Purpose:** To provide continued rehabilitation to aging collection mains and improve system performance and reduce I/I.

**Improvement Name: Collection Manhole Rehabilitation Program (Rehab/Replace)**

**Improvement IDs:** NT-CS-2 / MT-CS-2 / LT-CS-2

**Year:** 2014-2063

**Description:** Replacement or lining of collection manholes.

**Purpose:** To provide continued rehabilitation to aging collection manholes and improve system performance and reduce I/I.

**Improvement Name: Dry Creek Interceptor Rehabilitation (Rehab/Reline)**

**Improvement IDs:** NT-CS-11

**Year:** 2017-2018

**Description:** Cleaning and CIPP lining rehabilitation of 5,900 ft of 21 and 24-inch Dry Creek Interceptor.

**Purpose:** To provide rehabilitation to a parallel interceptor for condition.

**Improvement Name: North Crow Creek Interceptor Rehabilitation (Rehab/Reline)**

**Improvement IDs:** NT-CS-12

**Year:** 2015

**Description:** Cleaning and CIPP lining rehabilitation of 4,400 ft of 30 and 36-inch Crow Creek Interceptor.

**Purpose:** To provide rehabilitation to a currently used parallel interceptor for additional capacity and condition.

### 7.9.4 Preventative Maintenance

A detailed preventative maintenance plan and complete implementation of that plan is recommended for the collection system. Preventative maintenance practices are proven to support system sustainability, increase remaining life of assets and reduce I/I and SSOs. Currently, BOPU completes an area maintenance program that targets known problem areas; this program should be formalized and expanded into a complete program.

At a minimum the following components are recommended for implementation within the next 3 years:

- Enterprise asset management (EAM) and computerized maintenance management system (CMMS).
- Field data collection for increased accuracy and completeness of GIS data.
- Condition inspection (CCTV) program should be completed once every 5 years for interceptors (1/5 of interceptors per year) and once every 10 years for mains (1/10 of mains per year). Targeted CCTV inspection continued as needed.
- Main cleaning program should be completed in conjunction with condition inspection program depending on CCTV results once every 5 years for interceptors (1/5 of interceptors per year) and once every 10 years for mains (1/10 of mains per year). Targeted main cleaning continued as needed.
- Root control program should be completed once every 5 years in known problem areas from CCTV (1/5 of problem areas per year).
- On-going FOG and industrial pretreatment program.
- Customer complaint (odor) tracking program to support the cleaning and condition inspection programs.
- Sewer backup and SSO response program and tracking.

Levels of service goals for performance indicators such as defects per 100 miles of pipe and customer complaints should be established and tracked to determine the improvement of system performance over time. Appendix 7-C contains examples of common wastewater system performance indicators that are used for tracking level of service.

Volume 10 includes more details on the system hardware and software requirements to support a preventative maintenance plan including CMMS, EAM and mobile requirements. A full time equivalent, a preventative maintenance coordinator, with previous asset management and GIS experience is recommended to lead and implement the collection and distribution preventative maintenance program utilizing O&M staff for field work.

## 7.10 Capital Improvement Plan

From the recommended improvements in Section 7.9, a capital improvement plan was developed outlining the implementation phasing and cost of the collection system projects. Figure 7-20 presents the capital improvement projects in the distribution system.

### 7.10.1 Cost Estimating Assumptions

Cost estimates were developed for each of the capital improvement projects yearly from 2015 to 2023 and as a total cost for mid-term (2024-2033) projects. 2013 and 2014 are currently budgeted years and the cost estimates from the financial projections provided by BOPU were not changed. Cost estimates were not provided for the long-term projects since they too far in the future to be certain of their implementation or costs.

The cost estimates developed are order of magnitude costs to give an indication of probable cost to implement. It is normally expected that an estimate of this type would be accurate within +50% or -30%. A 30% design contingency was applied to the total construction costs and a 3.5% per year escalation rate to the construction year was used to account for inflation. Table 7-36 presents the 2013 unit pipe costs used for the estimates which include a manholes allowance, bedding materials and installation costs. Appendix 7-B contains more detailed cost estimates for the pipeline projects.

**Table 7-36**
**Pipe Material and Unit Cost Assumptions**

| Pipe Size (inches) | Pipe Material | 2013 Unit Cost ($/lf) (1) |
|---|---|---|
| 8 | PVC | $140 |
| 12 | PVC | $155 |
| 15 | PVC | $170 |
| 18 | PVC | $195 |
| 21 | PVC | $210 |
| 24 | PVC | $275 |
| 27 | PVC | $300 |
| 30 | FRP | $325 |
| 36 | FRP | $350 |
| 42 | FRP | $375 |
| 48 | FRP | $400 |
| 60 | FRP | $450 |

(1) Unit costs include a manholes allowance, bedding materials and installation.

### 7.10.2 Capital Improvement Plans by Planning Period

Table 7-37, Table 7-38 and Table 7-39 present the near-term (2014-2023), mid-term (2024-2033) and long-term (2034-2063) capital improvement plans for wastewater collection, respectively. Table 7-37 includes 2013 projects for reference but those projects are not considered part of the near-term capital improvement plan as they are currently in progress or under construction. The 2014 budget is based on the actual BOPU budget and uses cost estimates established by BOPU. Prior to these capital improvement projects being implemented, the scope and sizing of each project should be verified via pre-design investigation and planning including field confirmations, hydraulic modeling, cost estimating and siting and/or alignment studies.

**Table 7-37**
**Near-term (2014-2023) Recommended Capital Improvement Plan**

| Item # | CIP ID | Project | Adjusted Budget FY 2013 | Actual Budget FY 2014 | Projection FY 2015 | Projection FY 2016 | Projection FY 2017 | Projection FY2018 | Projection FY2019 | Projection FY2020 | Projection FY2021 | Projection FY2022 | Projection FY2023 | Near-term Expenditures Based on Year of Construction Dollars |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2013-CS-1 | Snyder Avenue from 28th to Pershing - City Project | $487,500 | | | | | | | | | | | $0 |
| 2 | NT-CS-1 | Collection Main Rehabilitation Program (Rehab/Replace) | $1,996,400 | $1,179,700 | $1,500,000 | $1,552,500 | $1,606,800 | $1,663,000 | $1,721,200 | $1,781,400 | $1,843,700 | $1,908,200 | $1,975,000 | $16,731,500 |
| 3 | NT-CS-2 | Collection Manhole Rehabilitation Program (Rehab/Replace) | $150,000 | $130,000 | $150,000 | $155,300 | $160,700 | $166,300 | $172,100 | $178,100 | $184,300 | $190,800 | $197,500 | $1,685,100 |
| 4 | NT-CS-3 | Reimburse Oversized Sewer Mains(1) | $270,800 | | $300,000 | $310,500 | $321,400 | $332,600 | $344,200 | $356,200 | $368,700 | $381,600 | $395,000 | $3,110,200 |
| 5 | NT-CS-4 | Special Sewer Projects(1) | $185,180 | $300,000 | $300,000 | $310,500 | $321,400 | $332,600 | $344,200 | $356,200 | $368,700 | $381,600 | $395,000 | $3,410,200 |
| 6 | NT-CS-5 | Logan Avenue from Nationway to 19th - City Project | | $542,500 | | | | | | | | | | $542,500 |
| 7 | NT-CS-6 | 19th St from Snyder to Morrie - City Project | | | $435,000 | | | | | | | | | $435,000 |
| 8 | NT-CS-7 | South Cheyenne Sewer Collection Main Phase I(4) | | $1,600,000 | $11,159,000 | | | | | | | | | $12,759,000 |
| 9 | NT-CS-8 | SCWSD to CCWRF Lift Station and Forcemain(4) | | $1,600,000 | $10,500,000 | | | | | | | | | $12,100,000 |
| 10 | NT-CS-9 | South Cheyenne Sewer Collection Main Phase II(2) | | | | | $900,000 | $8,361,000 | | | | | | $9,261,000 |
| 11 | NT-CS-10 | Southern Sewer Main Extensions by 2023(2/3) | | | | | | | | $8,799,000 | | | | $8,799,000 |
| 12 | NT-CS-11 | Dry Creek Interceptor Rehabilitation (Rehab/Reline) | | | | | $656,250 | $516,250 | | | | | | $1,172,500 |
| 13 | NT-CS-12 | North Crow Creek Interceptor Rehabilitation (Rehab/Reline) | | | | | | $2,000,000 | | | | | | $2,000,000 |
| 14 | NT-CS-13 | Flow Monitoring/Infiltration and Inflow Studies | *Costs in Volume 10 – except FY 2022* | | | | | | | | | $450,000 | | $450,000 |
| 15 | NT-CS-14 | Dry Creek North Near-term Replacement 1(2) | | | | | | $830,000 | | | | | | $830,000 |
| 16 | NT-CS-15 | Dry Creek North Near-term Replacement 2(2) | | | | | | | $1,325,000 | | | | | $1,325,000 |
| 17 | NT-CS-16 | Dry Creek South Near-term Replacement 1(2) | | | | | | | | $1,510,000 | | | | $1,510,000 |
| 18 | NT-CS-17 | Dry Creek South Near-term Replacement 2(2) | | | | | | | | | $1,860,000 | | | $1,860,000 |
| 19 | NT-CS-18 | Lincolnway Near-term Replacement 1(2) | | | | | | | | | | $1,827,000 | | $1,827,000 |
| 20 | NT-CS-19 | Henderson Near-term Replacement 1(2) | | | | | | | | | | | $750,000 | $750,000 |
| - | - | Total Projects per Year | $3,089,900 | $3,752,200 | $13,844,000 | $2,328,800 | $3,966,600 | $14,201,800 | $3,906,700 | $12,980,900 | $4,625,400 | $5,139,200 | $3,712,500 | $68,458,000 |
| | | | | | | | | | | Average Cost per Year (over 10 years) | | | | $6,845,800 |

(1) This project can involve unused funds being transferred over year to year. Value shown is estimated maximum expenditure per year (including escalation) which does not estimate transferred funding from previous year.

(2) This project could be delayed to future years due to actual development, increased flows, actual field conditions or budgeting priority; year shown is only representative of anticipated development timing or system need and project sequencing, actual project timing could vary.

(3) This project is system growth-related to serve future development areas with a majority of the project paid by developers (assumed 100% of shown cost) and BOPU participating in infrastructure oversizing costs, if necessary.

(4) These projects are alternatives for collection of the near-term south area of the sewer service area. NT-CS-8 is not included in the CIP totals.

**Table 7-38**
**Mid-term (2024-2033) Recommended Capital Improvement Plan**

| Item # | CIP ID | Project | Cost Estimate (Based on 2028 Dollars) |
|---|---|---|---|
| 1 | MT-CS-1 | Collection Main Rehabilitation Program (Rehab/Replace) | $23,978,900 |
| 2 | MT-CS-2 | Collection Manhole Rehabilitation Program (Rehab/Replace) | $2,398,300 |
| 3 | MT-CS-3 | Reimburse Oversized Sewer Mains(1) | $4,795,600 |
| 4 | MT-CS-4 | Special Sewer Projects(1) | $4,795,600 |
| 5 | MT-CS-5 | Porter Draw Lift Station and Forcemain - Phase 1(2/4) | $3,500,000 |
| 6 | MT-CS-6 | Childs Draw Lift Station and Forcemain(2/4) | $3,500,000 |
| 7 | MT-CS-7 | Flow Monitoring/Infiltration and Inflow Studies | $650,000 |
| 8 | MT-CS-8 | Southern Sewer Interceptor Extensions by 2033(2) | $11,415,000 |
| 9 | MT-CS-9 | Southern Sewer Main Extensions by 2033(2/3) | $20,494,000 |
| 10 | MT-CS-10 | Northern Sewer Main Extensions by 2033(2/3) | $2,317,000 |
| 11 | MT-CS-11 | Dry Creek North Mid-term Replacement 1(2) | $680,000 |
| 12 | MT-CS-12 | Dry Creek South Mid-term Replacement 1(2) | $2,692,000 |
| 13 | MT-CS-13 | Dry Creek South Mid-term Replacement 2(2) | $2,217,000 |
| 14 | MT-CS-14 | Dry Creek South Mid-term Replacement 3(2) | $5,384,000 |
| 15 | MT-CS-15 | Holliday Mid-term Replacement 1(2) | $7,772,000 |
| 16 | MT-CS-16 | Capitol South Mid-term Replacement 1(2) | $1,791,000 |
| - | | Total Projects | $98,380,400 |
| | | Average Cost per Year (over 10 years) | $9,838,000 |

(1) This project can involve unused funds being transferred over year to year. Value shown is estimated maximum expenditure per year (including escalation) which does not estimate transferred funding from previous year.

(2) This project could be delayed to future years due to actual development, increased flows, actual field conditions or budgeting priority; year shown is only representative of anticipated development timing or system need and project sequencing, actual project timing could vary.

(3) This project is system growth-related to serve future development areas with a majority of the project paid by developers (assumed 100% of shown cost) and BOPU participating in infrastructure oversizing costs, if necessary.

(4) This project is system growth-related to serve future development areas with a majority of the project by developers paid (assumed 80% of shown cost) and BOPU participating in infrastructure oversizing costs (assumed 20% of shown cost), if necessary.

**Table 7-39**
**Long-term (2034-2063) Recommended Capital Improvement Plan**

| Item # | CIP ID | Project |
|---|---|---|
| 1 | LT-CS-1 | Collection Main Rehabilitation Program (Rehab/Replace) |
| 2 | LT-CS-2 | Collection Manhole Rehabilitation Program (Rehab/Replace) |
| 3 | LT-CS-3 | Reimburse Oversized Sewer Mains(1) |
| 4 | LT-CS-4 | Special Sewer Projects(1) |
| 5 | LT-CS-5 | Porter Draw Lift Station and Forcemain - Phase 2(2/4) |
| 6 | LT-CS-6 | Little Simpson Creek Lift Station and Forcemain(2/4) |
| 7 | LT-CS-7 | Flow Monitoring/Infiltration and Inflow Studies |
| 8 | LT-CS-8 | Southern Sewer Main Extensions by 2063(2/3) |
| 9 | LT-CS-9 | Northern Sewer Main Extensions by 2063(2/3) |
| 10 | LT-CS-10 | Dry Creek North Long-term Replacement 1(2) |
| 11 | LT-CS-11 | Dry Creek North Long-term Replacement 2(2) |
| 12 | LT-CS-12 | Dry Creek South Long-term Replacement 1(2) |
| 13 | LT-CS-13 | Dry Creek South Long-term Replacement 2(2) |
| 14 | LT-CS-14 | Capitol South Long-term Replacement 1(2) |
| 15 | LT-CS-15 | Clear Creek Long-term Replacement 1(2) |
| 16 | LT-CS-16 | Clear Creek Long-term Replacement 2(2) |

(1) This project can involve unused funds being transferred over year to year.

(2) This project could be delayed to future years due to actual development, increased flows, actual field conditions or budgeting priority; year shown is only representative of anticipated development timing or system need and project sequencing, actual project timing could vary.

(3) This project is system growth-related to serve future development areas with a majority of the project paid by developers and BOPU participating in infrastructure oversizing costs, if necessary.

(4) This project is system growth-related to serve future development areas with a majority of the project paid by developers and BOPU participating in infrastructure oversizing costs, if necessary.

# Figure 7-20
# Wastewater Collection System Capital Improvement Projects

**(available in the inside back cover pocket of this binder)**

# Appendices

# Volume 7 – Wastewater Collection

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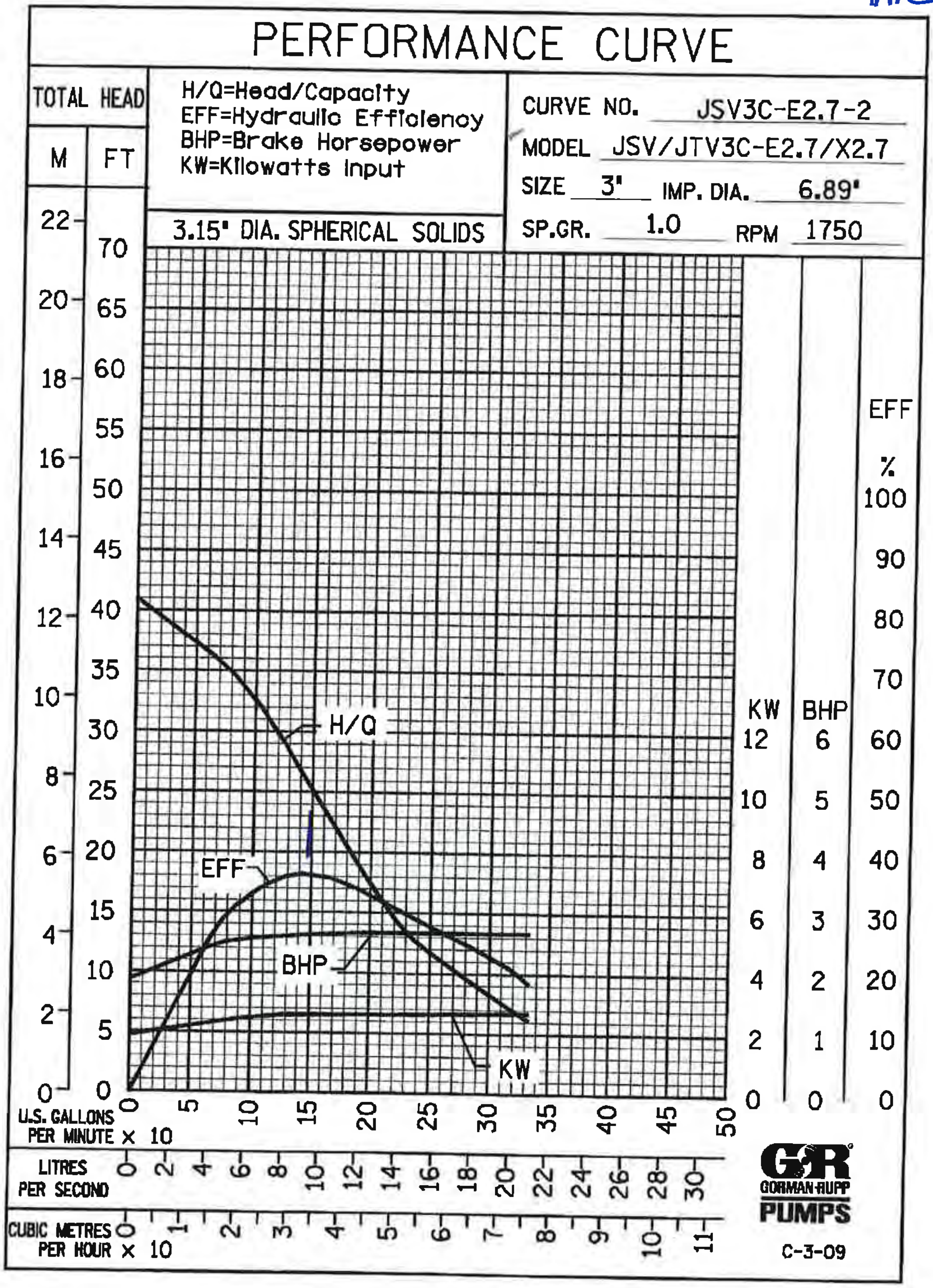
# Appendix 7-A
# Existing Operations Information

- Lift Station Pump Curves

Welcome Center
WC

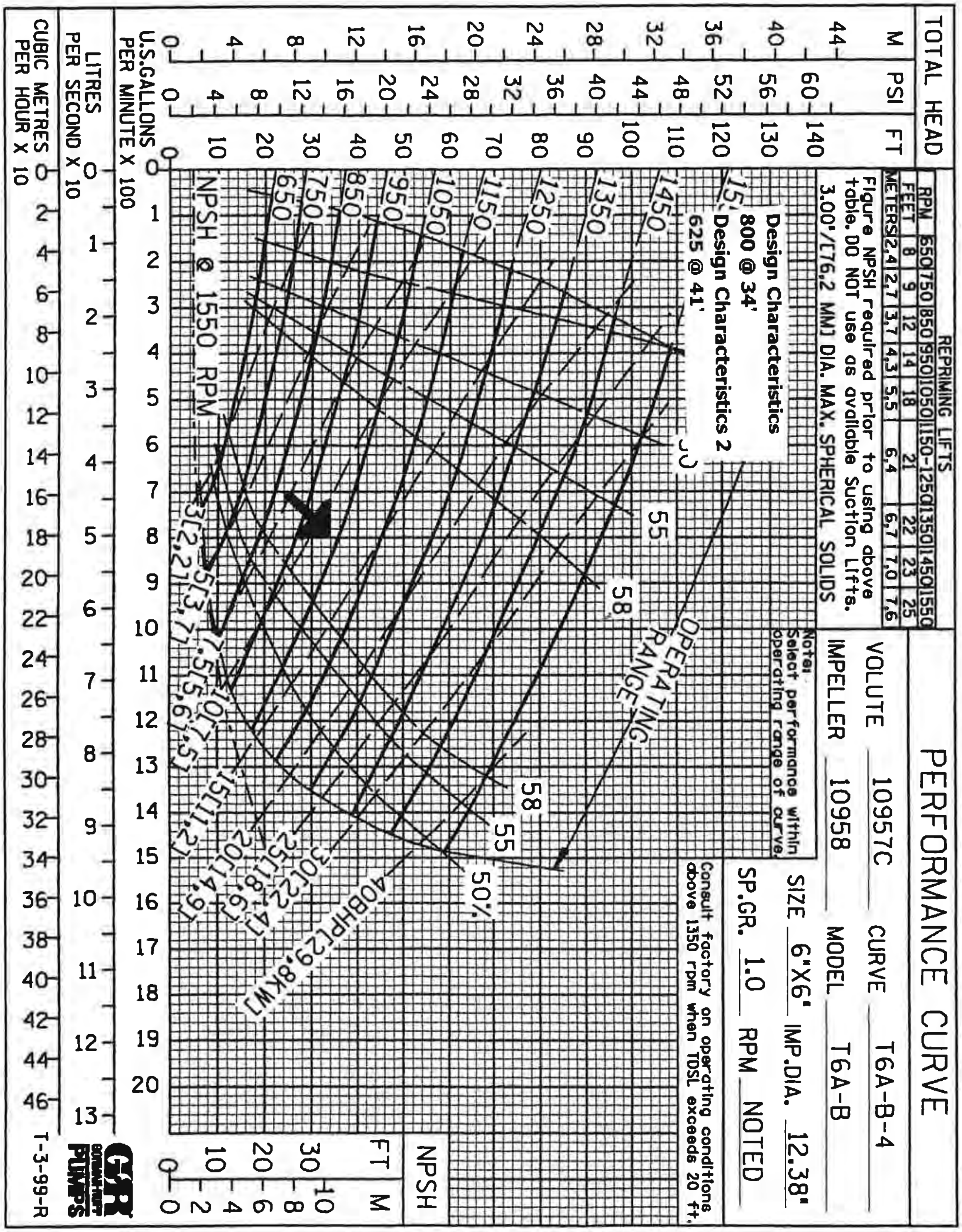
## PERFORMANCE CURVE – MODEL JSV3C60-X2.7

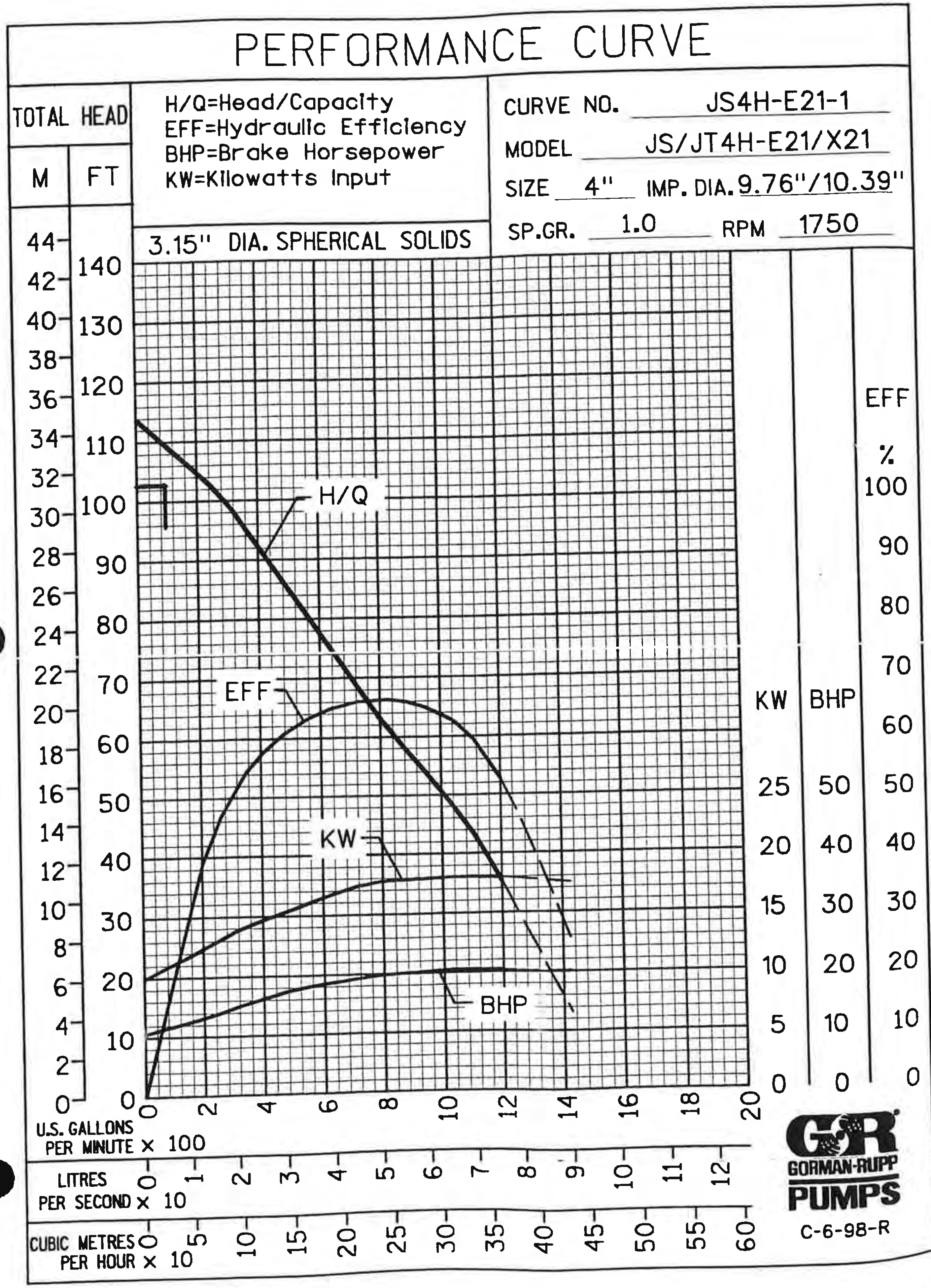


Point I

| Curve Data | Sec. 55 | PAGE 1254 |
|---|---|---|
| | | JUNE 1999 |

CD






## ENGINEERING ORDER

The Point II Miracle

GORMAN-RUPP PUMPS

ENGINEERED SYSTEMS
Mansfield, Ohio 44903

Date: 05/10/05

Revisions:

Serial No.: 05-573-SJP

## SUPPLEMENT SHEET

### Pump Data

| | |
|---|---|
| Pump No. 1 Serial No.:............................... | 1274710 |
| Pump No. 2 Serial No.:............................... | 1274711 |
| Pump No. 3 Serial No.:............................... | NONE |
| Pump No. 4 Serial No.:............................... | NONE |

### Engine Data

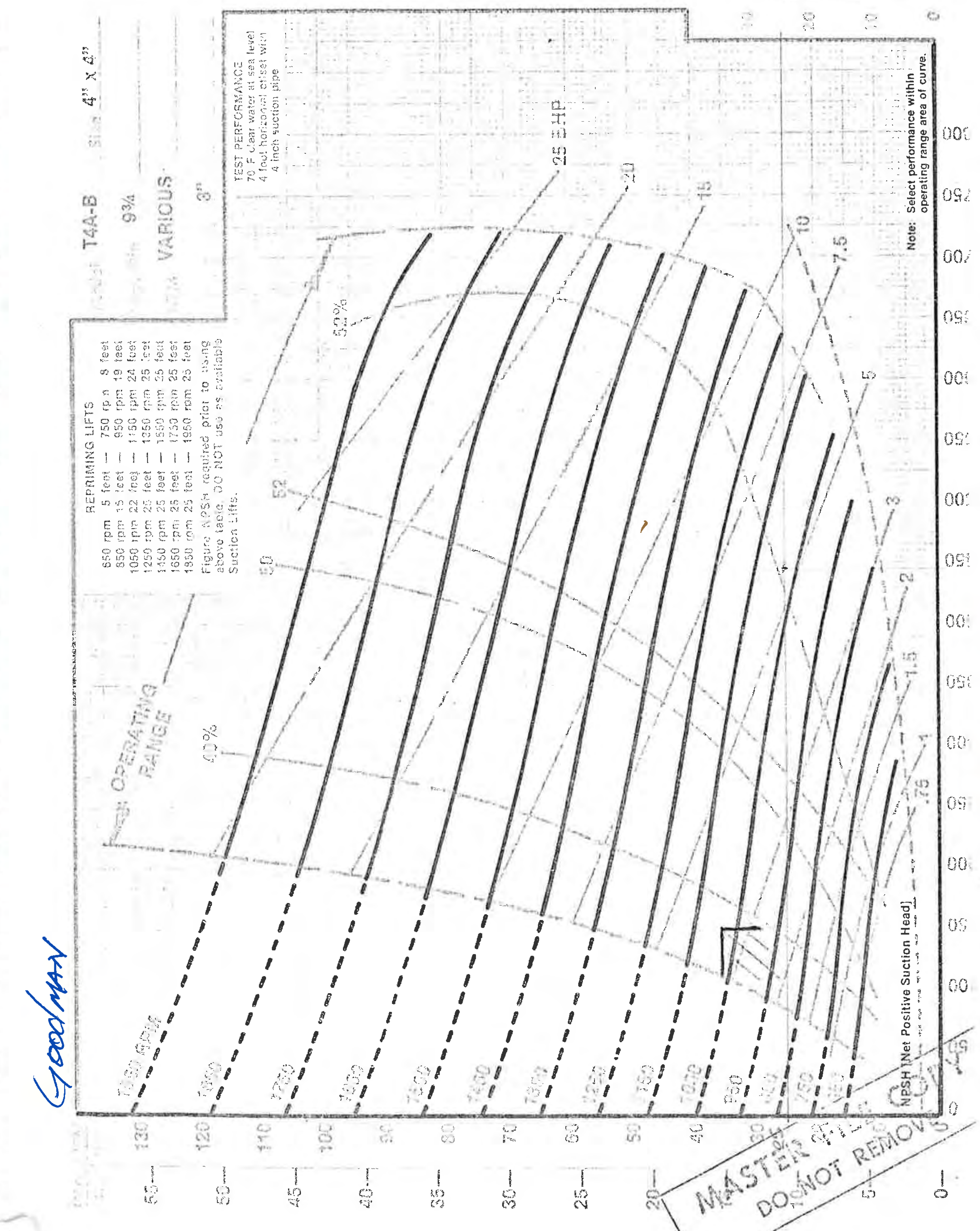
| | |
|---|---|
| Engine Serial No. (When Applicable)......... | NONE |

### Motor Data

| | |
|---|---|
| R.P.M. Full Load:....................................... | 1750 |
| Full Load Amps:....................................... | 32.2 |
| Service Factor:....................................... | 1.15 |
| Motor O/L Heater:....................................... | |
| Full Load Amp Setting:.................................. | 32.2 |
| Pump No. 1 Motor Serial No.:.................... | NONE |
| Pump No. 2 Motor Serial No.:.................... | NONE |
| Pump No. 3 Motor Serial No.:.................... | NONE |
| Pump No. 4 Motor Serial No.:.................... | NONE |

1085 RPM 7½HP





# Appendix 7-B
# Collection System Assessment Method
# Additional Information

- Assessment Means – Asset Attributes and Performance Parameters
- Assessment Method – Scoring Matrix
- Assessment Method – Data Structure Schematic

**REVISED** **8/22/13**

**Sewer Main Facility ID** Use this GIS field to link together all sources of data

**Asset Attributes**

| Name | Type (LoF/CoF) | GIS Feature Type | Phase | GIS Source | Unit | Data Quality | Obtain From | Comments |
|---|---|---|---|---|---|---|---|---|
| Pipe Material | LoF | Polyline | 1 | Mains | N/A | Good | As-builts, specs, field inspection | Confirm in field |
| Pipe Diameter | LoF | Polyline | 1 | Mains | inches | Good | As-builts, field inspection | Confirm in field |
| Pipe Age | LoF | Polyline | 1 | Mains | years | Fair | Pipe installed date | Convert from year to age by subtracting current year by pipe installed date |
| Surface Conditions | LoF | Polyline | 1 | Mains | N/A | Fair | Aerial, right-of-way, etc. | Assign based on surface - high traffic road, light traffic road, sidewalk, open space, etc. |
| Soil Type | LoF | Polygon | 1 | Soil Types | N/A | Good | USDA SSURGO data | Assign based on USDA SSURGO soil types |
| Pipe Depth | LoF | Polyline | 1 | Mains | feet | Fair | As-builts, field inspection | Calculate by subtracting inverts from the rims and averaging the upstream and downstream depths |
| Pipe Slope | LoF | Polyline | 1 | Mains | % | Fair | As-builts, field inspection | Calculate by dividing different in upstream and downstream invert by the pipe length |
| Pipe Wall Thickness | LoF | Polyline | 2 | Mains | N/A | None | As-builts, specs, field inspection | Assign based on as-builts, field inspection, or pipe material |
| Pipe Joint Type | LoF | Polyline | 2 | Mains | N/A | None | As-builts, specs, field inspection | Assign based on as-builts, field inspection, or pipe material |
| Pipe Bedding | LoF | Polyline | 2 | Mains | N/A | None | As-builts, specs, field inspection | Assign based on as-builts or field inspection |
| Trench Backfill | LoF | Polyline | 2 | Mains | N/A | None | As-builts, specs, field inspection | Assign based on as-builts or field inspection |
| Pipe Protection | LoF | Polyline | 2 | Mains | N/A | None | As-builts, specs, field inspection | Assign based on poly wrap, cathodic protection, etc. |
| Pipe Condition | LoF | Polyline | 2 | Mains | N/A | None | Field inspection | Document from field inspection (excellent, good, fair, poor) |
| Pipe Manufacturer | LoF | Polyline | 2 | Mains | N/A | None | Field inspection, submittals | Confirm in field |
| Installation Contractor | LoF | Polyline | 2 | Mains | N/A | None | As-builts, submittals | From as-builts or construction contracts |
| Soil Corrosivity | LoF | Point | 2 | Soil Points | ohm cm | None | Field soils testing | Assign based on nearest soil inspection point |
| Soil Resistivity | LoF | Point | 2 | Soil Points | ohm cm | None | Field soils testing | Assign based on nearest soil inspection point |
| Redox Potential | LoF | Point | 2 | Soil Points | mV | None | Field soils testing | Assign based on nearest soil inspection point |
| Soil pH | LoF | Point | 2 | Soil Points | pH | None | Field soils testing | Assign based on nearest soil inspection point |
| Soil Moisture Content | LoF | Point | 2 | Soil Points | % | None | Field soils testing | Assign based on nearest soil inspection point |
| Groundwater Table | LoF | Polygon | 2 | Groundwater Table | feet | None | Field inspection | Groundwater table layers may be available in GIS format |

**Performance Parameters**

| Name | Type (LoF/CoF) | GIS Feature Type | Phase | GIS Source | Unit | Data Quality | Obtain From | Comments |
|---|---|---|---|---|---|---|---|---|
| Pipe Function | CoF | Polyline | 1 | Mains | N/A | Good | Pipe diameter | Assign from diameter - Interceptor ≥ 18", Main < 18", Service Line, Forcemain |
| Infiltration and Inflow | LoF | Polyline | 1 | Model Results | % | Fair | Condition inspection database | Assign based on observed infiltration in CCTV records and I/I studies |
| Flow Velocity | LoF | Polyline | 1 | Model Results | ft/s | Good | Hydraulic model | Assign based on average velocity model results |
| SSO Risk | CoF | Point | 1 | Model Results | ft | Good | Hydraulic model | Assign based on connecting manhole SSO risk (unfilled depth from rim) |
| SSO/Backups | CoF | Point | 1 | SSO and Backups | N/A | Fair | SSO/Backups database | Assign based on nearest main |
| Blockages/Accumulation | LoF | Point | 1 | Blockages/Accumulation | N/A | Fair | Main cleaning database | Assign based on nearest main |
| Main Criticality | CoF | Polyline | 1 | Model Results | inch-gpm | Good | Hydraulic model | Assign based on diameter x flow based on model results |
| Critical Facility | CoF | Polyline | 1 | Mains | N/A | Good | Parcels, land use, zoning | Refinery, WAFB, South Cheyenne, Hospitals, Schools, etc. |
| Main Defects | LoF | Point | 1 | Main Defects | N/A | Fair | Condition inspection database | Assign based on PACP scores - 1 to 5 |
| Failure Impact | CoF | Polyline | 1 | Mains | N/A | Fair | Various GIS layers | Ditches, creeks, wetlands, bridges, roads, etc. |
| Remaining Life of Pipe | LoF | Polyline | 2 | GIS Main Data | N/A | None | Condition inspection database | Assign based on standard material values or derived from main defects data |
| Hydrogen Sulfide Measurements | LoF | Point | 2 | H2S Measurements | ppm | Good | Main cleaning database | Assign based on nearest main; collect when cleaning mains |
| Customer Complaints (Odor) | CoF | Point | 2 | Customer Complaints | N/A | None | Customer complaint database | Assign based on nearest main |
| Manhole Condition | LoF | Point | 2 | Leaks | N/A | None | Leak data | Assign to connecting mains |
| Industrial Pretreatment | LoF | Point | 2 | Industrial Pretreatment | N/A | None | Industrial pretreatment database | Assign to immediate downstream mains |
| FOG | LoF | Point | 2 | FOG | N/A | None | FOG database | Assign to nearest main based on FOG locations |
| Last Inspected | LoF | Polyline | 2 | Mains | Date | None | Field inspection | Assign based on last field inspection date |

**REVISED** **8/22/13**

**Sewer Main Facility ID** Use this GIS field to link together all sources of data

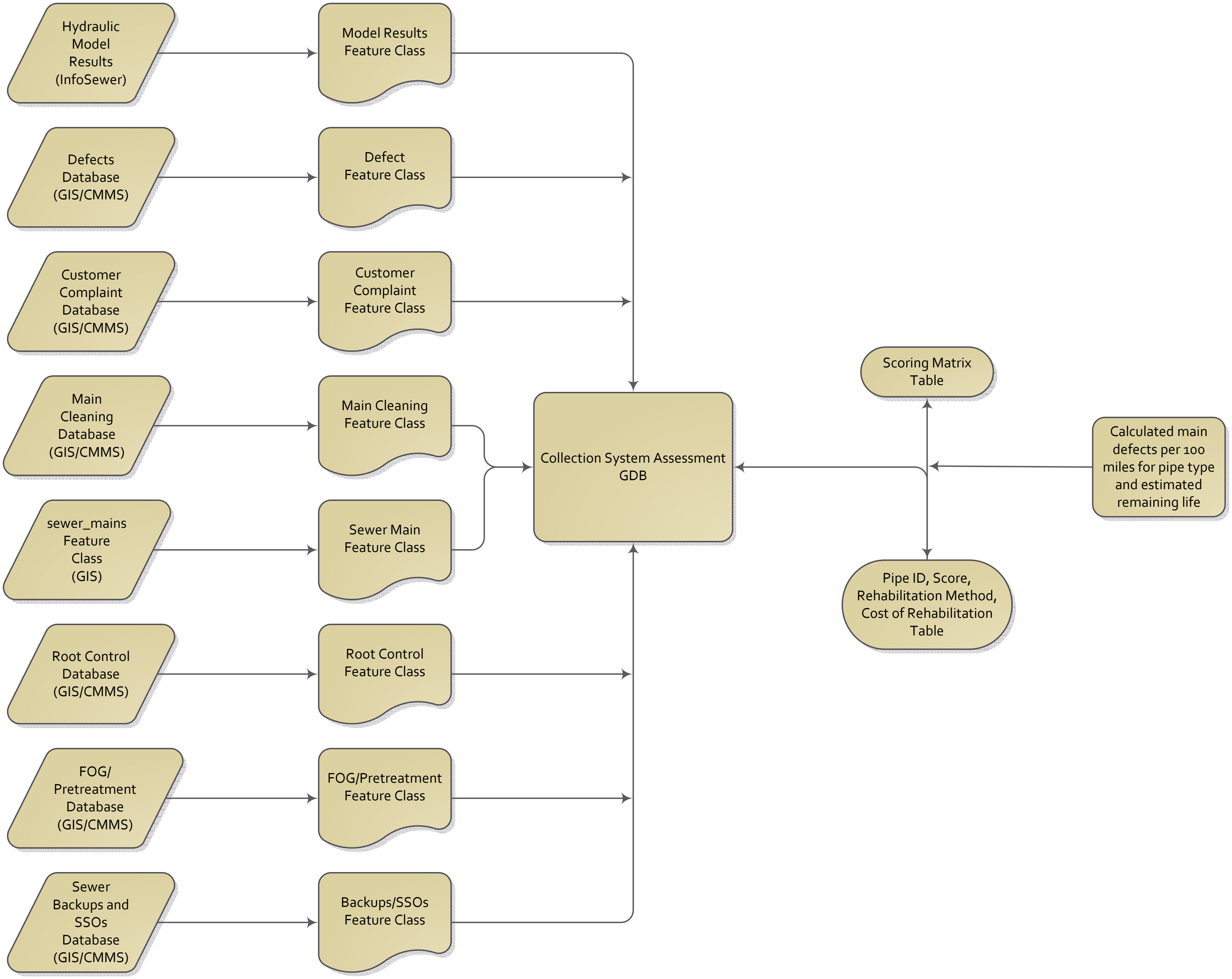
## Asset Attributes

| Name | Asset Attributes/Scoring | | | | | | | | | | | | | | | | | Category Factor | Maximum Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pipe Material Attributes | CIPU | VCP | DIP | RCP | FRP | Plastic (HDPE, PVC) | | | | | | | | | | | | - | - |
| **Pipe Material Score** | 5 | 4 | 3 | 3 | 2 | 1 | | | | | | | | | | | | 3 | 15 |
| Pipe Diameter Range (inches) | 4 | 6 | 8 | 10-12 | 15-24 | 30+ | | | | | | | | | | | | - | - |
| **Pipe Diameter Score** | 5 | 5 | 3 | 2 | 1 | 1 | | | | | | | | | | | | 3 | 15 |
| Pipe Age (years) | 70+ | 60 | 50 | 40 | 30 | 20 | 10 | | | | | | | | | | | - | - |
| **Pipe Age Score** | 4 | 5 | 5 | 5 | 3 | 2 | 1 | | | | | | | | | | | 4 | 20 |
| Surface Condition Attributes | Heavy Traffic | Medium Traffic | Light Traffic | Parking Lot | Sidewalk | Open Space/Park | | | | | | | | | | | | - | - |
| **Surface Condition Score** | 5 | 4 | 3 | 2 | 2 | 1 | | | | | | | | | | | | 3 | 15 |
| Soil Type (USDA SSURGO) | 101 | 102 | 104 | 131 | 138 | 142 | 145 | 158 | 162 | 171 | 182 | 183 | 184 | 186 | 187 | 188 | 189 | - | - |
| **Soil Type Score** | 1 | 1 | 2 | 2 | 1 | 1 | 5 | 1 | 2 | 1 | 5 | 2 | 3 | 5 | 5 | 4 | 3 | 1 | 5 |
| Pipe Depth Attributes (ft) | 0-3 | 20+ | 3-6 | 15-20 | 6-15 | | | | | | | | | | | | | - | - |
| **Pipe Depth Score** | 5 | 4 | 3 | 2 | 1 | | | | | | | | | | | | | 3 | 15 |
| Pipe Slope (%) | 0-0.5 | 25+ | 15-25 | 0.5-2 | 2-15 | | | | | | | | | | | | | - | - |
| **Pipe Slope Score** | 5 | 4 | 3 | 2 | 1 | | | | | | | | | | | | | 1 | 5 |
| **Max Asset Attribute Score** | | | | | | | | | | | | | | | | | | | **90** |

## Performance Parameters

| Name | Performance Parameters/Scoring | | | | | | | | | | | | | | | | | Category Factor | Maximum Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pipe Function Attributes | Interceptor | Main | Forcemain | Service Lateral | | | | | | | | | | | | | | - | - |
| **Pipe Function Score** | 5 | 4 | 3 | 2 | | | | | | | | | | | | | | 2 | 10 |
| Infiltration and Inflow | None | Minor | Medium | Major | | | | | | | | | | | | | | - | - |
| **Infiltration and Inflow Score** | 1 | 3 | 4 | 5 | | | | | | | | | | | | | | 4 | 20 |
| Flow Velocity Range (ft/s) | 0-2 | 2-4 | 4-7 | 7-10 | > 10 | | | | | | | | | | | | | - | - |
| **Flow Velocity Score** | 1 | 2 | 3 | 4 | 5 | | | | | | | | | | | | | 2 | 10 |
| SSO Risk (ft) | 0-3 | 3-5 | 5-10 | 10+ | | | | | | | | | | | | | | - | - |
| **SSO Risk Score** | 5 | 3 | 2 | 1 | | | | | | | | | | | | | | 3 | 15 |
| SSO/Backups | 2+ | 1 | 0 | | | | | | | | | | | | | | | - | - |
| **SSO/Backups Score** | 5 | 4 | 1 | | | | | | | | | | | | | | | 4 | 20 |
| Blockages/Accumulation | 2+ | 1 | 0 | | | | | | | | | | | | | | | - | - |
| **Blockages/Accumulation Score** | 5 | 4 | 1 | | | | | | | | | | | | | | | 3 | 15 |
| Criticality Range (inches x gpm) | 0-100 | 100-1000 | 1000-10000 | 10000-50000 | 50000+ | | | | | | | | | | | | | - | - |
| **Main Criticality Score** | 1 | 2 | 3 | 4 | 5 | | | | | | | | | | | | | 3 | 15 |
| Critical Facility Types | Frontier Refinery | Hospitals | Schools | Warren AFB | SCWSD | | | | | | | | | | | | | - | - |
| **Critical Facility Score** | 5 | 3 | 2 | 2 | 2 | | | | | | | | | | | | | 2 | 10 |
| Number of Main Defects | > 3 | 3 | 2 | 1 | 0 | | | | | | | | | | | | | - | - |
| **Main Defects Score** | 5 | 4 | 3 | 2 | 0 | | | | | | | | | | | | | 5 | 25 |
| Failure Impact | Interstate | Roadway | Bridge | Park | Wetland | Ditch | Stream | | | | | | | | | | | - | - |
| **Failure Impact Score** | 4 | 2 | 5 | 2 | 4 | 3 | 5 | | | | | | | | | | | 2 | 10 |
| **Max Performance Parameter Score** | | | | | | | | | | | | | | | | | | | **150** |
| **Total Max Score** | | | | | | | | | | | | | | | | | | | **240** |

## Collection System Assessment Method – Data Structure Schematic



# Appendix 7-C
# Preventative Maintenance
# Additional Information

- Example Performance Indicators for Wastewater Systems

# TEMPLATE FOR PERFORMANCE INDICATORS FOR WASTEWATER ASSETS

## Contents



## WASTEWATER COLLECTION SYSTEM ASSETS

| | | |
|---|---|---|
| PERFORMANCE INDICATOR: **Number of Collection System Complaints per Year** | | |
| Level 1 Asset: Wastewater Collection System | Tier 1 | Goal Area: Reliability |
| DEFINITION: Total number of customer complaints received at the customer service center/collection system/public works yard. Include all complaints related to collection system (e.g., odor, sewer backups, overflows, and other collection system related issues). | | |
| USE: This performance indicator is a specific measure of customer satisfaction with the quality of wastewater services received from the service provider. | | |
| ASSUMPTIONS/CHALLENGES: It is important to log all customer complaints and make a distinction between collection system service quality and other complaints. An added benefit would be to make a distinction between collection system complaints related to odor, sewer backups, or overflows. A complaint requires followup action and should not include general inquiries. | | |
| CALCULATION:<br><br>Total number of customer complaints on collection system per year<br><br>Data needed: Total number of collection system complaints. | | |
| RELATED INDICATORS: Number of overflows per year, number of odor complaints. | | |
| REPORTED VALUES IN INDUSTRY: The desired indicator value is zero per year. | | |

| PERFORMANCE INDICATOR: **Number of Collection System Overflows per 100 Miles per Year** | | |
|---|---|---|
| Level 1 Asset: Wastewater Collection System | Tier 1 | Goal Area: Adequacy |
| DEFINITION: Total number of overflows per 100 miles in the collection system. | | |
| USE: This performance indicator is a measure of collection system integrity and conditions. Can be used to prioritize and plan sewer inspection and rehabilitation. | | |
| ASSUMPTIONS/CHALLENGES: Some overflows may not be detected or reported (e.g., leaking sewer pipes underground). The duration and amount of overflow are not straightforward to capture. | | |
| CALCULATION: $\frac{\text{Total number of collection system overflows}}{\text{100 miles per year}}$ Data needed: Total number of overflows, total length of the collection system in miles. Can be calculated for the system as a whole, or can be measured by each major asset group. | | |
| RELATED INDICATORS: Number of collection system complaints per year, number of odor complaints. | | |
| REPORTED VALUES IN INDUSTRY: None provided. | | |

| PERFORMANCE INDICATOR: **Moratorium in Effect Due to Collection System per Year** | | |
|---|---|---|
| Level 1 Asset: Wastewater Collection System | Tier 1 | Goal Area: Reliability |
| DEFINITION: Extent and duration of moratorium due to collection system issues per year. | | |
| USE: This performance indicator is a specific measure of reliability of wastewater services to customer, condition of the collection system, and adequacy of operations and maintenance in the collection system. | | |
| ASSUMPTIONS/CHALLENGES: A moratorium tends to be in place for an extended time, so the measure would be the duration of a year (could be all year) and, in a few cases, the extent of the moratorium (generally system-wide). | | |
| CALCULATION: % of systems in moratorium due to collection system issues per year. Data needed: Number of systems for each moratorium. Can be calculated for the system as a whole, or can be measured by each major asset group. | | |
| RELATED INDICATORS: Total number of collection system complaints per year, and total number of overflows per year. | | |
| REPORTED VALUES IN INDUSTRY: The desired indicator value is zero moratoriums with zero hours of moratorium per year. The acceptable values will vary from system to system. | | |

| PERFORMANCE INDICATOR: **Time to Repair Collapse in Hours per Year** | | |
|---|---|---|
| Level 1 Asset: Wastewater Collection System | Tier 1 | Goal Area: Reliability |
| DEFINITION: Total hours spent to repair collapses per year. | | |
| USE: This performance indicator is a specific measure of collection system integrity and conditions. | | |
| ASSUMPTIONS/CHALLENGES: The data needed for this performance indicator requires a well-defined work order (WO) including emergency (unplanned) WO. | | |
| CALCULATION:<br><br>Number of hours to repair collapses per year<br><br>Data needed: Hours to repair collapse. Can be calculated for the system as a whole, or can be measured by each major asset group. | | |
| RELATED INDICATORS: Total number of collection system complaints per year, total number of overflows per year, and total number of moratoriums due to collection system. | | |
| REPORTED VALUES IN INDUSTRY: None provided. | | |

| PERFORMANCE INDICATOR: **Percentage of Pipe System Inspected per Year** | | |
|---|---|---|
| Level 1 Asset: Wastewater Collection System | Tier 1 | Goal Area: Reliability |
| DEFINITION: Total length of pipe inspected as a percentage of the total length of pipe in the system per year. Inspection implies closed-circuit television or other similar examination of pipe. | | |
| USE: This performance indicator is a measure of the condition of the collection system and the adequacy of maintenance activity. | | |
| ASSUMPTIONS/CHALLENGES: Manholes inspection was excluded from the calculation. | | |
| CALCULATION:<br>$\frac{\text{Length of pipe inspected}}{\text{Total length of the system (\%) per year}}$<br>Data needed: Length of pipe inspected and total length of pipe in the system. | | |
| RELATED INDICATORS: Total number of collection system complaints per year, total number of overflows per year, and total number of moratoriums due to collection system. | | |
| REPORTED VALUES IN INDUSTRY: None provided. | | |

| PERFORMANCE INDICATOR: **Level of Infiltration/Inflow** | | |
|---|---|---|
| Level 1 Asset: Wastewater Collection System | Tier 1 | Goal Area: Adequacy |
| DEFINITION: The total inflow and infiltration flow as a percentage of the total flow of the system. | | |
| USE: This performance indicator is a measure of the integrity and condition of the collection system. | | |
| ASSUMPTIONS/CHALLENGES: Collection system flowmetering data are needed to quantify infiltration and inflow. | | |
| CALCULATION: $$\text{Level of infiltration and inflow} = \frac{\text{Infiltration and inflow (MGD) \%}}{\text{Total flow of the system (MGD)}}$$ Data needed: Dry weather flow, wet weather flow, rainfall, total flow. | | |
| RELATED INDICATORS: Total number of collection system complaints per year, total number of overflows per year, total number of moratoriums due to collection system, percentage of system inspected per year, total number of collection system complaints per year. | | |
| REPORTED VALUES IN INDUSTRY: None provided. | | |

| PERFORMANCE INDICATOR: **Number of Blockages per Year per Mile** | | |
|---|---|---|
| Level 1 Asset: Wastewater Collection System | Tier 1 | Goal Area: Adequacy |
| DEFINITION: Total number of blockages per year per mile. | | |
| USE: This performance indicator is a measure of the integrity and condition of the collection system. The cause of the blockages is useful information to identify the issues. | | |
| ASSUMPTIONS/CHALLENGES: It is assumed that all the blockages are identified and reported. Some blockages may not be able to be identified until an overflow or backup occurs upstream. | | |
| CALCULATION: $$\frac{\text{Total number of blockages per year}}{\text{Total length of pipes (miles)}}$$ Data needed: Total number of blockages, total length of the collection system; can be calculated for the system as a whole or can be measured by each major asset group. | | |
| RELATED INDICATORS: Number of collection system complaints per year, number of odor complaints, number of overflows per year, number of collapses per year. | | |
| REPORTED VALUES IN INDUSTRY: None provided. | | |

| PERFORMANCE INDICATOR: **Number of Collapses per Year per Mile** | | |
|---|---|---|
| Level 1 Asset: Wastewater Collection System | Tier 1 | Goal Area: Reliability |
| DEFINITION: Total number of collapses per year per mile. | | |
| USE: This performance indicator is a measure of the integrity and condition of the collection system. | | |
| ASSUMPTIONS/CHALLENGES: All the collapses are identified and reported, although some collapses may not be able to be detected until inspection is conducted for that area. | | |
| CALCULATION: $\frac{\text{Total number of collapses per year}}{\text{Total length of pipes (miles)}}$ Data needed: Total number of collapses, total length of the collection system; can be calculated for the system as a whole or can be measured by each major asset group. | | |
| RELATED INDICATORS: Number of collection system complaints per year, number of odor complaints, number of overflows per year, number of blockages per year. | | |
| REPORTED VALUES IN INDUSTRY: None provided. | | |

| PERFORMANCE INDICATOR: **Maintenance Cost per Mile per Year** | | |
|---|---|---|
| Level 1 Asset: Wastewater Collection System | Tier 2 | Goal Area: Efficiency |
| DEFINITION: The total maintenance cost per mile of pipe maintained per year. | | |
| USE: This performance indicator is a measure of the economic efficiency of the collection system. | | |
| ASSUMPTIONS/CHALLENGES: Depreciation is excluded from the total maintenance costs. | | |
| CALCULATION: $\text{O\&M cost per MG processed} = \frac{\text{Total maintenance costs}}{\text{Length of pipe maintained during reporting period (miles)}}$ Data needed: Length of pipe maintained and total maintenance cost. | | |
| RELATED INDICATORS: Total number of collection system complaints per year, total number of overflows per year, total number of moratoriums due to collection system, percentage of system inspected per year. | | |
| REPORTED VALUES IN INDUSTRY: None provided. | | |

## WASTEWATER TREATMENT ASSETS

| PERFORMANCE INDICATOR: **Number of Exceedances per Year** | | |
|---|---|---|
| Level 1 Asset: Wastewater Treatment | Tier 1 | Goal Area: Efficiency |
| DEFINITION: Total number of exceedances per year. | | |
| USE: This performance indicator assesses the effectiveness of the treatment facility assets to meet regulatory requirements. This is one of the most critical parameters for a wastewater utility. Even when numbers are within acceptable limits, the values can suggest possible needs for treatment changes based on the raw wastewater characteristics. | | |
| ASSUMPTIONS/CHALLENGES: There are many parameters to measure and no effort is made here to weigh one more than another, although there may be merit in such an approach. Many parameters may never exceed the regulatory limits, and the focus will be on those that exceed or approach regulatory limits. There is no allowance for variations in raw wastewater characteristics that contribute to effluent quality issues. The goal is for the treatment process to adequately treat whatever raw wastewater characteristic is encountered. It is assumed that testing is done in a timely and comprehensive manner. | | |
| CALCULATION:<br><br>Sum of instances where a wastewater effluent quality parameter exceeds the discharge limit per year<br><br>Data needed: Results from compliance monitoring. | | |
| RELATED INDICATORS: Number of customer complaints per year. | | |
| REPORTED VALUES IN INDUSTRY: The target value for wastewater treatment would be zero exceedances for all parameters. Any exceedances would require immediate action on the part of the utility. | | |

| PERFORMANCE INDICATOR: **Number of Customer Complaints (Plant Operations) per Year** | | |
|---|---|---|
| Level 1 Asset: Wastewater Treatment | Tier 1 | Goal Area: Efficiency |
| DEFINITION: Total number of customer complaints received at the customer service center/plant/public works yard. Include all complaints related to effluent quality, spills, overflows, noise, odor, and all the other noneffluent quality issues. | | |
| USE: This performance indicator is a specific measure of customer satisfaction with the wastewater services received from the service provider. | | |
| ASSUMPTIONS/CHALLENGES: It is important to log all customer complaints. A complaint requires followup action and should not include general inquiries. | | |
| CALCULATION:<br><br>Total number of customer complaints per year<br><br>Data needed: Total number of customer complaints. | | |
| RELATED INDICATORS: Number of exceedances. | | |
| REPORTED VALUES IN INDUSTRY: The desired indicator value is zero per year. | | |

| PERFORMANCE INDICATOR: **Unit Cost of Treatment** | | |
|---|---|---|
| Level 1 Asset: Wastewater Treatment | Tier 2 | Goal Area: Efficiency |
| DEFINITION: The cost to treat raw wastewater from collection system to discharge the treated effluent. This would include operations and maintenance costs of treatment facilities including energy, chemical addition, pumping, piping, solids removal, controls, and monitoring associated with treating the wastewater and discharging the wastewater to receiving streams. | | |
| USE: This performance indicator assesses the cost to treat the wastewater and allows the utility to assess whether other treatment systems are more viable. | | |
| ASSUMPTIONS/CHALLENGES: The costs to treat the raw wastewater may not be clearly derived on a per-gallon basis, owing to how fixed costs for longstanding capital assets are attributed to costs. The cost to treat does not include the cost of the collection system to bring the wastewater to the treatment facility. | | |
| CALCULATION: For each treatment facility, $\frac{\text{Cost of treatment annually}}{\text{Million gallons treated effluent discharged (MG)}}$ Where: Cost of treatment = expenses to process and treat wastewater to produce treated effluent that meets regulatory requirements. Typically calculated on an annual basis.<br><br>Data needed: All costs associated with pumping, processing, and discharging of the treated effluent, including management of solids, facility permits, and monitoring of the processes. Total volume of wastewater treated. | | |
| RELATED INDICATORS: Cost per lab analysis. | | |
| REPORTED VALUES IN INDUSTRY: None provided. | | |

## RESIDUALS ASSETS

| PERFORMANCE INDICATOR: **Quality of Biosolids (Class A desired or class B)** | | |
|---|---|---|
| Level 1 Asset: Residuals | Tier 1 | Goal Area: Adequacy |
| DEFINITION: As defined in USEPA 40 CFR 503 regulations, Class A biosolids contain no detectible levels of pathogens. Class B biosolids are treated but still contain detectible levels of pathogens. Biosolids outside both classes are deemed of unsuitable quality. | | |
| USE: This performance indicator is a measure of biosolids quality in terms of pathogen reduction level. For Class B biosolids that are land applied, site restrictions are imposed to minimize the potential for human and animal contact with the biosolids for a period of time following land application until environmental factors have further reduced pathogens. No site restrictions are required with Class A biosolids. | | |
| ASSUMPTIONS/CHALLENGES: None. | | |
| CALCULATION:<br><br>Class A (fecal coliform < 1,000 MPN/g solids)<br>Class B (fecal coliform < 2,000,000 MPN/g solids)<br><br>Data needed: Biosolids pathogen level indicator (e.g., fecal coliform, *Salmonella*). | | |
| RELATED INDICATORS: Number of odor complaints per year, permit violations per year. | | |
| REPORTED VALUES IN INDUSTRY: None provided. | | |

| PERFORMANCE INDICATOR: **Permit Violations per Year** | | |
|---|---|---|
| Level 1 Asset: Residuals | Tier 1 | Goal Area: Adequacy |
| DEFINITION: On a parameter-by-parameter basis, the total number of violations of the regulated biosolids quality parameters. | | |
| USE: This performance indicator assesses the effectiveness of the sludge processing assets to meet regulatory requirements. This is one of the most critical parameters for a wastewater utility. Even when numbers are within acceptable limits, the values can suggest possible needs for treatment changes. | | |
| ASSUMPTIONS/CHALLENGES: There are many parameters to measure and no effort is made here to weigh one more than another, although there may be merit in such an approach. Many parameters may never exceed the regulatory limits, and the focus will be on those that exceed or approach regulatory limits. It is assumed that testing is done is a timely and comprehensive manner. | | |
| CALCULATION: For each treatment facility,<br><br>Sum of instances where a biosolids quality parameter is violated per year<br><br>Data needed: Results from compliance monitoring. | | |
| RELATED INDICATORS: None. | | |
| REPORTED VALUES IN INDUSTRY: The target value for biosolids management would be zero violations for all parameters. Any violation would require immediate action on the part of the utility. | | |

| PERFORMANCE INDICATOR: **Number of Odor Complaints per Year** | | |
|---|---|---|
| Level 1 Asset: Residuals | Tier 2 | Goal Area: Efficiency |
| DEFINITION: Total number of customer complaints related to odor issues received at the customer service center/plant/public works yard. | | |
| USE: This performance indicator is a measure of customer satisfaction with the quality of wastewater services received from the service provider. | | |
| ASSUMPTIONS/CHALLENGES: It is important to log all customer complaints and make a distinction between of the odors generated from biosolids and other sources of odors. | | |
| CALCULATION:<br><br>Total number of customer complaints about odors per year<br><br>Data needed: Total number of odor complaints. | | |
| RELATED INDICATORS: Quality of biosolids permit violations per year. | | |
| REPORTED VALUES IN INDUSTRY: The desired indicator value is zero per year. | | |

| PERFORMANCE INDICATOR: **Dry Ton Biosolids Produced Annually per Million Gallons of Wastewater Treated** | | |
|---|---|---|
| Level 1 Asset: Residuals | Tier 2 | Goal Area: Efficiency |
| DEFINITION: The total amount of biosolids produced per million gallons of wastewater treated. | | |
| USE: This indicator is a measure of efficiency of sludge production. | | |
| ASSUMPTIONS/CHALLENGES: The lower the value, the more likely that there is an inflow and infiltration issue. The wastewater strength (i.e., biochemical oxygen demand [BOD] or total suspended solids concentration) is not included in this indicator. | | |
| CALCULATION: For each treatment facility,<br>$\frac{\text{Total dry ton biosolids produced annually}}{\text{MG of wastewater treated}}$<br>Data needed: Total dry ton biosolids produced, and total volume of wastewater treated. | | |
| RELATED INDICATORS: Dry ton biosolids produced per ton BOD treated in raw wastewater. | | |
| REPORTED VALUES IN INDUSTRY: None provided. | | |

| PERFORMANCE INDICATOR: **Dry Ton Biosolids Produced per Ton Biochemical Oxygen Demand Treated in Raw Wastewater** | | |
|---|---|---|
| Level 1 Asset: Residuals | Tier 2 | Goal Area: Efficiency |
| DEFINITION: The total amount of biosolids produced per ton BOD (biochemical oxygen demand) treated in raw wastewater. | | |
| USE: This performance indicator is a measure of efficiency of sludge production. | | |
| ASSUMPTIONS/CHALLENGES: None. | | |
| CALCULATION: For each treatment facility, $\frac{\text{Total dry ton biosolids produced annually}}{\text{Total tons BOD treated}}$ Data needed: Total dry ton biosolids produced, and total tons BOD treated in raw wastewater. | | |
| RELATED INDICATORS: Dry tons produced per million gallons of wastewater treated. | | |
| REPORTED VALUES IN INDUSTRY: None provided. | | |

| PERFORMANCE INDICATOR: **Cost per Dry Ton Biosolids Disposed** | | |
|---|---|---|
| Level 1 Asset: Residuals | Tier 2 | Goal Area: Efficiency |
| DEFINITION: The cost of biosolids disposal per dry ton of solids disposed, including hauling costs. | | |
| USE: This performance indicator assesses the cost to dispose the biosolids and allows the utility to assess whether other disposal methods are more viable. | | |
| ASSUMPTIONS/CHALLENGES: The cost of biosolids disposal does not include the cost of sludge processing. | | |
| CALCULATION: For each treatment facility, $\frac{\text{Cost of biosolids disposal annually}}{\text{Dry ton biosolids disposed}}$ Data needed: Total dry ton biosolids disposed annually and total disposal cost. | | |
| RELATED INDICATORS: Cost per ton-mile, chemical cost per dry ton, power cost per dry ton, fuel cost per dry ton (incineration). | | |
| REPORTED VALUES IN INDUSTRY: None provided. | | |

| PERFORMANCE INDICATOR: **Chemical Cost per Dry Ton Biosolids Produced** | | |
|---|---|---|
| Level 1 Asset: Residuals | Tier 2 | Goal Area: Efficiency |
| DEFINITION: The cost of chemicals used per dry ton biosolids produced, including polymer cost and other chemicals used for sludge processing. | | |
| USE: This performance indicator allows the utility to assess the efficiency of the chemical use, and it allows the utility to assess whether other options are more viable. | | |
| ASSUMPTIONS/CHALLENGES: None. | | |
| CALCULATION: For each treatment facility, $\frac{\text{Cost of treatment annually}}{\text{Dry ton biosolids produced}}$ Data needed: Chemical cost associated with processing the sludge, and total dry ton biosolids produced. | | |
| RELATED INDICATORS: Disposal cost per dry ton, power cost per dry ton, fuel cost per dry ton (incineration), gas utilization credit. | | |
| REPORTED VALUES IN INDUSTRY: None provided. | | |

| PERFORMANCE INDICATOR: **Power Cost per Dry Ton Biosolids Produced** | | |
|---|---|---|
| Level 1 Asset: Residuals | Tier 2 | Goal Area: Efficiency |
| DEFINITION: The cost of power per dry ton biosolids produced. The cost does not include the cost of fuel, if used, for sludge processing. | | |
| USE: This performance indicator is a measure of the efficiency of the energy use for sludge processing. | | |
| ASSUMPTIONS/CHALLENGES: It is assumed that the data of power use for solids processing is available or can be estimated if there is no dedicated meter installed. | | |
| CALCULATION: For each treatment facility, $\frac{\text{Cost of power for sludge processing annually}}{\text{Dry ton biosolids produced}}$ Data needed: Power cost associated with processing the sludge and total dry ton biosolids produced. | | |
| RELATED INDICATORS: Disposal cost per dry ton, chemical cost per dry ton, fuel cost per dry ton (incineration), gas utilization credit. | | |
| REPORTED VALUES IN INDUSTRY: None provided. | | |

| PERFORMANCE INDICATOR: **Fuel Cost per Dry Ton Biosolids Produced** | | |
|---|---|---|
| Level 1 Asset: Residuals | Tier 2 | Goal Area: Efficiency |
| DEFINITION: The cost of fuel used in sludge incineration process per dry ton biosolids produced. | | |
| USE: This performance indicator is a measure of the efficiency of the fuel used for sludge incineration. | | |
| ASSUMPTIONS/CHALLENGES: None. | | |
| CALCULATION: For each treatment facility, $$\frac{\text{Cost of fuel for sludge incineration annually}}{\text{Dry ton biosolids produced}}$$ Data needed: Fuel cost associated with sludge incineration and total dry ton biosolids produced. | | |
| RELATED INDICATORS: Disposal cost per dry ton, chemical cost per dry ton, power cost per dry ton, gas utilization credit. | | |
| REPORTED VALUES IN INDUSTRY: None provided. | | |

| PERFORMANCE INDICATOR: **Gas Utilization Credit in SCF/MG (standard cubic feet per million gallons)** | | |
|---|---|---|
| Level 1 Asset: Residuals | Tier 2 | Goal Area: Efficiency |
| DEFINITION: The volume of biogas produced per million gallons of wastewater treated in an anaerobic digestion process. | | |
| USE: This performance indicator is a measure of the efficiency of the anaerobic digestion process in terms of the biogas production. | | |
| ASSUMPTIONS/CHALLENGES: It is assumed that all the biogas produced is captured and measured. | | |
| CALCULATION: For each treatment facility, $$\frac{\text{Total volume of biogas produced annually (SCF)}}{\text{MG of wastewater treated}}$$ Data needed: Total volume of biogas produced and total volume of wastewater treated. | | |
| RELATED INDICATORS: None. | | |
| REPORTED VALUES IN INDUSTRY: None provided. | | |

# Appendix 7-D
# Pipeline Capital Improvement Projects
# Cost Estimates

**REVISED** **9/20/13**

## Collection System Near-term Projects

| Item Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **South Cheyenne Sewer Collection Main - Phase 1** | | | | |
| Sewer Main | | | | |
| 42-inch FRP Pipe including installation | 6,000 | LF | 375.00 | $2,250,000 |
| 36-inch FRP Pipe including installation | 12,210 | LF | 350.00 | $4,273,500 |
| **SUBTOTAL** | | | | **$6,523,500** |

| | | | | |
|---|---|---|---|---|
| **GENERAL REQUIREMENTS** | | | | |
| Mobilization, Bonds and Insurance (15% of subtotal) | | LS | | $978,500 |
| Contractor Overhead & Profit (12% of subtotal) | | LS | | $782,800 |
| **Construction Subtotal** | | **LS** | | **$8,284,800** |
| Year of Construction | 2015 | YR | | |
| Escalation Rate | 3.5% | % | | |
| Escalation Costs (year of construction - 2013) | | LS | | $579,900 |
| Administrative and Easement Costs (5% of construction subtotal) | | LS | | $414,200 |
| Engineering (12% of construction subtotal) | | LS | | $994,200 |
| Design Contigency (30% of construction subtotal) | | LS | | $2,485,400 |
| **South Cheyenne Sewer Collection Main - Phase 1** | | | | **$12,759,000** |

| Item Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **South Cheyenne Sewer Collection Main - Phase 2** | | | | |
| Sewer Main | | | | |
| 36-inch FRP Pipe including installation | 6,048 | LF | 350.00 | $2,116,800 |
| 27-inch PVC Pipe including installation | 5,120 | LF | 300.00 | $1,536,000 |
| 18-inch PVC Pipe including installation | 4,000 | LF | 195.00 | $780,000 |
| **SUBTOTAL** | | | | **$4,432,800** |

| | | | | |
|---|---|---|---|---|
| **GENERAL REQUIREMENTS** | | | | |
| Mobilization, Bonds and Insurance (15% of subtotal) | | LS | | $664,900 |
| Contractor Overhead & Profit (12% of subtotal) | | LS | | $531,900 |
| **Construction Subtotal** | | **LS** | | **$5,629,600** |
| Year of Construction | 2018 | YR | | |
| Escalation Rate | 3.5% | % | | |
| Escalation Costs (year of construction - 2013) | | LS | | $985,200 |
| Administrative and Easement Costs (5% of construction subtotal) | | LS | | $281,500 |
| Engineering (12% of construction subtotal) | | LS | | $675,600 |
| Design Contigency (30% of construction subtotal) | | LS | | $1,688,900 |
| **Total South Cheyenne Sewer Collection Main - Phase 2** | | | | **$9,261,000** |

| Item Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **Southern Sewer Main Extensions by 2023** | | | | |
| Sewer Main | | | | |
| 15-inch PVC Pipe including installation | 6,400 | LF | 170.00 | $1,088,000 |
| 12-inch PVC Pipe including installation | 10,600 | LF | 155.00 | $1,643,000 |
| 8-inch PVC Pipe including installation | 9,350 | LF | 140.00 | $1,309,000 |
| **SUBTOTAL** | | | | **$4,040,000** |

| | | | | |
|---|---|---|---|---|
| **GENERAL REQUIREMENTS** | | | | |
| Mobilization, Bonds and Insurance (15% of subtotal) | | LS | | $606,000 |
| Contractor Overhead & Profit (12% of subtotal) | | LS | | $484,800 |
| **Construction Subtotal** | | **LS** | | **$5,130,800** |
| Year of Construction | 2020 | YR | | |
| Escalation Rate | 3.5% | % | | |
| Escalation Costs (year of construction - 2013) | | LS | | $1,257,000 |
| Administrative and Easement Costs (5% of construction subtotal) | | LS | | $256,500 |
| Engineering (12% of construction subtotal) | | LS | | $615,700 |
| Design Contigency (30% of construction subtotal) | | LS | | $1,539,200 |
| **Total Southern Sewer Main Extensions by 2023** | | | | **$8,799,000** |

| Item Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **Southern Sewer Interceptor Extensions by 2033** | | | | |
| Sewer Main | | | | |
| 21-inch PVC Pipe including installation | 5,370 | LF | 210.00 | $1,127,700 |
| 18-inch PVC Pipe including installation | 17,320 | LF | 195.00 | $3,377,400 |
| **SUBTOTAL** | | | | **$4,505,100** |

| | | | | |
|---|---|---|---|---|
| **GENERAL REQUIREMENTS** | | | | |
| Mobilization, Bonds and Insurance (15% of subtotal) | | LS | | $675,800 |
| Contractor Overhead & Profit (12% of subtotal) | | LS | | $540,600 |
| **Construction Subtotal** | | **LS** | | **$5,721,500** |
| Year of Construction | 2028 | YR | | |
| Escalation Rate | 3.5% | % | | |
| Escalation Costs (year of construction - 2013) | | LS | | $3,003,800 |
| Administrative and Easement Costs (5% of construction subtotal) | | LS | | $286,100 |
| Engineering (12% of construction subtotal) | | LS | | $686,600 |
| Design Contigency (30% of construction subtotal) | | LS | | $1,716,500 |
| **Total Southern Sewer Inteceptor Extensions by 2033** | | | | **$11,415,000** |

| Item Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **Southern Sewer Main Extensions by 2033** | | | | |
| Sewer Main | | | | |
| 15-inch PVC Pipe including installation | 16,000 | LF | 170.00 | $2,720,000 |
| 12-inch PVC Pipe including installation | 22,560 | LF | 155.00 | $3,496,800 |
| 8-inch PVC Pipe including installation | 13,370 | LF | 140.00 | $1,871,800 |
| **SUBTOTAL** | | | | **$8,088,600** |

| | | | | |
|---|---|---|---|---|
| **GENERAL REQUIREMENTS** | | | | |
| Mobilization, Bonds and Insurance (15% of subtotal) | | LS | | $1,213,300 |
| Contractor Overhead & Profit (12% of subtotal) | | LS | | $970,600 |
| **Construction Subtotal** | | **LS** | | **$10,272,500** |
| Year of Construction | 2028 | YR | | |
| Escalation Rate | 3.5% | % | | |
| Escalation Costs (year of construction - 2013) | | LS | | $5,393,100 |
| Administrative and Easement Costs (5% of construction subtotal) | | LS | | $513,600 |
| Engineering (12% of construction subtotal) | | LS | | $1,232,700 |
| Design Contigency (30% of construction subtotal) | | LS | | $3,081,800 |
| **Total Southern Sewer Main Extensions by 2033** | | | | **$20,494,000** |

| Item Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **Northern Sewer Main Extensions by 2033** | | | | |
| Sewer Main | | | | |
| 18-inch PVC Pipe including installation | 240 | LF | 195.00 | $46,800 |
| 15-inch PVC Pipe including installation | 3,240 | LF | 170.00 | $550,800 |
| 12-inch PVC Pipe including installation | 1,690 | LF | 155.00 | $261,950 |
| 8-inch PVC Pipe including installation | 1,020 | LF | 140.00 | $142,800 |
| **SUBTOTAL** | | | | **$1,002,350** |

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| **GENERAL REQUIREMENTS** | | | | |
| Mobilization, Bonds and Insurance (15% of subtotal) | | LS | | $150,400 |
| Contractor Overhead & Profit (12% of subtotal) | | LS | | $120,300 |
| **Construction Subtotal** | | **LS** | | **$1,273,100** |
| Year of Construction | 2023 | YR | | |
| Escalation Rate | 3.5% | % | | |
| Escalation Costs (year of construction - 2013) | | LS | | $445,600 |
| Administrative and Easement Costs (5% of construction subtotal) | | LS | | $63,700 |
| Engineering (12% of construction subtotal) | | LS | | $152,800 |
| Design Contigency (30% of construction subtotal) | | LS | | $381,900 |
| **Total Northern Sewer Main Extensions by 2033** | | | | **$2,317,000** |

| Item Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **Dry Creek North Near-term Replacement 1** | | | | |
| Sewer main | | | | |
| 18-inch PVC Pipe including installation | 1,675 | LF | 195.00 | $326,625 |
| 12-inch PVC Pipe including installation | 510 | LF | 155.00 | $79,050 |
| **SUBTOTAL** | | | | **$405,675** |

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| **GENERAL REQUIREMENTS** | | | | |
| Mobilization, Bonds and Insurance (15% of subtotal) | | LS | | $60,900 |
| Contractor Overhead & Profit (12% of subtotal) | | LS | | $48,700 |
| **Construction Subtotal** | | **LS** | | **$515,300** |
| Year of Construction | 2017 | YR | | |
| Escalation Rate | 3.5% | % | | |
| Escalation Costs (year of construction - 2013) | | LS | | $72,100 |
| Administrative and Easement Costs (5% of construction subtotal) | | LS | | $25,800 |
| Engineering (12% of construction subtotal) | | LS | | $61,800 |
| Design Contigency (30% of construction subtotal) | | LS | | $154,600 |
| **Total Dry Creek North Near-term Replacement 1** | | | | **$830,000** |

| Item Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **Dry Creek north Near-term Replacement 2** | | | | |
| Sewer Main | | | | |
| 18-inch PVC Pipe including installation | 751 | LF | 195.00 | $146,445 |
| 12-inch PVC Pipe including installation | 3,146 | LF | 155.00 | $487,630 |
| **SUBTOTAL** | | | | **$634,075** |

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| **GENERAL REQUIREMENTS** | | | | |
| Mobilization, Bonds and Insurance (15% of subtotal) | | LS | | $95,100 |
| Contractor Overhead & Profit (12% of subtotal) | | LS | | $76,100 |
| **Construction Subtotal** | | **LS** | | **$805,300** |
| Year of Construction | 2018 | YR | | |
| Escalation Rate | 3.5% | % | | |
| Escalation Costs (year of construction - 2013) | | LS | | $140,900 |
| Administrative and Easement Costs (5% of construction subtotal) | | LS | | $40,300 |
| Engineering (12% of construction subtotal) | | LS | | $96,600 |
| Design Contigency (30% of construction subtotal) | | LS | | $241,600 |
| **Total Dry Creek north Near-term Replacement 2** | | | | **$1,325,000** |

**REVISED** **9/20/13**

| Item Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **Dry Creek South Near-term Replacement 1** | | | | |
| Sewer Main | | | | |
| 15-inch PVC Pipe including installation | 300 | LF | 170.00 | $51,000 |
| 12-inch PVC Pipe including installation | 4,238 | LF | 155.00 | $656,890 |
| **SUBTOTAL** | | | | **$707,890** |

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| **GENERAL REQUIREMENTS** | | | | |
| Mobilization, Bonds and Insurance (15% of subtotal) | | LS | | $106,200 |
| Contractor Overhead & Profit (12% of subtotal) | | LS | | $84,900 |
| **Construction Subtotal** | | **LS** | | **$899,000** |
| Year of Construction | 2019 | YR | | |
| Escalation Rate | 3.5% | % | | |
| Escalation Costs (year of construction - 2013) | | LS | | $188,800 |
| Administrative and Easement Costs (5% of construction subtotal) | | LS | | $45,000 |
| Engineering (12% of construction subtotal) | | LS | | $107,900 |
| Design Contigency (30% of construction subtotal) | | LS | | $269,700 |
| **Total Dry Creek South Near-term Replacement 1** | | | | **$1,510,000** |

| Item Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **Dry Creek South Near-term Replacement 2** | | | | |
| Sewer Main | | | | |
| 48-inch FRP Pipe including installation | 1,110 | LF | 400.00 | $444,000 |
| 42-inch FRP Pipe including installation | 725 | LF | 375.00 | $271,875 |
| 36-inch FRP Pipe including installation | 394 | LF | 350.00 | $137,900 |
| **SUBTOTAL** | | | | **$853,775** |

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| **GENERAL REQUIREMENTS** | | | | |
| Mobilization, Bonds and Insurance (15% of subtotal) | | LS | | $128,100 |
| Contractor Overhead & Profit (12% of subtotal) | | LS | | $102,500 |
| **Construction Subtotal** | | **LS** | | **$1,084,400** |
| Year of Construction | 2020 | YR | | |
| Escalation Rate | 3.5% | % | | |
| Escalation Costs (year of construction - 2013) | | LS | | $265,700 |
| Administrative and Easement Costs (5% of construction subtotal) | | LS | | $54,200 |
| Engineering (12% of construction subtotal) | | LS | | $130,100 |
| Design Contigency (30% of construction subtotal) | | LS | | $325,300 |
| **Total Dry Creek South Near-term Replacement 2** | | | | **$1,860,000** |

| Item Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **Lincolnway Near-term Replacement 1** | | | | |
| Sewer Main | | | | |
| 27-inch PVC Pipe including installation | 2,740 | LF | 300.00 | $822,000 |
| **SUBTOTAL** | | | | **$822,000** |

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| **GENERAL REQUIREMENTS** | | | | |
| Mobilization, Bonds and Insurance (15% of subtotal) | | LS | | $123,300 |
| Contractor Overhead & Profit (12% of subtotal) | | LS | | $98,600 |
| **Construction Subtotal** | | **LS** | | **$1,043,900** |
| Year of Construction | 2021 | YR | | |
| Escalation Rate | 3.5% | % | | |
| Escalation Costs (year of construction - 2013) | | LS | | $292,300 |
| Administrative and Easement Costs (5% of construction subtotal) | | LS | | $52,200 |
| Engineering (12% of construction subtotal) | | LS | | $125,300 |
| Design Contigency (30% of construction subtotal) | | LS | | $313,200 |
| **Total Lincolnway Near-term Replacement 1** | | | | **$1,827,000** |

**REVISED** **9/20/13**

| Item Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **Henderson Near-term Replacement 1** | | | | |
| Sewer Main | | | | |
| 15-inch PVC Pipe including installation | 1,945 | LF | 170.00 | $330,650 |
| **SUBTOTAL** | | | | **$330,650** |

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| **GENERAL REQUIREMENTS** | | | | |
| Mobilization, Bonds and Insurance (15% of subtotal) | | LS | | $49,600 |
| Contractor Overhead & Profit (12% of subtotal) | | LS | | $39,700 |
| **Construction Subtotal** | | **LS** | | **$420,000** |
| Year of Construction | 2022 | YR | | |
| Escalation Rate | 3.5% | % | | |
| Escalation Costs (year of construction - 2013) | | LS | | $132,300 |
| Administrative and Easement Costs (5% of construction subtotal) | | LS | | $21,000 |
| Engineering (12% of construction subtotal) | | LS | | $50,400 |
| Design Contigency (30% of construction subtotal) | | LS | | $126,000 |
| **Total Henderson Near-term Replacement 1** | | | | **$750,000** |

| Item Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **Dry Creek North Mid-term Replacement 1** | | | | |
| Sewer Main | | | | |
| 12-inch PVC Pipe including installation | 1,730 | LF | 155.00 | $268,150 |
| **SUBTOTAL** | | | | **$268,150** |

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|---|---|---|---|---|
| **GENERAL REQUIREMENTS** | | | | |
| Mobilization, Bonds and Insurance (15% of subtotal) | | LS | | $40,200 |
| Contractor Overhead & Profit (12% of subtotal) | | LS | | $32,200 |
| **Construction Subtotal** | | **LS** | | **$340,600** |
| Year of Construction | 2028 | YR | | |
| Escalation Rate | 3.5% | % | | |
| Escalation Costs (year of construction - 2013) | | LS | | $178,800 |
| Administrative and Easement Costs (5% of construction subtotal) | | LS | | $17,000 |
| Engineering (12% of construction subtotal) | | LS | | $40,900 |
| Design Contigency (30% of construction subtotal) | | LS | | $102,200 |
| **Total Dry Creek North Mid-term Replacement 1** | | | | **$680,000** |

**REVISED** **9/20/13**

| Item Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **Dry Creek South Mid-term Replacement 1** | | | | |
| Sewer Main | | | | |
| 15-inch PVC Pipe including installation | 3,815 | LF | 170.00 | $648,550 |
| 12-inch PVC Pipe including installation | 2,670 | LF | 155.00 | $413,850 |
| **SUBTOTAL** | | | | **$1,062,400** |
| **GENERAL REQUIREMENTS** | | | | |
| Mobilization, Bonds and Insurance (15% of subtotal) | | LS | | $159,400 |
| Contractor Overhead & Profit (12% of subtotal) | | LS | | $127,500 |
| **Construction Subtotal** | | **LS** | | **$1,349,300** |
| Year of Construction | 2028 | YR | | |
| Escalation Rate | 3.5% | % | | |
| Escalation Costs (year of construction - 2013) | | LS | | $708,400 |
| Administrative and Easement Costs (5% of construction subtotal) | | LS | | $67,500 |
| Engineering (12% of construction subtotal) | | LS | | $161,900 |
| Design Contigency (30% of construction subtotal) | | LS | | $404,800 |
| **Total Dry Creek South Mid-term Replacement 1** | | | | **$2,692,000** |

| Item Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **Dry Creek South Mid-term Replacement 2** | | | | |
| Sewer Main | | | | |
| 36-inch FRP Pipe including installation | 2,500 | LF | 350.00 | $875,000 |
| **SUBTOTAL** | | | | **$875,000** |
| **GENERAL REQUIREMENTS** | | | | |
| Mobilization, Bonds and Insurance (15% of subtotal) | | LS | | $131,300 |
| Contractor Overhead & Profit (12% of subtotal) | | LS | | $105,000 |
| **Construction Subtotal** | | **LS** | | **$1,111,300** |
| Year of Construction | 2028 | YR | | |
| Escalation Rate | 3.5% | % | | |
| Escalation Costs (year of construction - 2013) | | LS | | $583,400 |
| Administrative and Easement Costs (5% of construction subtotal) | | LS | | $55,600 |
| Engineering (12% of construction subtotal) | | LS | | $133,400 |
| Design Contigency (30% of construction subtotal) | | LS | | $333,400 |
| **Total Dry Creek South Mid-term Replacement 2** | | | | **$2,217,000** |

| Item Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **Dry Creek South Mid-term Replacement 3** | | | | |
| Sewer Main | | | | |
| 60-inch FRP Pipe including installation | 2,500 | LF | 450.00 | $1,125,000 |
| 48-inch FRP Pipe including installation | 2,500 | LF | 400.00 | $1,000,000 |
| **SUBTOTAL** | | | | **$2,125,000** |

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|---|---|---|---|---|
| **GENERAL REQUIREMENTS** | | | | |
| Mobilization, Bonds and Insurance (15% of subtotal) | | LS | | $318,800 |
| Contractor Overhead & Profit (12% of subtotal) | | LS | | $255,000 |
| **Construction Subtotal** | | **LS** | | **$2,698,800** |
| Year of Construction | 2028 | YR | | |
| Escalation Rate | 3.5% | % | | |
| Escalation Costs (year of construction - 2013) | | LS | | $1,416,900 |
| Administrative and Easement Costs (5% of construction subtotal) | | LS | | $134,900 |
| Engineering (12% of construction subtotal) | | LS | | $323,900 |
| Design Contigency (30% of construction subtotal) | | LS | | $809,600 |
| **Total Dry Creek South Mid-term Replacement 3** | | | | **$5,384,000** |

| Item Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **Holliday Mid-term Replacement 1** | | | | |
| Sewer Main | | | | |
| 42-inch FRP Pipe including installation | 8,180 | LF | 375.00 | $3,067,500 |
| **SUBTOTAL** | | | | **$3,067,500** |

| | | | | |
|---|---|---|---|---|
| **GENERAL REQUIREMENTS** | | | | |
| Mobilization, Bonds and Insurance (15% of subtotal) | | LS | | $460,100 |
| Contractor Overhead & Profit (12% of subtotal) | | LS | | $368,100 |
| **Construction Subtotal** | | **LS** | | **$3,895,700** |
| Year of Construction | 2028 | YR | | |
| Escalation Rate | 3.5% | % | | |
| Escalation Costs (year of construction - 2013) | | LS | | $2,045,200 |
| Administrative and Easement Costs (5% of construction subtotal) | | LS | | $194,800 |
| Engineering (12% of construction subtotal) | | LS | | $467,500 |
| Design Contigency (30% of construction subtotal) | | LS | | $1,168,700 |
| **Total Holliday Mid-term Replacement 1** | | | | **$7,772,000** |

| Item Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| **Capitol South Mid-term Replacement 1** | | | | |
| Sewer Main | | | | |
| 12-inch PVC Pipe including installation | 4,560 | LF | 155.00 | $706,800 |
| **SUBTOTAL** | | | | **$706,800** |

| | | | | |
|---|---|---|---|---|
| **GENERAL REQUIREMENTS** | | | | |
| Mobilization, Bonds and Insurance (15% of subtotal) | | LS | | $106,000 |
| Contractor Overhead & Profit (12% of subtotal) | | LS | | $84,800 |
| **Construction Subtotal** | | **LS** | | **$897,600** |
| Year of Construction | 2028 | YR | | |
| Escalation Rate | 3.5% | % | | |
| Escalation Costs (year of construction - 2013) | | LS | | $471,200 |
| Administrative and Easement Costs (5% of construction subtotal) | | LS | | $44,900 |
| Engineering (12% of construction subtotal) | | LS | | $107,700 |
| Design Contigency (30% of construction subtotal) | | LS | | $269,300 |
| **Total Capitol South Mid-term Replacement 1** | | | | **$1,791,000** |