CHAPTER 5

EXISTING COLLECTION SYSTEM EVALUATION

5.1. INTRODUCTION

The City of Helena wastewater collection system is comprised of approximately 3,000 manholes, approximately 154-miles of gravity sewer mains, and 10 lift stations with associated wet wells, pumps, and force mains. All wastewater is conveyed to the City of Helena Wastewater Treatment Facility (WWTF). This chapter provides an overview of the existing collection system, describes the hydraulic model developed for the City, and provides an evaluation of the existing collection system.

5.2. WASTEWATER COLLECTION SYSTEM DESCRIPTION

The primary objective of this section is to describe the existing collection facilities that were incorporated into the hydraulic model for analysis and evaluation. Figure 5-1 provides an overview of the existing City of Helena wastewater collection system, and shows all of the major system components.

5.2.1. *Gravity System*

To provide a comprehensive method of collection main modeling and evaluation, the existing gravity sewer system was broken into two classes as follows:

- Collectors / Laterals
- Trunks

Collector and lateral mains make up the smallest diameter mains in the system. These mains are designed to collect wastewater from residential, commercial, and industrial services. In the Helena system, collector and lateral mains are typically 8-inches in diameter which is the minimum main size required by the Montana Department of Environmental Quality. However, the City's system also contains 6-inch diameter pipes which were installed prior to the establishment of DEQ2 requirements. Collector and lateral mains account for approximately 74 percent of the City's total collection system footage.

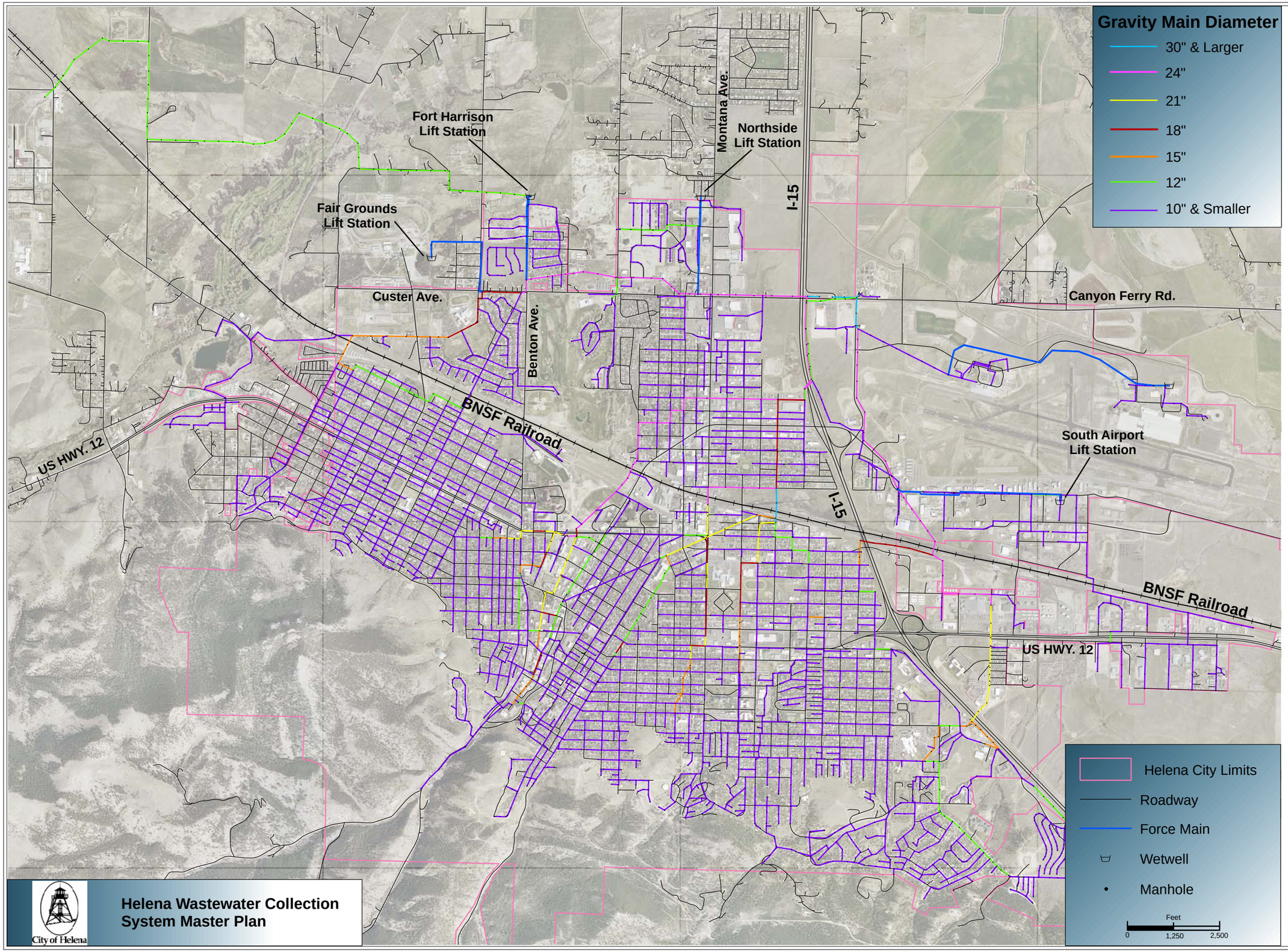

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Figure 5-1
Existing Wastewater Collection System
Helena Wastewater Collection System Master Plan

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For the purposes of this report, trunk mains are classified as pipes with diameters 10-inches and larger. The City's largest diameter trunk main is 30-inches. The primary purpose of trunk mains is to intercept wastewater flows from collectors and laterals, but can also collect additional individual service flows when collectors and laterals are not within close proximity to users. Trunk mains account for approximately 26 percent of the total collection system footage.

Larger diameter mains (24-inches and larger) are often classified as interceptor mains. These mains intercept and accumulate wastewater flows from a large drainage basin. They are typically fed by trunk mains or other interceptors. In the Helena collection system, there is only one true interceptor main, although there are several mains with a diameter of 24-inches or greater. The WWTF interceptor is a 42-inch diameter line located at the WWTF and conveys flow from the Washington Street and Custer Avenue trunk mains. The remainder of the large diameter mains in the collection system are more accurately classified as trunk mains because they collect and convey wastewater from laterals and some individual services.

The City of Helena collection system has seven major trunk mains. Table 5-1 summarizes the characteristics of these trunk mains, which are described in the following paragraphs.

All four of the described trunk mains eventually discharge to the wastewater treatment plant interceptor. The diameter of the interceptor is 42-inches and originates at the intersection of Custer Avenue and Washington Street. The length of the Interceptor is approximately 170-feet long and discharges directly to the Helena WWTF headworks. The maximum capacity of the interceptor is estimated to be 70-mgd.

- **Washington Street Trunk Main.** This trunk main follows an alignment similar to that of Washington Street. It drains the Eastside basin and primarily serves areas east of Interstate 15. However, the Washington Street trunk main shares a flow split in an upstream basin of the Home Depot 12-inch (HD-12) trunk main. The flow split is located at the intersection of E. Broadway Street and Saddle Drive, and contributes a small portion of flow originating west of the interstate. At the discharge to the wastewater treatment plant interceptor, the diameter of the trunk is 24-inches. This trunk main typically accounts for approximately 23 percent of the total wastewater flow to the treatment facility.

- **Home Depot 24-inch Trunk Main (HD-24).** Located adjacent to the east side of Interstate 15, this trunk main is named for its proximity to Home Depot. For a portion of its alignment the trunk parallels the HD-12 trunk main. The HD-24 trunk crosses the interstate near Cole Avenue, and follows an alignment upstream along Cedar Street and Last Chance Gulch. It drains the Central/West basin and primarily serves the Last Chance Gulch and downtown areas. At the discharge to the Custer Avenue trunk main, the diameter is 24-inches. This trunk main typically accounts for approximately 22 percent of the total wastewater flow to the treatment facility.

- **Home Depot 12-inch Trunk Main (HD-12).** As previously mentioned, the downstream alignment of this trunk main parallels the HD-24 trunk main. It also

crosses Interstate 15 near Cole Avenue, but then follows an alignment upstream to Harris Street. The HD-12 trunk main drains the Central/East basin and primarily serves the area between Last Chance Gulch and Interstate 15. At the discharge to the wastewater treatment plant interceptor, the diameter of the trunk is 12-inches. This trunk main accounts for approximately 29 percent of the total wastewater flow to the treatment facility.

Table 5-1
Summary of Trunk Main Characteristics

Trunk Main	Size (in)	Length (ft)	Capacity (MGD)	Avg. Slope (ft/ft)	Year Installed	Avg. Manning	Contributing Drainage Basin
WWTF Interceptor	42	170	70	0.0114	1960	0.013	All
Washington Street	30 24 21 18 15 12 10	488 10,388 3,639 2,003 1,984 3,713 3,926	16.84 21.82 19.43 7.32 9.25 4.61 1.44	0.0025 0.0138 0.0223 0.0072 0.0304 0.0248 0.0064	1950- 2004	0.011	Eastside
Home Depot 24-Inch	24 21 18 15 12 10	10,608 4,679 2,322 3,117 3,540 2,092	18.60 15.22 10.22 7.54 5.05 2.57	0.0140 0.0191 0.0196 0.0282 0.0416 0.0286	1999- 1940	0.013	Central/West
Home Depot 12-Inch	30 24 21 18 15 12 10	1,385 3,879 7,337 5,512 5,236 16,099 24,694	40.81 17.36 15.45 10.06 7.46 4.24 2.50	0.0205 0.0122 0.0197 0.0190 0.0276 0.0293 0.0269	2004- 1940	0.013	Central/East
Custer Avenue	30 24 18 15 12 10	1,784 8,162 3,020 4,393 4,610 17,666	22.70 13.52 6.13 4.71 2.67 2.85	0.0054 0.0063 0.0060 0.0094 0.0099 0.0299	2005- 1950	0.012	Westside
Fort Harrison [1]	12	18,873	2.75	0.0073	1999- 1991	0.010	Westside
South Airport [2]	12 10	2,102 5,940	2.84 1.69	0.0078 0.0073	1995- 1970	0.010	Eastside
Northside [1]	12	3,071	2.77	0.0074	1997	0.010	Westside

[1] Force main discharges into the gravity main which conveys flow from lift station to Custer Avenue trunk main.
[2] Force main discharges into the gravity main which conveys flow from Airport lift station to Washington Street trunk

- **Custer Avenue Trunk Main.** This trunk main follows the Custer Avenue alignment for the greater portion of its length, before turning south near Valley Drive. The Custer Avenue trunk main drains the Westside basin and primarily serves the western portion of the City in addition to all areas north of Custer

Avenue. At the discharge to the wastewater treatment plant interceptor, the diameter of the trunk is 30-inches. This trunk main conveys approximately 26 percent of the total wastewater flow to the treatment facility.

5.2.2. *Lift Stations*

There are ten lift stations located within the City of Helena service area, including three that are owned and operated by the City of Helena. Table 5-2 summarizes pertinent data about the five larger capacity lift stations.

TABLE 5-2
Summary of Major Lift Station Data

Lift Station	Ownership	Force Main Dia (in)	No. of Pumps	Firm Capacity (gpm)	Standby Power	Discharge Trunk	Year Installed
Northside	City	8	2	355	Yes	Custer Avenue	2002
South Airport	City	8	2	375	Portable Generator	Washington Street	1975
Fort Harrison	City	10	2	1,150	Yes	Custer Avenue	2000
Airport	Private	6	2	180	Unknown	Washington Street	1994
Fairgrounds	L&C County	8	Unknown	Unknown	Unknown	Custer Avenue	1978

The remaining lift stations not listed in the table are all privately owned and operated, serving only single buildings or small developments. The following list provides a more detailed description of the major lift stations.

- **Northside Lift Station:** The Northside Lift Station serves commercial and residential developments north of Custer Avenue between McHugh and N. Montana Avenue. The lift station consists of two identical Gorman-Rupp 18-horsepower submersible pumps. Each pump has a design capacity of 355 gpm with a maximum total dynamic head (TDH) of 100-feet. The lift station operates with one pump until the water level rises to approximately 8-feet above the wet well floor. The lift station discharges via 2,580 lineal feet of 8-inch PVC force main to the 24-inch Custer Avenue Trunk near the intersection of Custer Avenue and Dredge Drive.

- **South Airport Lift Station:** The South Airport Lift Station serves a combination of residential, industrial, and commercial developments north of Airport Road to Alice Street. The lift station consists of two identical Smith and Loveless 23-horsepower constant speed sewage pumps located in a dry pit adjacent to the lift station wet well. Each pump has a design capacity of 375 gpm with a maximum TDH of 115-feet. The lift station operates with one pump until the water level rises to approximately 6-feet above the wet well floor. The lift station discharges

via 4,750 lineal feet of 8-inch PVC force main to the 24-inch Washington Street Trunk at the intersection of N. California Street and Airport Road.

- **Fort Harrison Lift Station:** The Fort Harrison Lift Station primarily serves the Fort Harrison complex located east of Williams Street. Flow from the Fort Harrison complex is conveyed via the Fort Harrison gravity main to the lift station located approximately one-half mile north of the intersection of Custer and Benton Avenues. The lift station consists of two identical Gorman-Rupp 55-horsepower submersible pumps. Each pump has a design capacity of 1,150 gpm with a maximum TDH of 200-feet. The lift station operates with one pump until the water level rises to an approximately 8.5-feet above the wet well floor. The lift station discharges via 2,395 lineal feet of 10-inch PVC force main to the 24-inch Custer Avenue Trunk at the intersection of Custer Avenue and Benton Avenue.

- **Airport Lift Station:** The Airport Lift Station serves a combination of industrial and commercial developments along Skyway Drive, east of the Helena Regional Airport. The lift station consists of two identical 5-horsepower submersible pumps. Each pump has an approximate design capacity of 180 gpm with a maximum TDH of 64-feet. The lift station operates with one pump until the water level rises to approximately 6-feet above the wet well floor. The lift station discharges via 6,750 lineal feet of 6-inch PVC force main to the 10-inch Skyway Drive trunk main.

- **Fairgrounds Lift Station:** The Fairgrounds Lift Station serves the Fairgrounds Complex located north of Custer Avenue and east of Mitchell Avenue. The lift station consists of two pumps located in a dry pit adjacent to the lift station wet well. The design capacity and maximum TDH of the pumps is unknown. The operating water level in the wet well is approximately 8.5-feet above the wet well floor. The lift station discharges via 2,965 lineal feet of 8-inch PVC force main to the 18-inch Custer Avenue trunk main near the intersection of Green Meadow Drive and Custer Avenue.

5.2.3. *Existing Condition and Problem Areas*

The wastewater collection system can be described and evaluated based on several considerations, including size, age of mains, and material of construction. General conclusions regarding the system can be made based on these factors. Figures 5-2 and 5-3 show the collection system by pipe age and pipe material. Table 5-3 summarizes the pipe in the collection system by material.

Meetings with City maintenance personnel were held during the preparation of the collection system model to discuss areas where problems have occurred in the collection system. They include the following:

- Home Depot 12-inch Trunk Main from I-15 crossing to Custer Avenue. This line is undersized and frequently experiences surcharging in the manholes in the downstream section of the line adjacent to Interstate 15.

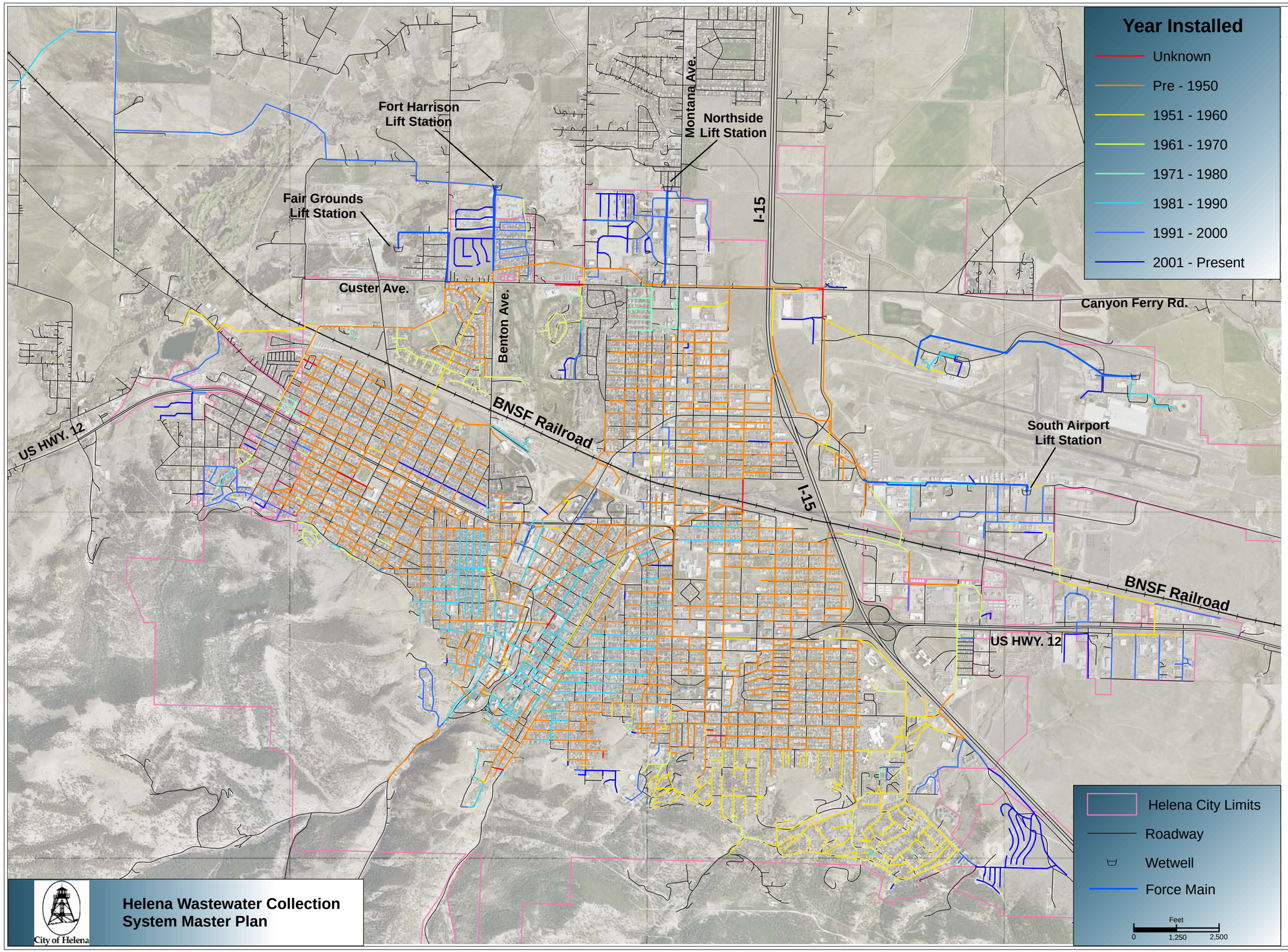

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Figure 5-2
Existing Wastewater Collection System - Age Classification
Helena Wastewater Collection System Master Plan

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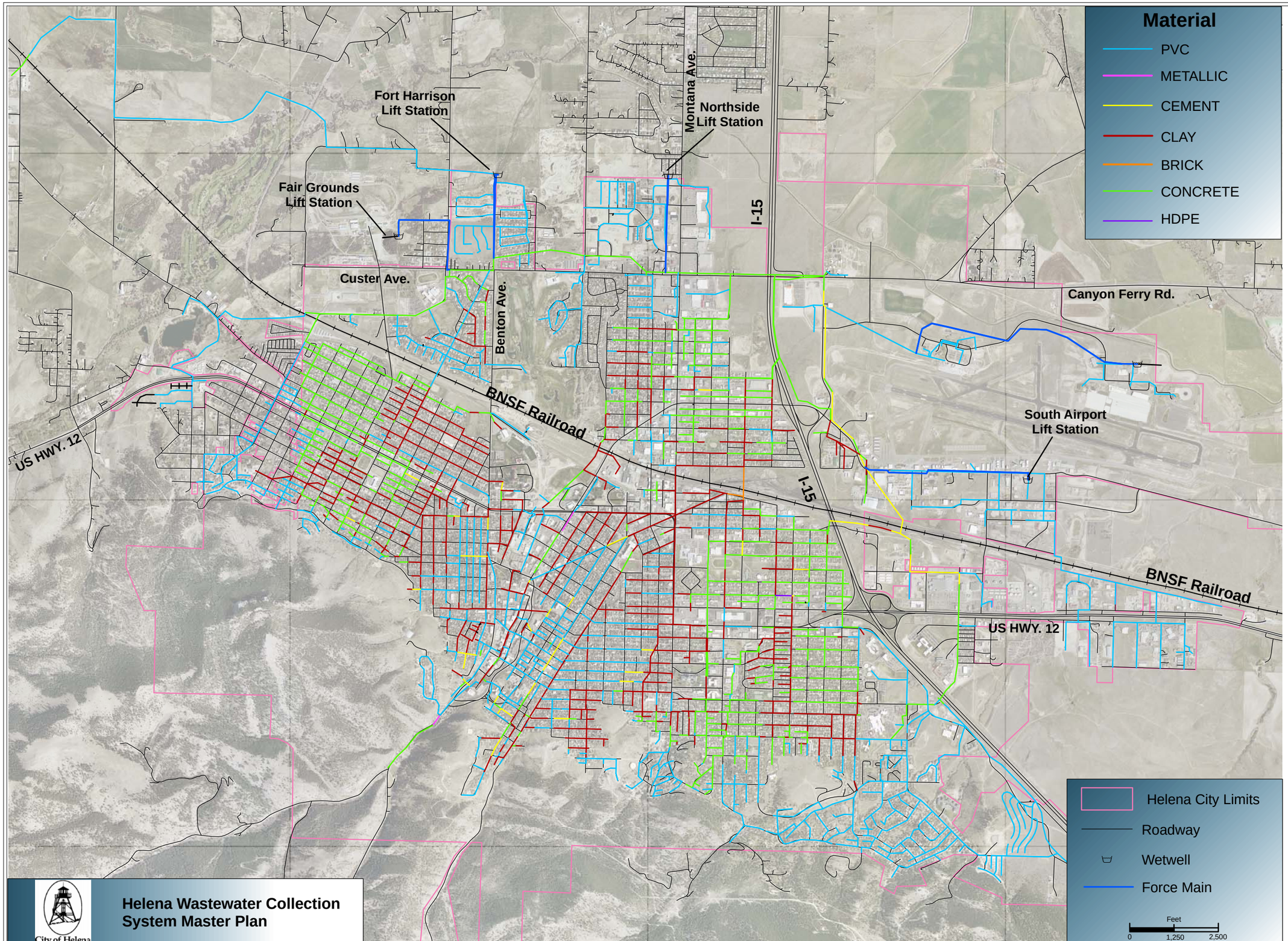

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Figure 5-3
Existing Wastewater Collection System Material Classification
Helena Wastewater Collection System Master Plan

City of Helena

Helena Wastewater Collection System Master Plan

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- N. Harris St. between Phoenix and Cedar St. This section of Harris St. experiences surcharging due to storm events. City staff have bolted down numerous manhole lids on the N. Harris St. line to prevent overflows during storm events. The N. Harris line was identified in the *1997 Wastewater Facility Master Plan* as being at 88 percent capacity on a peak hourly basis.

- Ten block area on Boulder and E. Lyndale Avenues and bounded by N. Harris Street and N. Washington Street. This area experiences frequent surcharging due to insufficient pipe slopes. Two blocks of this area were recommended for replacement by the *1997 Wastewater Facility Master Plan* and were since replaced by pipe bursting although the pipe slopes were not increased.

Table 5-3
Summary of Collection System Pipe Material

Diameter	# of Mains	PVC, Plastic	Vitrified Clay Pipe	Concrete	Cement	Cast Iron	RCP[1]	Brick or ACP[2]	Total (lineal ft)
3	1	900							900
6	52	846	8,128	875	1,094	2,637			13,580
7	180	56,685							56,685
8	2,166	269,081	133,114	140,876	7,317		968		551,356
9	44	1,335	8,080	752	3,413				13,580
10	206	34,919	15,773	10,268	1,014				61,974
12	169	32,674	7,526	9,186	564	595	1,219		51,764
15	56	1,866	3,992	1,681	150		7,161		14,850
18	42	525	5,383	470	1,080		3,817	1,350	12,625
19	5	1,515							1,515
21	50	823	8,874				5,741		15,438
22	1	460							460
24	95		8,028	1,883			13,485	9,938	33,334
30	12				50		2,173	1,420	3,643
42	2						150		150
TOTAL	**3,081**	**401,629**	**198,898**	**165,991**	**14,682**	**3,232**	**34,714**	**12,708**	**831,854**

[1] Reinforced Concrete Pipe (RCP)
[2] Asbestos Cement Pipe (ACP)

The City maintenance staff performs annual closed circuit television (CCTV) inspection and jetting of sewer mains. In recent years, the annual program goal is approximately 500,000 lineal feet of jetting and 65,000 lineal feet of CCTV each year. The jetting and CCTV activities are scheduled on a three-year basis and the amount actually performed is modified every year based on the amount performed in the previous one to two years. Information about the system collected during CCTV and jetting activities are input to

the Hanson database. This list is used to generate capital improvements on a prioritized basis for collection system rehabilitation by lining or replacement. Table 5-4 summarizes by diameter, the currently identified lining, replacement and upsizing projects. A detailed list of these projects is included in Appendix A.

Table 5-4
Summary of Identified Collection System Rehabilitation Projects

Type of Rehabilitation	Pipe Size (in)	Pipe Type	Length (LF)	Replacement Size/Type
Lining due to Age	8	Clay	4,003	8” PVC
	8	Cement	20,742	8” PVC
	9	Clay	821	9” PVC
	9	Cement	1,940	9” PVC
	10	Clay	1,690	10” PVC
	10	Cement	3,346	10” PVC
	12	Cement	376	12” PVC
	SUBTOTAL		**32,400**	
Replacement[1]	6	Clay / Steel	3,667	8” PVC
	8	Clay / Cement	1,919	8” PVC
	18 x 13	Cement	730	24“ PVC
	SUBTOTAL		**6,316**	
Eliminate Bottleneck[2]	8	PVC	1,419	12” PVC
Replace Lift Station & Force Main (Airport Gravity Main)	12	Force main	9,500	24” PVC
TOTAL			**49,630**	

[1] Replacement projects are required to replace undersized 6” mains to meet DEQ requirements and to replace known breaks identified during CCTV.
[2] A bottleneck, located on Boulder Avenue exists between a 10” pipe upstream and a 12” pipe downstream.

Since 1989, the City has performed annual slip lining and replacement of aging and broken pipes. Since then, a total of 69,246 lineal feet of pipe has been slip lined. This represents approximately 8.5 percent of the total collection system at an average of 3,850 lineal feet per year. In addition, the City has lined 131 manholes since 1996, which is 4 percent of the total manholes in the system. These improvements have likely contributed to a reduction in infiltration and inflow as demonstrated by declining flows to the wastewater treatment plant despite an increase in service connections as previously discussed in Chapter 3.

The projects currently identified for slip lining total another 32,400 lineal feet which represents approximately 4 percent of the total collection system. Most of the projects identified for replacement are due to aging clay and cement pipe, much of which was originally installed prior to 1900. General conclusions about the condition of the collection system are as follows:

- Aging infrastructure continues to be a long term challenge for the entire system despite a comprehensive annual program of manhole lining and pipe lining and replacement.

- City staff indicate that the majority of the sump pump and storm drain cross connections in the collection system have been eliminated; however, there are likely remaining an unknown number of sump pump connections in the downtown (Last Chance Gulch) area. This is supported by flow monitoring results discussed in the following section.

- The airport lift station has inadequate capacity for the development currently identified on the southeast side of Helena. The City has identified replacement of the lift station and force main with a gravity trunk main; however, the planned diameter may need to be increased.

Costs of the planned capital expenditures for collection system improvements are discussed Chapter 7.

5.3. DATA COLLECTION

5.3.1. *Surveying*

The City's Hansen data contains 3,029 manhole features including a depth field. However, the Hansen data did not include any information relating to the rim elevation of the manholes. Without manhole rim elevations it was not possible to use the pipe invert depth and manhole depth information to create flow lines through the system in the development of the hydraulic model of the collection system.

This data gap was identified as the most significant gap in the City's existing data that had to be filled in order to create an accurate hydraulic model of the collection system. Several ways of extracting this information were analyzed including using existing City Engineering survey data, existing topography information and actual field surveys. It was determined that field surveys were the best means to collect this information and ensure the accuracy of the information throughout the system. All of the manholes on pipes with a diameter of ten inches and larger, as well as selected manholes on eight inch diameter pipes, were selected to be field surveyed to collect an accurate location and rim elevation for the manholes.

While the field survey was being completed, the data for the pipe and manhole system within the GIS was cleaned so that the spatial data was accurate and all pipes terminated at a manhole. Additionally, the Hansen data was joined to the GIS information and additional attribute fields were added to the GIS such as upstream and downstream invert depths, upstream and downstream manhole IDs, pipe slopes, and manhole depths. The approach was to fill any voids present in the pipe invert depths by using other data fields such as manhole depths and pipe slopes once the manhole rim elevations were surveyed.

Upon completion of the field survey, the new rim elevations were added to the GIS manhole data. In addition, the topography data from the 2006 aerial photos of the City was used to assign rim elevations for the remaining manholes in the model that were not surveyed as part of this project. These data are assumed to be within one foot accuracy. The construction of the model flowline through the system was completed with assistance from City staff who provided manhole invert depths where discrepancies could not be resolved by reasonable assumptions or from available data.

It is recommended that the City engage in a renewed program of systematic measurement of all manhole invert depths to within one tenth foot accuracy. City staff should gather these measurements in a consistent way and using similar measurement devices so that accuracy is achieved. In addition, continued survey of manhole rim elevations of the remaining 8-inch diameter pipe is recommended. As the data is improved, it should be added to the Hansen system so that it can be incorporated into the collection system model. As these efforts proceed, the accuracy of the model will be improved resulting in more reliable output.

5.3.2. *Wastewater Flow Measurement*

To fully characterize the Helena wastewater collection system, four drainage basins were delineated. These basins were further divided into subbasins. The basins and subbasins are shown in Figure 5-4. The basin boundaries generally follow those developed for the *1997 Helena Wastewater Facility Plan*. Each of the basins is drained by one of the four main trunk lines as discussed previously in Section 5.2.1.

In order to create an accurate hydraulic model of the collection system, the existing domestic flows were measured at key locations and the data analyzed. On March 31, 2006, five Marsh-McBirney Flo-Dar flow meters were installed in the collection system with the assistance of City staff. Four of the flow meters were placed in the downstream-most sections of the four main trunk lines of the system. The fifth meter was placed in the sewer main in 18th Avenue near in the southeast area of Helena to characterize existing flows in anticipation of near-term planned development. In order to fully characterize the flows in the system, four rain gauge locations were established within the collection system. The flow meter and rain gauge locations are shown in Figure 5-4.

For three months, from April 1, 2006 to June 28, 2006, sewer flow and rainfall data was continuously collected and logged. It should be noted that an analysis of infiltration and inflow was outside the scope of this project; however, the rainfall data allowed general observations regarding the collection system flow response to rainfall events. This is discussed further in Section 5.3.3. The locations of the flow meters in each of the four major trunk mains enabled a characterization of flow in each of the four basins.

To supplement the flow monitoring performed in 2006, historical flow measurements at the wastewater treatment plant were incorporated into the analysis of system flows. The City of Helena provided ten years of daily flow data to support the analysis.

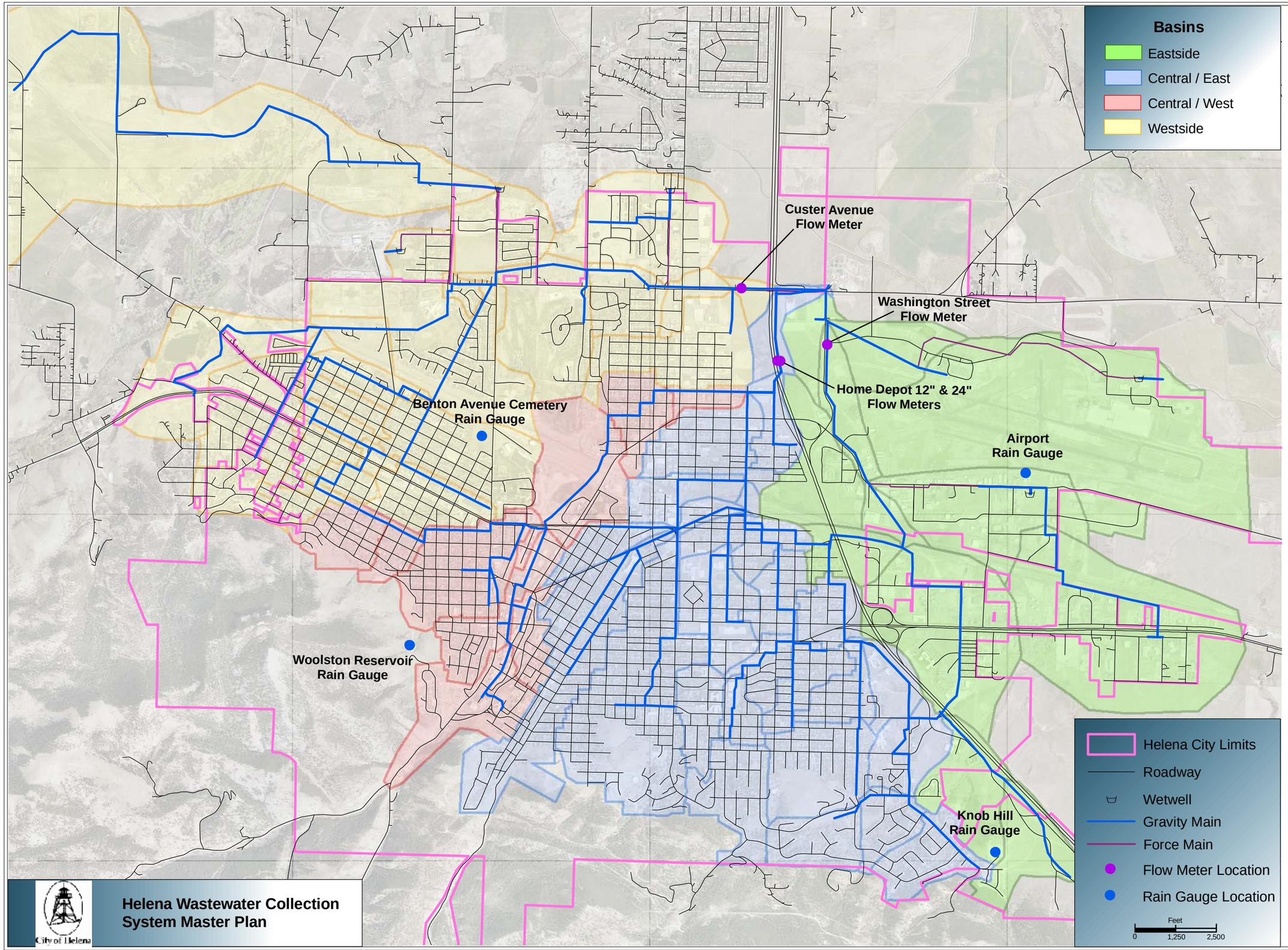

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Figure 5-4
Wastewater Basins & Sub-Basins

Helena Wastewater Collection System Master Plan

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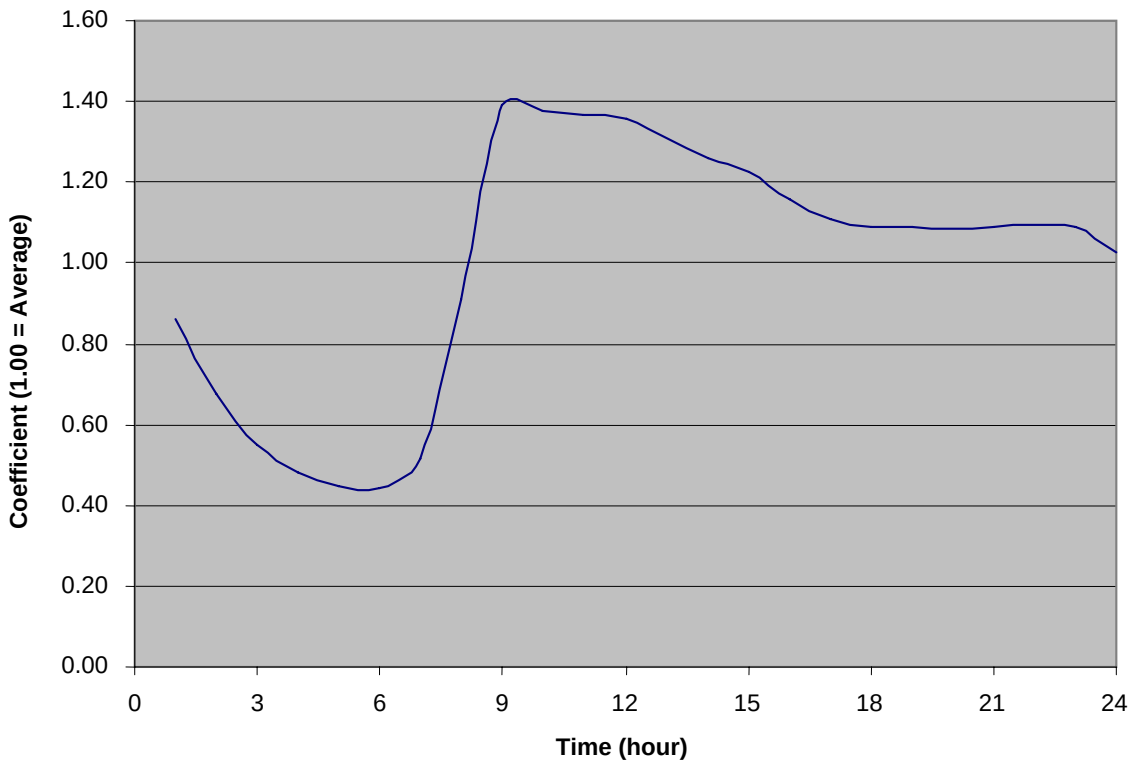
5.3.3. *General Conclusions of Flow and Rainfall Data*

The measured wastewater flows were checked against daily flows measured at the WWTF and found to be within ± 6 percent on a daily basis, yielding a high confidence in the flow monitoring data. The measured flows averaged 3.19 mgd.

The flow meter data for each basin was plotted on a 24-hour scale, and an average diurnal flow pattern was generated for the three month period, minus the days with rainfall events. The analysis yielded nearly identical diurnal curves in each basin. The typical diurnal curve for the collection system, which was incorporated into the hydraulic model, is shown in Figure 5-5.

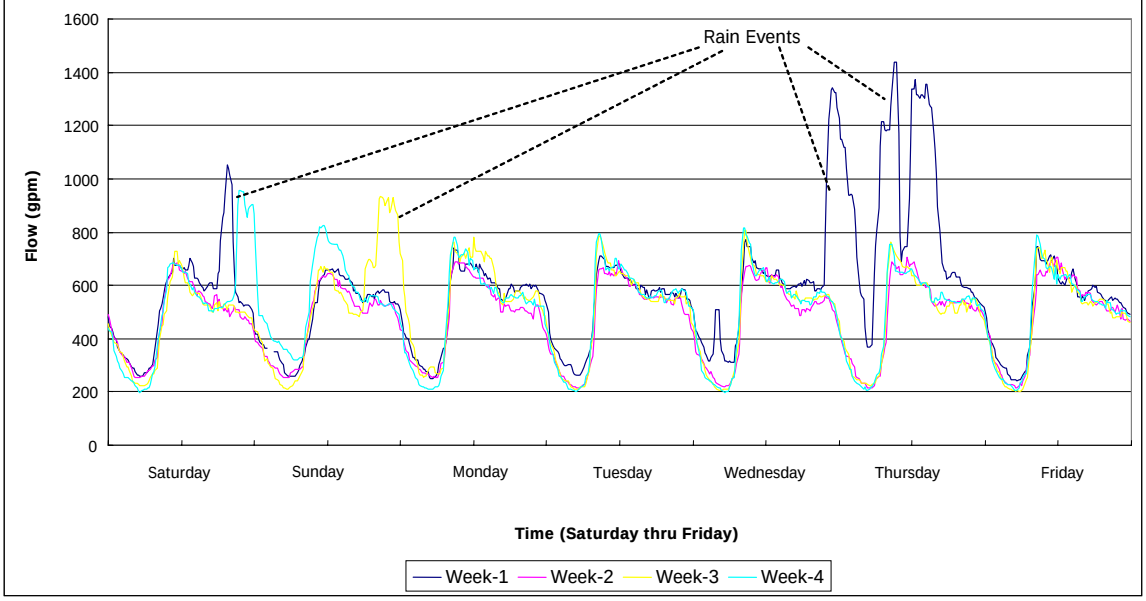
Figure 5.5 City of Helena Diurnal Sewer Flow Pattern



Rainfall response within the collection system was analyzed for each basin using the flow and rainfall data collected from April through June of 2006. There were 10 rainfall events captured during that period ranging from a trace to 0.6 inches. The corresponding increase in sanitary flows measured for each rainfall event in each basin was plotted. An example of the response observed is shown in Figure 5-6, which shows increased sewer flows in April 2006 during numerous rain events as measured in the Home Depot 24-inch line. The rainfall measured on Thursday of Week 1 was approximately 0.1 inches.

Analysis of this data showed that each of the four drainage basins had distinct inflow attributable to storm events. Response to rainfall varied due to variable distribution of rainfall across the collection system as well as differences in rainfall intensity and duration between storm events. The plots for the entire flow monitoring period for each flow meter are included in Appendix B.

Figure 5.6 Home Depot 24 inch Wastewater Flows for April 2006



5.4. MODEL DESCRIPTION

5.4.1. *Introduction*

A hydraulic model of a community's wastewater collection system is an effective tool for use in assessing a system's existing capacity and evaluating improvements for existing problem areas as well as planning for future expansion. For this master plan, a hydraulic model of the City's collection system was created. The hydraulic model software selected and purchased for the City of Helena was MWH Soft InfoSewer/Professional Suite for ArcGIS. The hydraulic model was built within an ArcGIS environment to allow background databases to be graphically displayed with collection system elements, and also allow continued updating of both ArcGIS and model databases as the utilities are upgraded or expanded in the future.

5.4.2. *Physical Model Development*

One of the first steps during the data collection process was the review of existing data sources to determine their adequacy to support the different master planning tasks. The different data sources were grouped into tiers of information that ranged from mandatory data to data that could be used, but was not necessary to complete the master plan. As an example, data defining the wastewater collection system was

mandatory for the completion of the master plan and model whereas a data set such as road centerlines would not adversely impact the collection system planning process if it was missing. The list below is a summary of the mandatory data sets that were collected.

Tier 1: Mandatory Data Sets

- Wastewater Collection System Piping
- Wastewater Collection System Manholes
- Wastewater Collection System Lift Stations
- Hansen Maintenance Management System Data
- Existing Water Customer Data
- Future Land Use Data

The mandatory data sets received the highest level of scrutiny to determine if there were any missing pieces of information. Checks were performed on the data to determine if the data was present as well as checks to assess the quality of the data.

The physical databases of key collection system elements were established by associating the ArcGIS software with the existing City of Helena Hansen utility databases. Collection system elements such as manholes, gravity mains, force mains, and similar critical items were queried and filtered from the Hansen databases, and assigned to individual layers within the hydraulic model. The ArcGIS databases were then employed to create model elements.

Because the City undertook the compilation of the Hansen data for the primary purpose of maintenance of the collection system, for which it has been very effective, the accuracy of the data was not consistent. It was determined that much of the data was not appropriate for the purpose of the collection system model due to contradictory invert information between adjoining pipes and between pipes and manholes in the Hansen data, and between the Hansen data and the GIS.

Resolution of these data gaps was performed by manually analyzing the data gaps and working closely with City Staff to determine the best solution in each case. There were approximately 200 pipes that were missing either an upstream or downstream invert, or both. In some cases, field measurement of manhole depths was performed.

The final model incorporates all 10-inch diameter and greater gravity mains, key 8-inch gravity mains, and all manholes associated with these mains. Also included in the model were the larger capacity lift stations and associated force mains. Table 5-5 shows the ratio of existing collection system elements to those included in the model.

Table 5-5 Summary of Modeled Elements			
Collection System Element Type	**Existing System Elements**	**Modeled System Elements**	**Percentage Modeled (%)**
Manholes	3,000	704	23%
Gravity Mains	3,026	707	23%
Lift Stations[1] and Force Mains	10	5	50%
[1] Lift Stations include wet wells, chambers, and pumping units.			

After the selection of model elements were created, database errors such as reverse flow direction, orphan elements, and topology had to be corrected. Therefore, connectivity of mains to manholes had to be established. Also, hydraulic grade of the mains had to be assessed to ensure that the existing system grades and flow directions were accurately reflected within the modeled elements.

5.4.3. *Wastewater Flow Loading*

Because the flow monitoring was limited to the main trunk lines, sanitary flows in the pipes upstream of the flow monitoring locations had to be estimated in order to load the pipes in the hydraulic model. Water meter data obtained from the City for the months of November through March was used to estimate dry weather sewer flows. Water meter data within each subbasin was allocated to the closest manhole. The resulting flows generated by the model were compared to the measured flows and the loading was scaled appropriately to approximate the measured flows. It should be noted that the precipitation events were excluded from the average of the measured flows.

Finally, the diurnal flow pattern for each of the four basins was applied in order to simulate the high and low flow periods of a typical day. The results of the initial dry weather flow loading process are shown in Table 5-6.

Table 5-6 Wastewater Flow Calibration Results			
Trunk Main / Drainage Basin	**Water Meter Winter Usage Flow (gpd)**	**Recorded Wastewater Flow (gpd)**	**Difference Multiplier**
Washington Street / Eastside	391,066	743,962	1.90
Home Depot 24-inch (HD-24) / Central West	374,631	684,241	1.83
Home Depot 12-inch (HD-12) / Central East	878,425	928,246	1.06
Custer Avenue / Westside	657,433	832,633	1.27

Table 5-6 shows that each of the four major trunk mains/drainage basins has varying differences between the total measured wastewater flows, compared to a percentage of domestic water consumption. These differences might be attributed to a number of factors. It was verified that in the Washington Street / Eastside basin, there is a small residential area (approximately 15 manufactured homes) that has sewer service but is not served by City water. In the same basin, City maintenance staff identified a manhole on Airport Road that has an 8-inch plug with a 1½-inch relief valve that is flowing full into the manhole. It was reported that the line is flowing at an unknown rate. The discrepancy observed in the Washington Street line is equivalent to 245 gpm and is assumed to be partly attributed to these sources.

The flow monitoring was performed in the spring (April, May and June) and there were ten rainfall events. While any inflow was excluded from the data, some of the flows may be attributed to groundwater infiltration. It is noted that the Harris Street gravity main is vitrified clay pipe, and runs parallel to a major storm water outfall for the City. If the storm drain pipe is leaking, there may be a contribution due to infiltration. In addition, the Home Depot 24 drains the Last Chance Gulch area where City staff speculates there may still be connections from sump pumps and other drains.

Calibration of the model focused on approximating the total daily flows listed in the recorded wastewater flow column of Table 5-6, over a 24-hour period. The 24-hour simulation allows specific time analysis of the collection system, taking into account the high and low flow periods of the daily diurnal curves associated with each trunk main/drainage basin. Flows from lift stations were also calibrated using either discharge flow meter records or pump run time records associated with each individual lift station. Due to pump run times on a per minute basis, the resulting model simulations produce dynamic results analyzed by minute over a 24-hour period.

The final collection system model contains four flow condition scenarios as shown below.

- Dry Weather (Average Day) Loading Condition
- Wet Weather (Maximum Day) Loading Condition
- Wet Weather (Maximum Day) Loading Condition with 5-Year 60-Minute Storm Event
- Wet Weather (Maximum Day) Loading Condition with 10-Year 60-Minute Storm Event

5.4.4. *Wet Weather and Storm Flow Development*

The wet weather flow condition was created using the dry weather flow condition and diurnal curve as the basis for manhole loading. The dry weather manhole loadings were scaled up to correspond with the typical maximum day flow rate experienced at the wastewater treatment plant.

In order to simulate peak flow conditions in the system, 5-year and 10-year, 60-minute storm events were imposed on the wet weather scenario. The 5-year and 10-year, 60-minute storm flows were derived using historic WWTF flow records, in conjunction with archived precipitation data from the National Oceanographic and Atmospheric Administration (NOAA). Based on the data, the 5-year 60-minute storm event for the Helena area is 0.71 inches. The 10-year 60-minute storm for the Helena area is 0.84 inches.

The rainfall events which occurred during the flow monitoring were all less than the 5-year and 10-year, 60-minute storm events. Therefore, the measured storm inflow values were scaled up to correspond with the intensity of both a 5-year and 10-year storm event for the City of Helena area. These storm inflow values were allocated to the manholes in the model. To simulate a worst-case model scenario, the storm inflow values were imposed during hour ten (10:00 AM) of the model simulation, which corresponds with the approximate peak hour flow condition for each of the four major trunk mains/drainage basins.

Using the flow monitoring data collected for the largest rainfall event, which occurred on May 28, 2006, and scaling it up to a 5-year storm event, results in a total influent flow at the WWTF of 3.80 mgd. The 10-year storm event would scale up to a WWTF influent flow of 3.81 mgd. The fact that the 5-year and 10-year events result in nearly identical flows to the WWTF can be explained by the small difference in the total rainfall of the two events (0.14 inches) over a 60 minute period and attenuation through surface runoff versus what flows into the collection system.

Table 5-7 summarizes the model scenario flows for each of the four major trunk mains/drainage basins.

Table 5-7
Summary of Model Scenario Loading Flows

Model Loading Scenario	Trunk Main/Drainage Basin	Dry Weather Flow (gpd)	Wet Weather Flow (gpd)	5-Year 60-Minute Storm Flow (gph)	10-Year 60-Minute Storm Flow (gph)	Total Flow (gpd)
Dry Weather (Ave. Day)	Washington Street	743,962	-	-	-	743,962
	Home Depot 24-Inch	684,241	-	-	-	684,241
	Home Depot 12-Inch	928,246	-	-	-	928,246
	Custer Avenue	832,633	-	-	-	832,633
					Total Collection System Flow	**3,189,082**
Wet Weather (Max. Day)	Washington Street	-	844,551	-	-	844,551
	Home Depot 24-Inch	-	776,755	-	-	776,755
	Home Depot 12-Inch	-	1,053,751	-	-	1,053,751
	Custer Avenue	-	945,211	-	-	945,211
					Total Collection System Flow	**3,620,268**
Wet Weather (Max. Day) w/ 5-Yr 60-Min Storm Event	Washington Street	-	844,551	18,403	-	862,954
	Home Depot 24-Inch	-	776,755	79,373	-	856,128
	Home Depot 12-Inch	-	1,053,751	55,242	-	1,108,993
	Custer Avenue	-	945,211	29,764	-	974,975
					Total Collection System Flow	**3,803,051**

Table 5-7 Summary of Model Scenario Loading Flows						
Wet Weather	Washington Street	-	844,551	-	19,488	864,039
(Max .Day)	Home Depot 24-Inch	-	776,755	-	84,049	860,805
w/ 10-Yr 60-Min	Home Depot 12-Inch	-	1,053,751	-	58,496	1,112,247
Storm Event	Custer Avenue	-	945,211	-	31,518	976,729
					Total Collection System Flow	**3,813,819**

5.5. EXISTING SYSTEM EVALUATION

The City of Helena wastewater collection system currently experiences some deficiencies with sewer main capacity. These capacity issues are primarily due to either under-sized mains or inadequate main slopes. This section will provide a detailed explanation of known and model predicted problem areas within the existing collection.

5.5.1. *Model Evaluation Criteria*

Evaluation of the existing collection system was performed using the four model loading scenarios described in Section 5.4. Model output for these loading scenarios was evaluated based on the following parameters:

- q/Q, the ratio of actual flow to the total theoretical open channel flow rate. This parameter indicates the portion of main capacity currently used under the different flow conditions. q/Q ratios in excess of 0.75 indicate capacity issues attributable to inadequate slopes or under-sized pipe diameters.

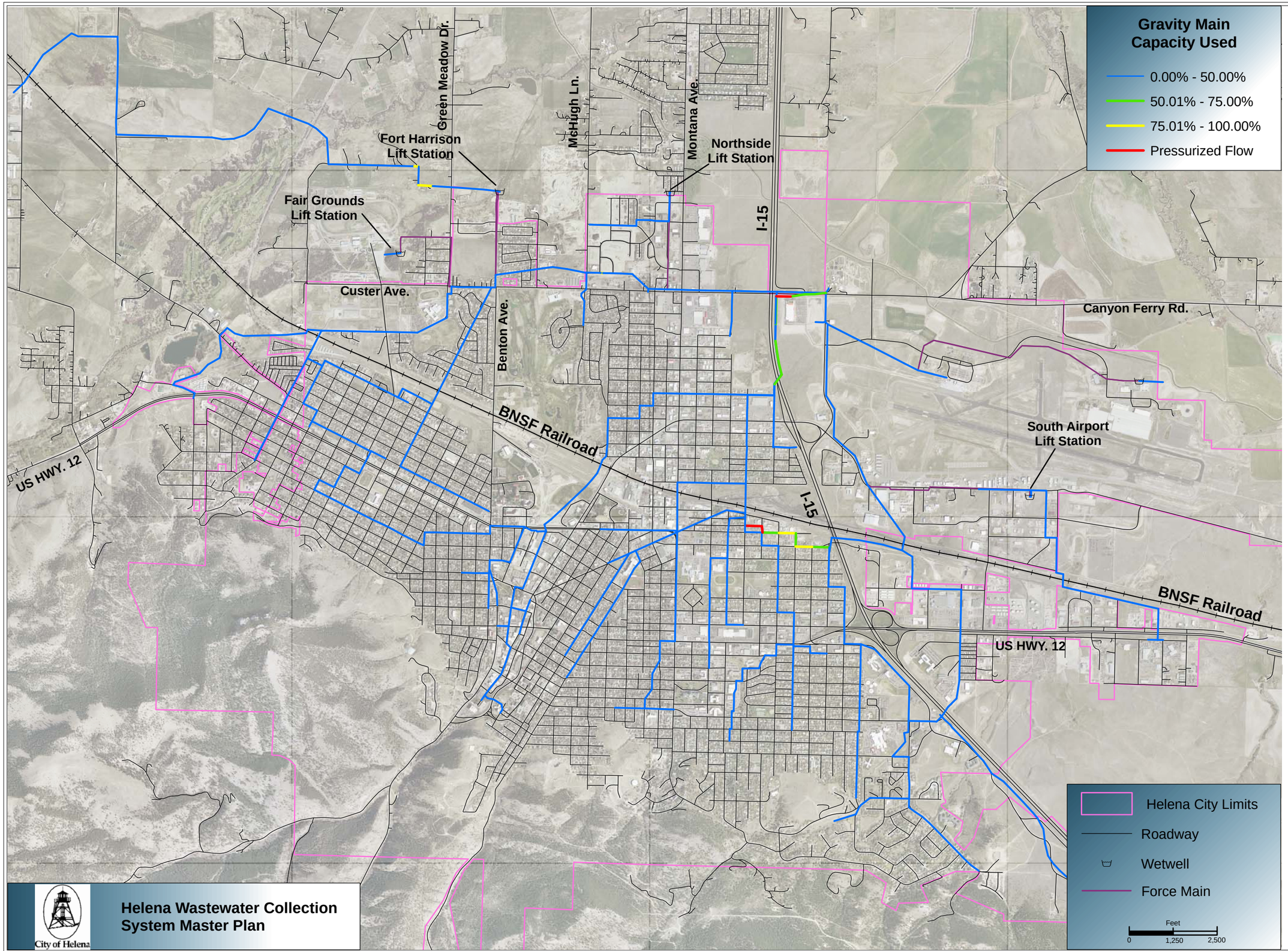
- V, the maximum velocity. This parameter is used to determine whether the main is susceptible to erosion/scouring from excessive velocity, or sedimentation and septic conditions due to inadequate velocity. The desired system operating range for flow velocity is between 2 and 15-feet/second.

5.5.2. *Model Evaluation Results*

The following sections summarize the results of the modeling for each flow scenario. Table 5-8 summarizes gravity mains with current flows in excess of 75 percent of total capacity (q/Q > 0.75) under each flow scenario. The results of the existing system modeling with capacity deficiencies for the dry weather, peak day and peak day wet weather flow conditions are also shown in Figures 5-7, 5-8 and 5-9, respectively. Appendix C includes detailed tables of the modeling results. It should be noted that numerous segments in the model have assumed slopes as discussed previously, and should be field verified.

Dry Weather (Average Day) Loading Condition

Model analysis of the existing collection system during Dry Weather (Average Day) flows showed very few capacity deficiencies. Overall, the existing system is adequately



Helena Wastewater Collection System Master Plan

City of Helena

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Figure 5-7
Dry Weather Capacity

Helena Wastewater Collection System Master Plan

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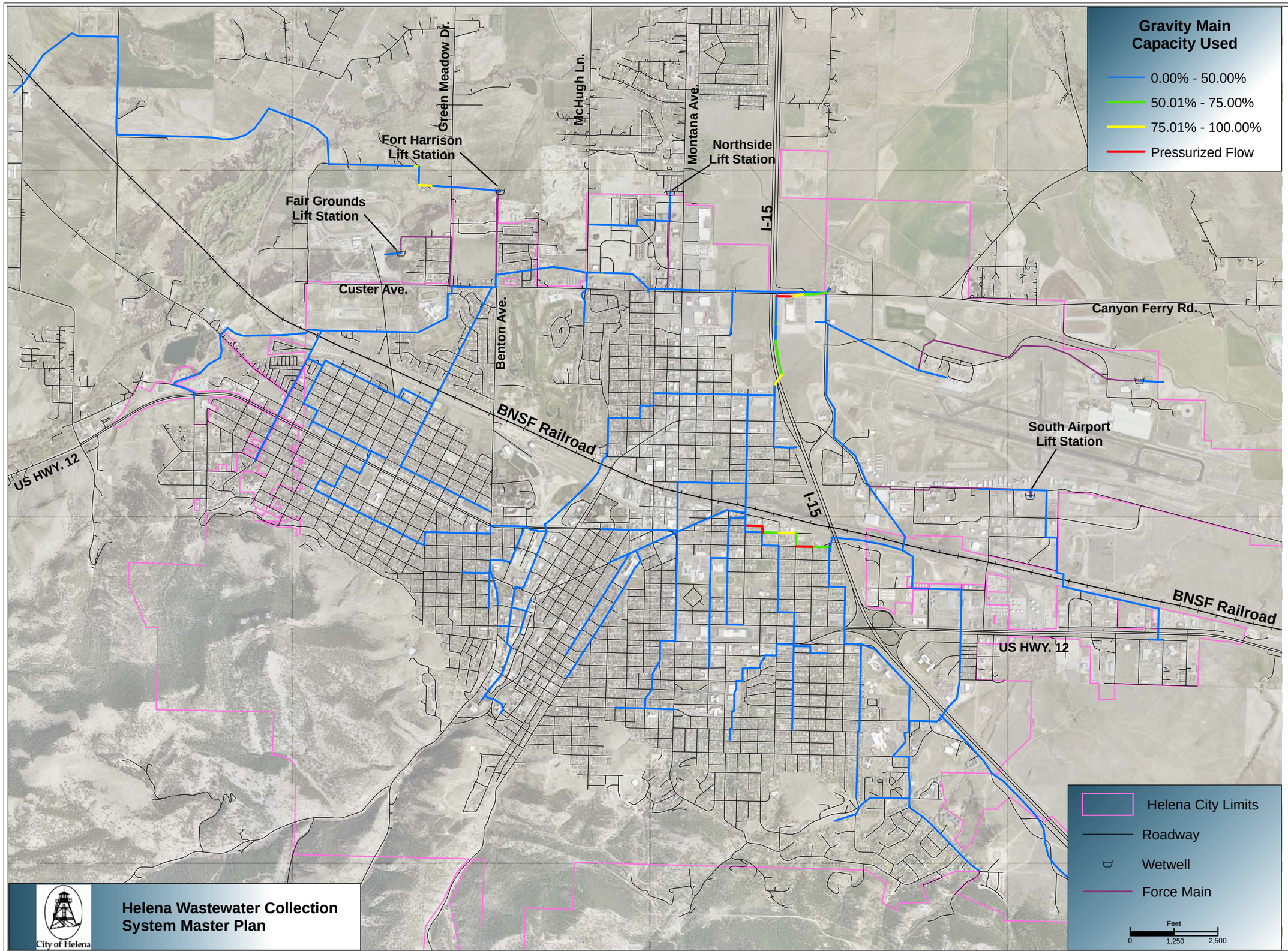

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Figure 5-8
Wet Weather Capacity

Helena Wastewater Collection System Master Plan

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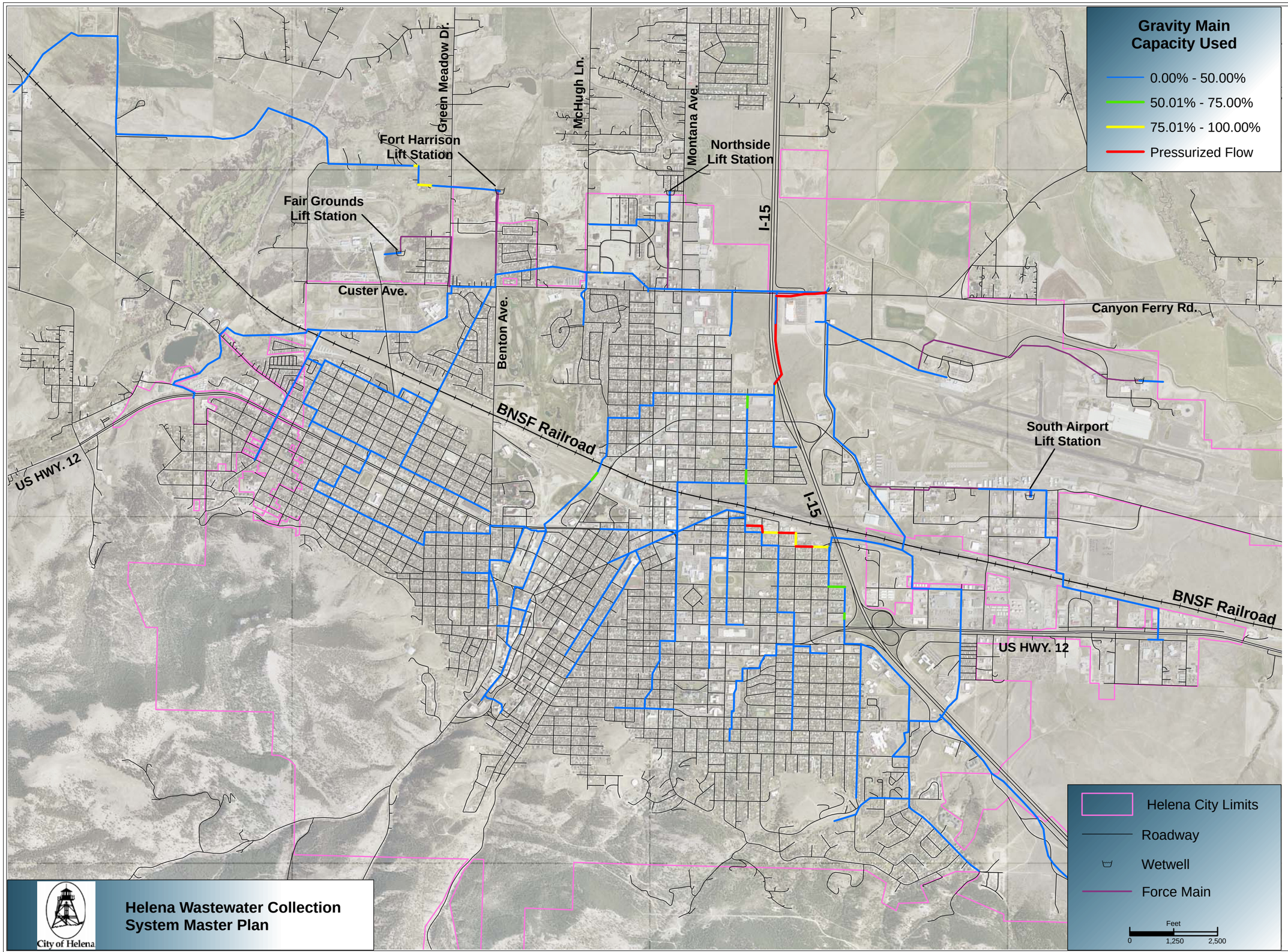

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Figure 5-9
Wet Weather 10-Yr Storm Capacity
Helena Wastewater Collection System Master Plan

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sized to convey the average day flow conditions with the exception of eight gravity main sections. In general, these are located in the 10 block area described in Section 5.2.3 between N. Harris Street, Boulder Avenue, E. Lyndale Avenue, and N. Washington Street. One section of pipe on North Oakes (P2915 between MH254-2 and MH254-3) in the 10-block area is at 141 percent of capacity. The problem is due to inadequate pipe size and slope. The section is an 8-inch concrete pipe with a slope of 0.0026 ft/ft. The gravity mains immediately upstream of this section have a 10-inch diameter, and the gravity mains downstream are 12-inch, creating a "bottleneck" in the collection system.

The model also indicates that one section of pipe (P1803 between MH445-5 and MH445-6) on the 12-inch Home Depot line where it turns east along Custer Avenue is at 126 percent of capacity. This pipe has a slope of 0.2 percent, which causes some surcharging in this section.

Table 5-8
Summary of Modeled System Capacity Deficiencies[1]

Sewer Line	Average Day Flow (gpm)		Peak Day Flow (gpm)		Peak Wet Weather Flow		Total Capacity (gpm)	Total Length (ft)	Diameter (in)
	(gpm)	q/Q	(gpm)	q/Q	(gpm)	q/Q			
Ft Harrison Gravity Main (current)	42	0.08	51	0.10	56	0.11	514	273	12
Ft Harrison Gravity Main (w/ committed flow of 415 gpm)	*457*	*0.89*	*466*	*0.90*	*471*	*0.91*	*514*	*273*	*12*
Hannaford					534	0.8	666	372	10
Boulder	365	0.9	412	1.02	529	1.31	404	940	10
Lyndale	367	0.88	414	1	538	1.3	415	931	10
Lewis	363	1.04	415	1.19	551	1.57	350	469	8
N. Oakes	364	1.41	415	1.61	546	2.12	260	178	8
HD -12 on Custer	943	1.26	1,132	1.51	2,377	3.16	750	1,391	12
HD-12 (behind Home Depot			1,140	0.76	2,360	1.57	1,500	2,792	12
Riverrock Dr.	408	1	494	1	982	1	982	54	24
Skyway			192	0.78	212	0.86	245	400	10
Total Length								7,800	

[1] Model results for the most limiting sections are reported. See Appendix C for information specific to individual pipe segments.

Wet Weather (Maximum Day) Loading Condition

Similar to the dry weather scenario, an analysis of the existing collection system under Wet Weather (Maximum Day) flow loadings showed very few capacity deficiencies. As previously described, the model assumes that the daily peak flow occurs at 10:00 AM. Overall, the existing system is adequately sized to convey the maximum day flow conditions with the exception of four additional gravity main sections, all of which are located in the vicinity of either the ten block area in the Central/west basin or on the HD-12 line.

Wet Weather Loading Condition with 10-Year 60-Minute Storm Event

Modeling of the wet weather (Maximum Day) flows with a 10-year 60-minute storm event did not demonstrate significant capacity deficiencies within the system. There were 22 gravity mains sections with flows in excess of 75 percent compared to the 12 mains identified under maximum day conditions. As previously discussed, the model assumes that the one hour precipitation event occurs during the peak of the diurnal curve so that the resulting peak flow occurs at 10:00 AM. The 10 additional lines are located in the vicinity of the ten block area in the Central/west basin, on the HD-12 line, the Harris Street line, and two sections on the Fort Harrison gravity line.

5.5.3. *Model Evaluation Summary*

The model was able to simulate the problems within the existing collection system that were originally reported by City of Helena Maintenance staff. In particular, under the wet weather loading conditions, the model confirmed full flow gravity mains and surcharging manholes in the Home Depot 12-inch (HD-12) trunk main between Interstate 15 and Home Depot, in the N. Harris Street line and in the area of Boulder Avenue and East Lyndale Avenue. Surcharge conditions were recorded by the flow meter in the Home Depot 12-inch line and all of these problems were previously identified by the City of Helena.

In the sewer lines on Boulder Avenue and E. Lyndale Avenue, the model reproduces similar capacity problems during all loading conditions due to the relatively shallow grade of the gravity mains in this area.

5.6. CONCLUSIONS

A total of 49,635 lineal feet of pipe in the collection system has been identified for slip lining or replacement due to age, condition, or capacity of the pipe. A total of 32,400 lineal feet or 65 percent of that pipe is scheduled for slip lining due to aging clay and cement pipe. These projects should remain a priority for the City. As discussed in this chapter, it is evident that the City's sliplining efforts since 1989 have helped reduce flows to the wastewater treatment plant, effectively adding hydraulic capacity to the plant.

The scope of this project did not include an Infiltration and Inflow (I/I) study. Based on the flow monitoring performed and the documented response to rainfall within the

system, it is recommended that the City continue flow monitoring to further define and quantify the inflow and infiltration so that collection system improvements can be better prioritized. In general, it is recommended that sliplining projects in the Central basin be given a higher priority, given the significant response to rainfall measured in these basins.

The City's current program of CCTV inspection and documentation has been very effective in identifying specific problems in the collection system. Currently, there is no qualitative scoring system in place, although the Hansen software allows for a scoring system for structural and root defect problems. Scoring should be associated with each manhole and segment of pipe so that projects can more easily be prioritized by City staff.

Several projects which were identified in the *1997 Wastewater Facility Plan* that have not yet been completed, including the Harris Street line and the Home Depot-12 line. While the results of the modeling show that the majority of the Harris Street line has adequate slope and capacity, the City experiences frequent surcharging in this line. It is recommended that the pipe slopes and pipe condition be verified and that additional flow monitoring be performed on Harris Street prior to making any improvements. The HD-12 line is undersized and should be added to the capital improvements plan.