Sewer Collection System

Master Plan Report

Prepared For:

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EXECUTIVE SUMMARY

The Nibley City sewer collection system is relatively new, having been installed in 2003. However, the following factors made it prudent to complete an evaluation of the capacity of the system:

- The City has expanded its sewer service area outside of the original area used for design
- Some of the City zoning densities have increased
- The City has grown at a faster rate than was projected
- The system was approaching its capacity limits based on the flow assumptions used for design

The City hired J-U-B to complete a collection system master plan that includes:

- Sewer flow metering to determine actual flows in the system
- A computer model to identify any system deficiencies now and in the future.
- Required sizes of future sewer trunk lines for areas that are not yet developed.
- A list of capital improvement projects with associated opinions of probable cost.
- Evaluation of the Hansen Lift Station capacity to pump existing and future sewer flows to Logan.

Through this master plan process, it has been determined that the actual flows in the system are smaller than the estimates that were used to design the system. The following overall conclusions and recommendations are based on the assumptions and results of the plan:

- **Existing Capacity -** No capacity improvements need to be made to the existing collection system during the next 10 years.
- **Inflow and Infiltration (I&I)** - The amount of I&I increases during irrigation season, but is within the normal range for collection systems. However, this may be reduced by watching for sources of I&I and eliminating those flows where possible. The City should monitor flow data recorded by the Supervisory Control and Data Acquisition (SCADA) system at times when large rain events occur to quantify and take steps to eliminate inflow sources. Also, the City should require new developments to be built to stringent standards that will minimize new I&I.
- **Daily Sewer Volume Per Person** - The sewer contribution per capita in Nibley is approximately 90 gallons per capita per day (GPCD) instead of the estimated 100 GPCD used for design.
- **Capacity for Additional Equivalent Residential Units (ERU's)** - All of the existing collection lines can serve approximately 500 or more additional ERU's. The City should require an update to the existing sewer model to verify that there is adequate capacity prior to permitting new developments. The City should also track the number of new ERU's added to the system to know when the capacity of certain pipes is being approached.
- **Millville City Flows** - The collection system has adequate capacity through 2024 including the planned flows from Millville City. The City should require Millville to install a flow meter to measure any sewer flows that enter the system from Millville. The City should communicate and coordinate with Millville staff anytime new flows are added from Millville and update the existing model.

- **Future Upgrades to Existing Pipes -** Some of the existing trunk lines will exceed capacity before Nibley is completely built out (See Figure 13: 2046 Reserve Capacity*). The City should begin planning a funding mechanism for long range system upgrades (Figure 14: Existing and Proposed Diameters*).
- **Future Upgrades to Hansen Lift Station -** The Hansen Lift Station will need an additional third pump around year 2030. The City should regularly monitor the performance of the station. Once both existing pumps are frequently running at the same time, add a third pump.
- **Future Sewer Collection South of City -** The undeveloped area south of the current service area and east of 1500 West can be served by gravity to the Hansen Lift Station. Approximately 475 ERU's can be added to the existing trunk line in 1500 west near 3350 South. Monitor the number of connections added at this point and then plan to spit some of the peak flows at this location off to go through a future lift station to the west.
- **Future Lift Stations -** At least two new additional future regional lift stations will be needed to serve all of the study area. The City should plan for regional lift stations based on the recommended system layout given in this master plan to minimize the number of lift stations the City will need to operate and maintain.
- **Development Permitting –** Require an update to the existing sewer model to verify that there is adequate capacity prior to permitting new developments.

** All of the report figures are found on fold-out pages in Appendix A*

REPORT

1 INTRODUCTION

1.1 BACKGROUND

The Nibley City sanitary sewer system was constructed in 2003 and collects sewer flows from homes, and businesses within the current Nibley City limits. An overview of the collection system is shown in Figure 1: Existing System*. The collection system delivers the wastewater to a trunk line in the Logan City collection system at 1000 West 600 South and is then transported to the Logan City Wastewater Treatment Facility. Most of the collection system is made up of 8-inch diameter pipe lines with a few larger trunk lines that serve larger service areas. There is a 21-inch sewer line that runs in 2600 South from the east side of the City to the west side of the City. This line was sized to include some future flows from Millville City.

Nibley has grown significantly over the last few decades as shown in Table 1-1 below.

Table 1-1: Population Growth

Nibley City Growth		
Year	**Population**	**Average Annual Growth Rate**
1990	1220	6%
2000	2083	10%
2010	5438	3.5%
2013	6029	

Source: U.S. Census Bureau. The 2013 population is estimated based on 3.5% annual population growth since 2010 per City Planner.

* *All of the report figures are found on fold-out pages in Appendix A*

A master plan is an essential element in the development of any community experiencing growth. With a master plan, a community has a tool to guide infrastructure improvements. This master plan provides direction to continue providing adequate sewer collection services for the residents of Nibley in the future.

The following factors made it prudent to evaluate the capacity of the system to convey the current and projected flows at this point in time:

- The system was designed and sized to serve only the areas inside the city boundary in 2003. The City is responsible for providing safe and cost effective services. Anticipating growth is critical to that effort.
- Some of the city zoning densities have increased since the collection system was built. The higher densities allow for potentially larger sewer flows in the system.
- The City has grown at a faster rate than was projected in 2003.
- Based on the original flow assumptions used to design the system, the system appeared to be approaching the capacity limits.

Because of these facts, and because of a new high school in Millville that will soon connect to the sewer system, the City decided to complete this master plan. The City hired J-U-B ENGINEERS, Inc. (J-U-B) to evaluate the capacity of the existing collection system and propose collection system improvements to accommodate projected growth.

The goals of the master plan are to:

- Develop and calibrate a hydraulic model of the system.
- Evaluate the capacity of the existing collection system as outlined in Table 1-2.

Table 1-2: Time Frames Analyzed

Time Frames Analyzed	
Title	**Description**
2014 Winter	Calibration - Existing flows during low infiltration time of year used to quantify sanitary flows
2014 Summer	Existing flows during summer irrigation months when infiltration is high. Includes effects or rain inflow during a 3 year storm event
2019	Projected 2019 flows during summer irrigation months and during a 3 year storm event
2024	Projected 2024 flows during summer irrigation months and during a 3 year storm event
2046	Projected 2046 flows during summer irrigation months and during a 3 year storm event. 2046 is the estimated year when all of the areas within the existing city limits will be developed to the current planned densities.
2064	Projected 2064 flows during summer irrigation months and during a 3 year storm event. 2064 is the estimated year when all of the areas within the study area boundary (Figure 1: Existing System*) will be developed to the current planned densities

- Identify projected deficiencies in the existing collection system.
- Provide a prioritized list of capital improvement projects with associated cost estimates (Opinions of probable cost).
- Identify the required sizes of future sewer trunk lines.
- Evaluate the capacity of the lift station that pumps to Logan (Hansen Lift Station) to meet existing and future sewer needs.

This master plan will allow Nibley City to be more prepared for future growth, and plan for required improvements.

1.2 Project Tasks

The following tasks were followed to complete the plan:

- Mapped the existing collection system.
- Collected and analyzed winter sewer flow data at strategic locations in the collection system and documented general conclusions drawn from the data.Evaluated summer flow data collected by

the flow meter at the Hansen Lift Station and recorded by the Supervisory Control and Data Acquisition **(**SCADA) system.

- Evaluated the existing system to determine the current capacity status.
- Established growth criteria based on input from City staff.
- Identified capacity improvements at the time frames analyzed based on growth criteria.
- Master planned a conceptual sewer trunk line system to serve the undeveloped areas of the city up to the time that the area within the study area boundary is (Figure 1: Existing System*) built-out 2064.
- Created project descriptions and conceptual cost estimates to meet projected requirements.
- Provided an overall list of conclusions and recommendations drawn from the master plan study.
- Provided hardcopies of the master plan documents.
- Provided digital models, figures, and text in native file formats.

A central component of these tasks is the use of computer modeling software to simulate current and future sanitary sewer system capacity. The software and planning parameters (see Key Assumptions, Section 2) used for this study are discussed in greater detail in the following sections.

1.3 Master Plan Goal

The main goal of the master plan is to provide a planning document in an efficient and organized manner that outlines how Nibley City can budget to meet its future sewer collection needs. Future conditions (development patterns and densities) have been modeled using the planned land use densities from the City's Future Land Use Plan map. (CRSA, 2007). Land uses and other conditions may change and ultimately affect the master plan. The analysis and recommendations contained herein should be updated as necessary. The City should revisit this document prior to engaging in detailed design of any sanitary sewer facilities to verify that the model and conclusions are still valid. The model and plan should be updated and verified with any significant changes to the system.

** All of the report figures are found on fold-out pages in Appendix A*

2 EXISTING SYSTEM EVALUATION

2.1 INTRODUCTION

The evaluation of the existing sewer collection system included mapping the system, collecting flow data at key locations in the system, and creating a computer hydraulic model to simulate the actual flow conditions. The hydraulic model was built using InfoSWMM Version 5.1 software created by Innovyze. InfoSWMM is fully integrated into ESRI ArcGIS software which allows for easy assimilation of other city mapping that is contained in GIS shape files. The ArcGIS software used during the model creation was Version 10.2.2. The model allows the system to be evaluated to assess the existing hydraulic conditions of the modeled trunk lines.

Not all of the sewer lines in the City were modeled. Sanitary sewer lines were selected for modeling based on the amount of area they serve. The lines modeled are considered trunk lines since they carry flows from several contributing lines and have contributing areas that could produce flows that are greater than the capacity of an 8-inch pipe. Minor lines serving smaller areas are mapped, but not modeled since the probability of those lines having sufficient capacity now and in the future is very high. For example, an 8-inch line at minimum grade flowing half full will serve more than 300 residential units. Minor lines that will never serve more than 300 Equivalent Residential Units (ERU's) will always have adequate capacity.

2.2 EXISTING SYSTEM MAPPING

The existing collection system has been mapped (Figure 1: Existing System*) as part of this project based on existing data. Existing mapping was collected from the City GIS maps and record drawings.

The following items are included in the mapping:

- Aerial image of the city
- Existing major gravity sewer lines
- Existing pressure sewer lines (force mains)
- Locations of minor sewer lines (not modeled)
- Existing lift stations and associated force mains
- Existing Nibley City limits
- Study area boundary

** All of the report figures are found on fold-out pages in Appendix A*

- Locations of temporary flow meters installed to gather flow data for the model calibration
- Street labels

Meetings were held with City staff during the model creation to review sewer record drawings, identify where other lines exist that are not shown on the record drawings, and determine which sewer lines could potentially serve significant areas to be developed in the future. The lines that were identified as major lines are included in the hydraulic model. As previously stated, minor lines are mapped but not modeled.

2.3 Winter Flow Metering

Flow data is critical for calibration of a model and understanding the system. Winter flows are typically less influenced by groundwater infiltration or irrigation water infiltration and are used to determine the base sanitary flows. Temporary flow meters were installed during November and December of 2013 at strategic locations throughout the collection system to measure flows in the system.

2.3.1 Meter Equipment

For this master plan J-U-B rented three Hach 910 area velocity flow monitors. The Hach 910 monitors measure depths and velocities to calculate flow. These meters provided flow data at five minute intervals during a three week monitoring period.

2.3.2 Meter Locations

The locations of the three temporary meters are listed in Table 2-1 and shown in Figure 1: Existing System*.

** All of the report figures are found on fold-out pages in Appendix A*

Table 2-1: Flow Meter Sites

FLOW METER SITES			
METER ID	**LOCATION**	**PIPE DESCRIPTION**	**TYPE OF CONTRIBUTING FLOWS**
*B9	APPROX. 1180 WEST 2200 SOUTH	10" PVC	Residential. A very small number of homes currently contribute to this site.
A3	IN VACANT LOT AT APPROX. 2400 SOUTH JUST WEST OF HERITAGE DRIVE. ABOUT 250 FEET SOUTH AND 60 FEET WEST OF HANSEN LIFT STATION	21" PVC	Mostly residential with a small amount of commercial and industrial area. 3 pump stations are located upstream.
C2	IN FIELD APPROX. 500 FEET SOUTH EAST OF THE CENTER OF HWY 89/91 AND APPROX. 600 FEET SOUTH OF THE CENTERLINE OF 2600 SOUTH STREET	12" PVC	Mostly residential with a small amount of commercial and industrial area. 2 pump stations are located upstream.

*Meter B9 was initially installed at manhole B8 (1241 West 2200 South). The meter was moved to manhole B9 on November 26th because there was too much silt in manhole B8. The silt was covering the meter probe preventing it from gathering velocity data.

The meter locations are identified using the same numbering system that the City uses for all of the manholes in the collection system. The areas that contribute flows to each of the three temporary flow meter sites are shown in Figure 2: Meter Collection Areas*. Portions of the contributing areas to meters C2 and A3 overlap.

The three meter locations were chosen to provide a representation of the flows throughout the collection system at the same time. This allows for a more accurate representation of actual flow conditions as flow peaks and volumes typically vary from day to day. Sites B9 and A3 were selected because the combined flow from these two sites goes through the permanent meter at the Hansen Lift Station and represents all of the flows in the collection system. The combined total flow from these two sites can be compared to the flows at the Hansen Lift Station permanent meter. Site C2 was selected because a lot of future development and associated flows will be added upstream and pass through the "C" trunk line. The data from Site C2 provides better understanding of the excess capacity available for future growth in that line.

** All of the report figures are found on fold-out pages in Appendix A*

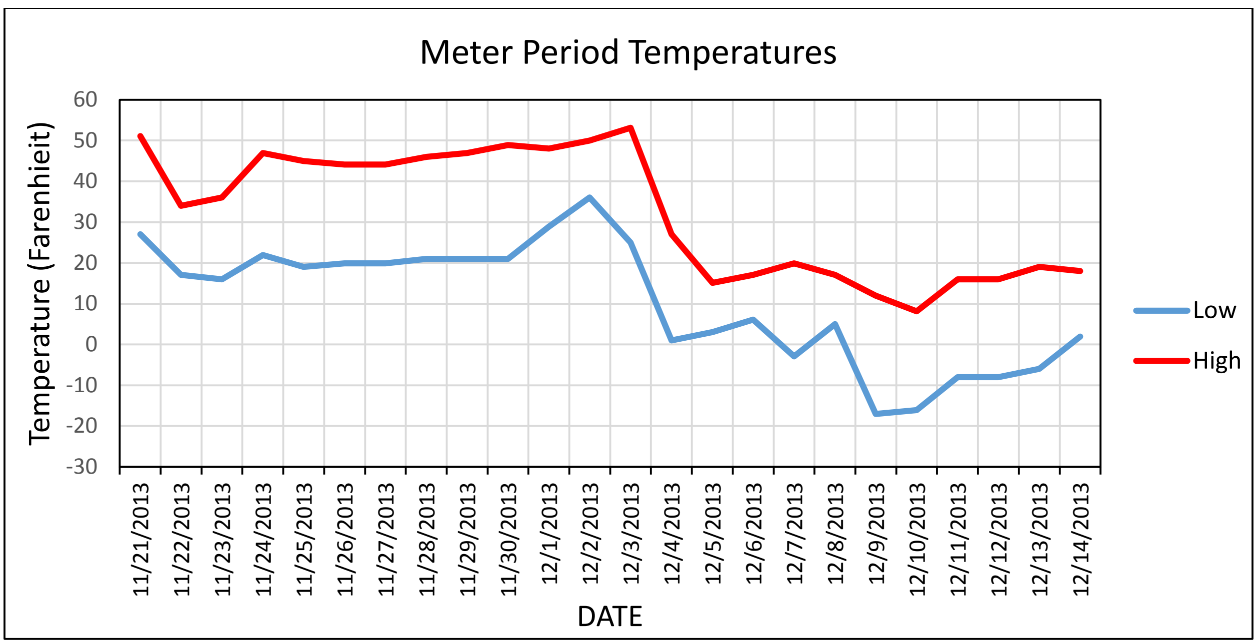
2.3.3 Meter Schedule

The temporary flow meters collected flow data from November 21, 2013 through December 14, 2013. This meter period included the Thanksgiving holiday. Thanksgiving has been found to be the day with the highest peak flows in some collection systems in the state. Thanksgiving produced high flows in Nibley with the peak on Thanksgiving being slightly higher than the peaks on the weekends.

2.3.4 Meter Weather Conditions

No major precipitation events occurred during the meter period and the weather was generally cold. Graph 2-1 shows the high and low temperatures recorded for each day of the meter period as recorded by the Utah Climate Center COOP Station USC00425194. This station is located at the Caine Dairy (Approximately 3600 South HWY 89).

Graph 2-1: Temperatures during Temporary Flow Metering



2.4 Winter Flow Meter Data Analysis

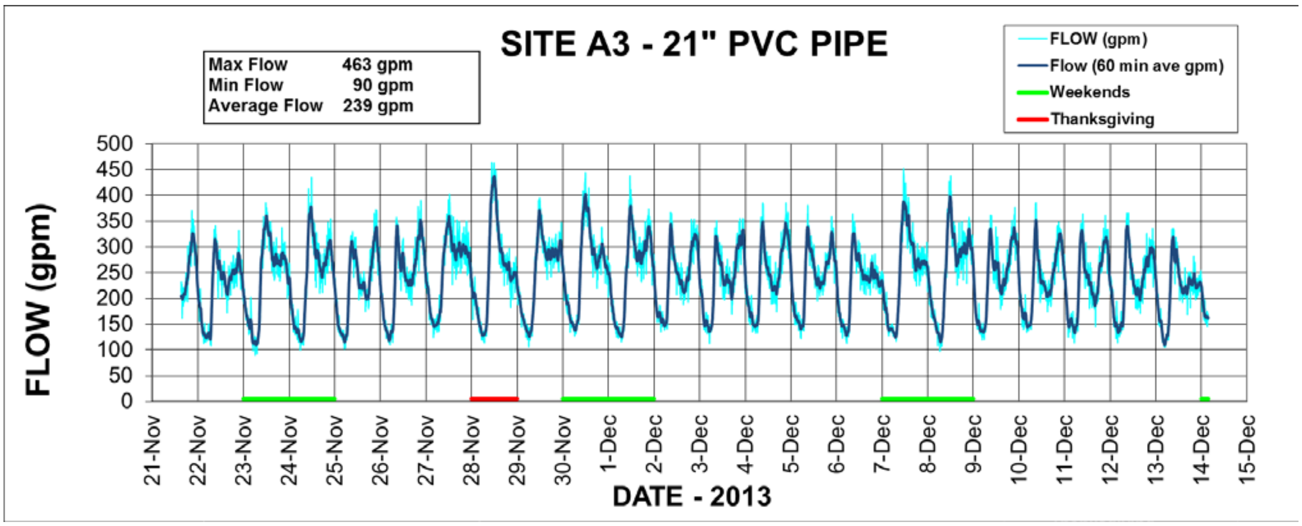
The data collected from the winter flow meter data was graphed and analyzed. Some site specific conclusions were drawn from the data and given in the following sub-sections. The meter sites are identified according to the manhole numbering convention that the City utilizes.

For each site, a Flow-versus-Time graph is given along with a graph that shows the Velocity-versus-Level scatter plot. Larger copies of these graphs are included in Appendix B along with Level and Velocity-versus-Time graphs and graphs that show only Velocity-versus-Time for each site.

2.4.1 Meter Site A3 (Just south of Hansen Lift Station)

The flows recorded by the temporary meter installed in manhole A3 are plotted in Graph 2-2.

Graph 2-2: Site A3 Flow-versus-Time



Site A3 collects most of the flows in the city but does not include the small volume of flow that comes from the north into the Hansen Lift Station (Figure 2: Meter Collection Areas*). Some conclusions drawn from the data collected at this site are:

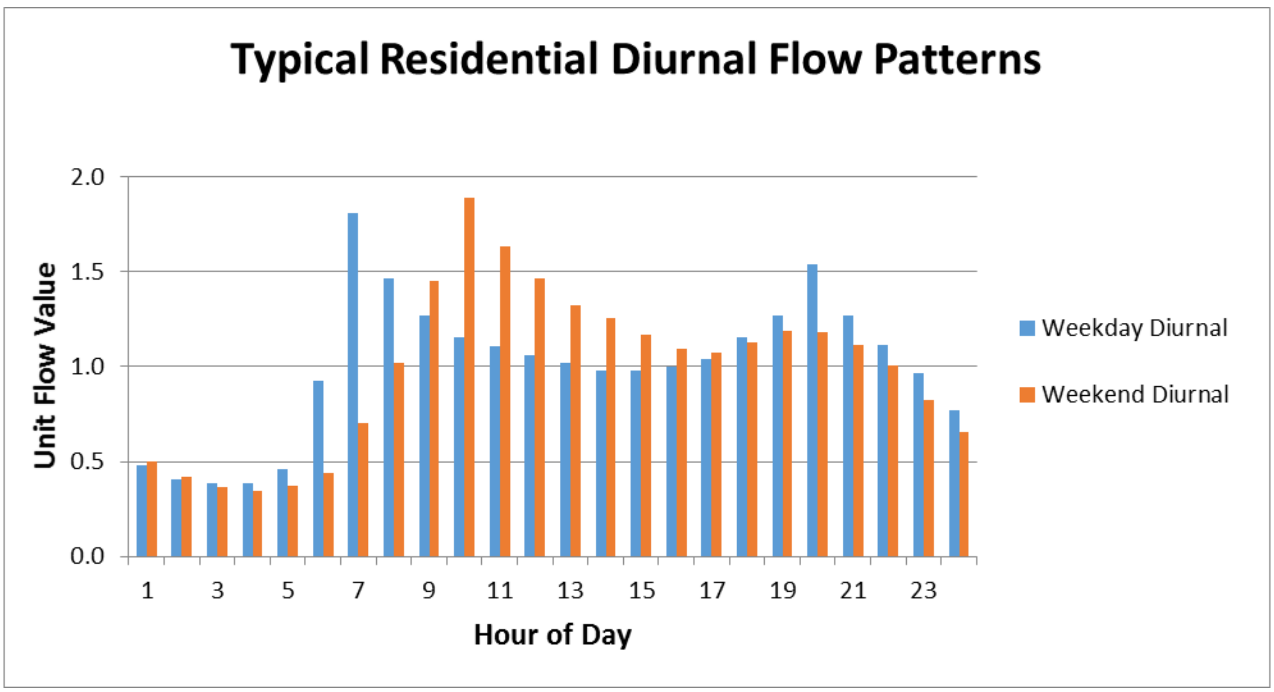
- The peak flows recorded during the weekends are higher than the weekday flows, which is consistent with typical residential flow patterns.
- Thanksgiving produced a peak flow that is slightly larger than the flows that were recorded on the weekends at this site. The peak flow recorded on Thanksgiving was 460 gallons per minute (GPM). The peak weekend flow recorded was 450 GPM and occurred on Saturday December 7, 2013. These flows are statistically the same given the margin of potential error in the flow meters.

** All of the report figures are found on fold-out pages in Appendix A*

- Some small pumping peaks can be seen at this site from the lift stations upstream. The most notable pump peaks occurred on December 7th at about the same time as the gravity peak. The pump peaks added 50 to 75 GPM at this meter site.
- The estimated amount of groundwater flow from infiltration at this point is 80 GPM based on the amount of flows recorded in the early morning hours of each day (Graph 2-2).
- The recorded flows range between 90 GPM and 460 GPM with a flow pattern that is very typical for an area that is largely residential.

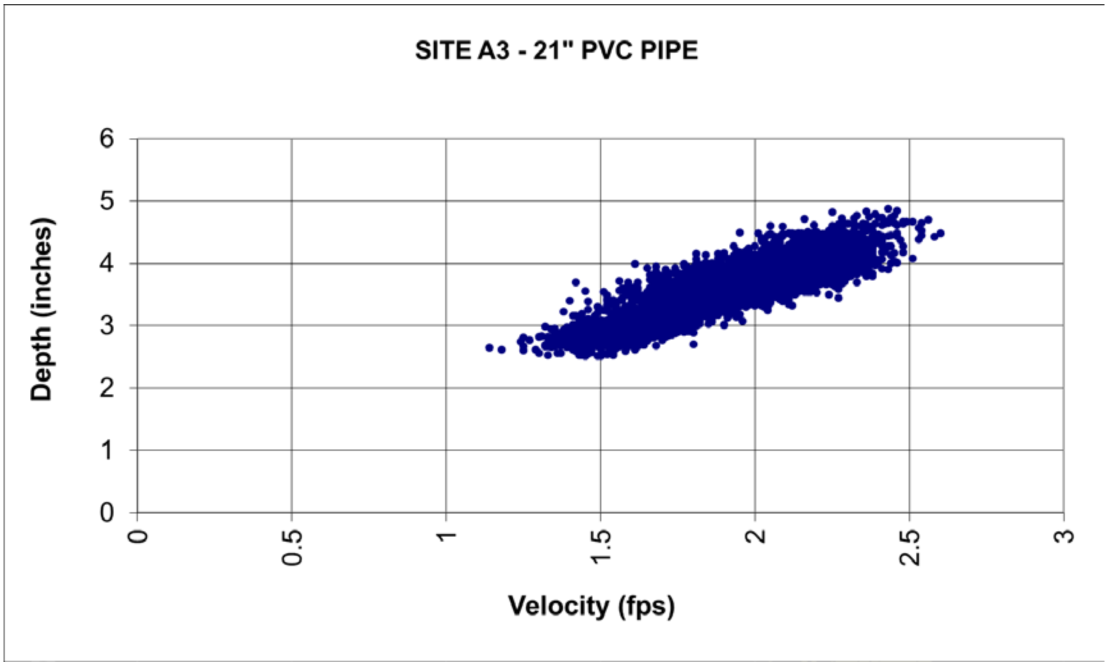
Graph 2-3 shows typical residential flow patterns for a weekday and a weekend day that have been developed based on past flow meter data collected by J-U-B from residential areas in other cities.

Graph 2-3: Typical Residential Flow Patterns



The data collected at Site A3 has good velocity to depth correlation as indicated by the tight scatter of points on the velocity-versus-level scatter plot in Graph 2-4.

Graph 2-4: Site A3 Depth-versus-Velocity



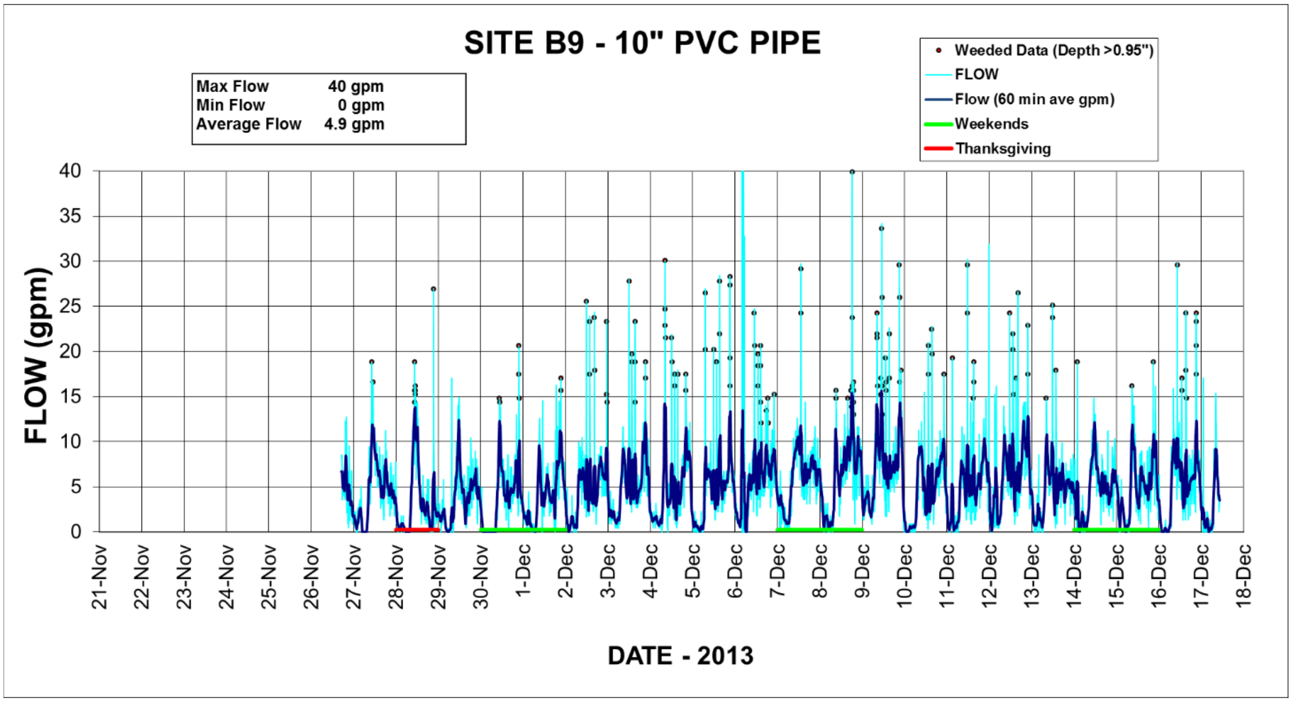
2.4.2 Meter Site B9 (1182 West 2200 South)

The flows in this trunk line are small because there is not a lot of developed area upstream (the area is too small to accurately measure with the flow meters used for the data collection). Manhole B8 was initially used for the placement of this meter. The flow velocities in manhole B8 were very slow causing sediment to build over the top of the meter which prevented the meter from gathering flow velocity data. Five days after installation the meter was moved upstream to manhole B9 because a suitable manhole could not be found downstream on the same line. Because this meter was moved upstream, the flows in the pipe were reduced because fewer homes contribute to manhole B9. Most of the data points logged at this location (Manhole B9) are not usable because the depth of flow in the pipe was less than one-inch for most of the meter period.

The flows need to be at least an inch deep for the meter to give an accurate flow calculation. This is because the area velocity probe that is placed in the bottom of the pipe is approximately one-inch tall. Also the depth sensor on the meter could not be accurately calibrated during installation because of the shallow flows.

The flows recorded by the temporary meter installed in manhole B9 are plotted in Graph 2-5.

Graph 2-5: Site B9 Flow-versus-Time



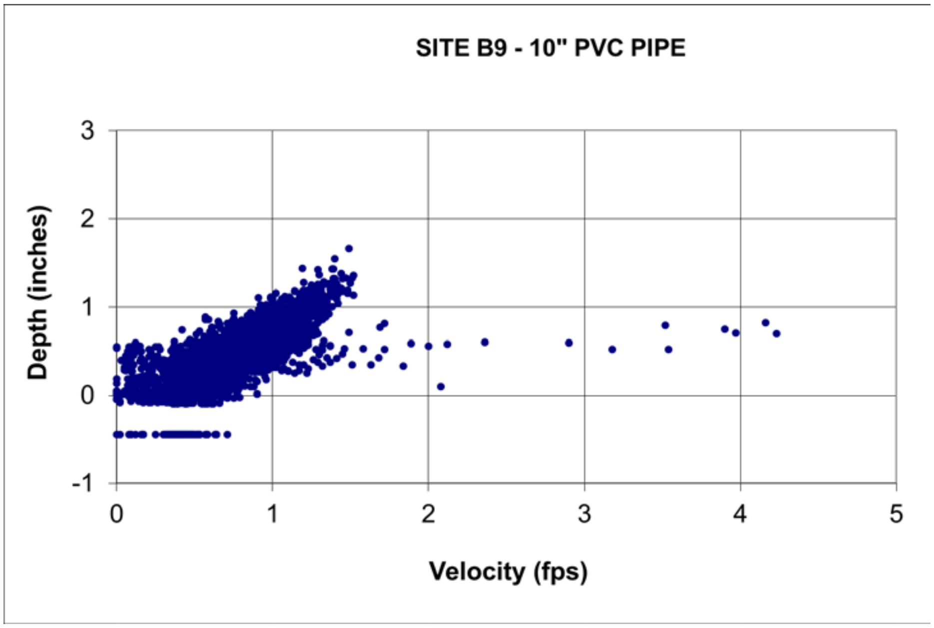
Site B9 collects data form the northwest corner of the City (Figure 2: Meter Collection Areas*). Some conclusions drawn from the collected data at this site are:

- The low flows at this manhole indicate that the collection system has very little infiltration upstream of this location.
- This meter recorded some flow spikes when the depths were greater than one-inch, which are probably closer to the actual flow magnitudes at this site. The accuracy of the flow spikes is still questionable because there was not enough flow in this pipe to get an accurate depth of flow measurement to calibrate the flow meter during installation.

The Depth-versus-Velocity Scatter graph for the data points recorded at this site is shown in Graph 2-6.

** All of the report figures are found on fold-out pages in Appendix A*

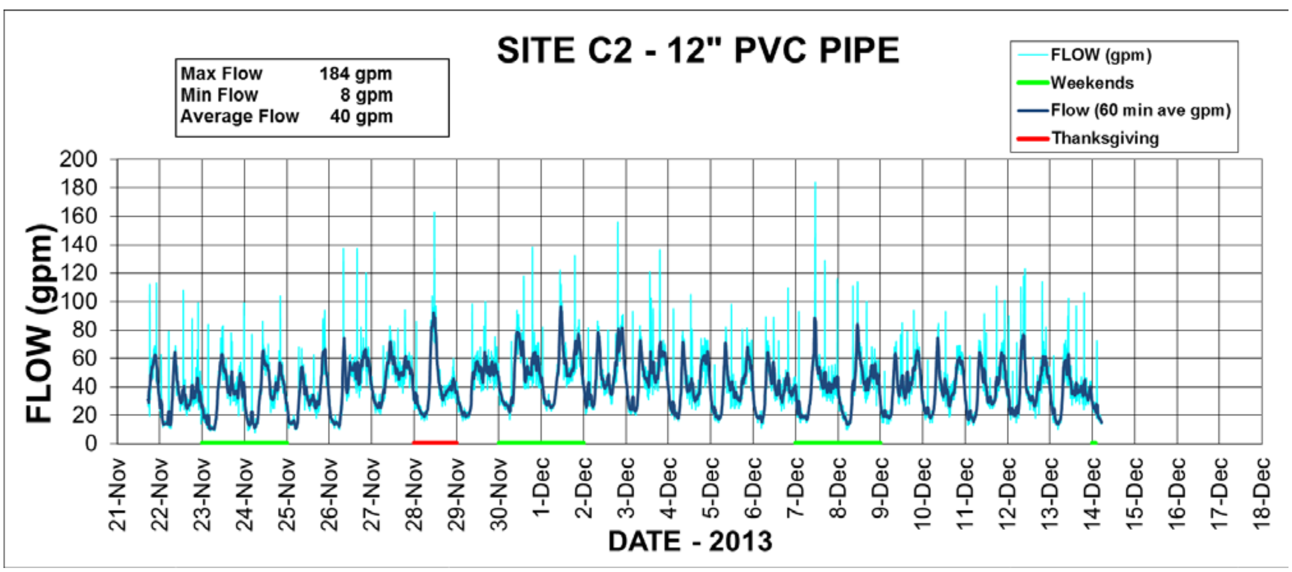
Graph 2-6: Site B9 Depth-versus-Velocity



2.4.3 Meter Site C2 (In field at approximately 2700 South 1650 West)

The flows recorded by the temporary meter installed in manhole C2 are plotted in Graph 2-7.

Graph 2-7: Site C2 Flow-versus-Time



- Site C2 collects flows from the southwest corner of the city (Figure 2: Meter Collection Areas*). The contributing area to this site currently is not large, but most of the large undeveloped area to the south of the city may be served through this

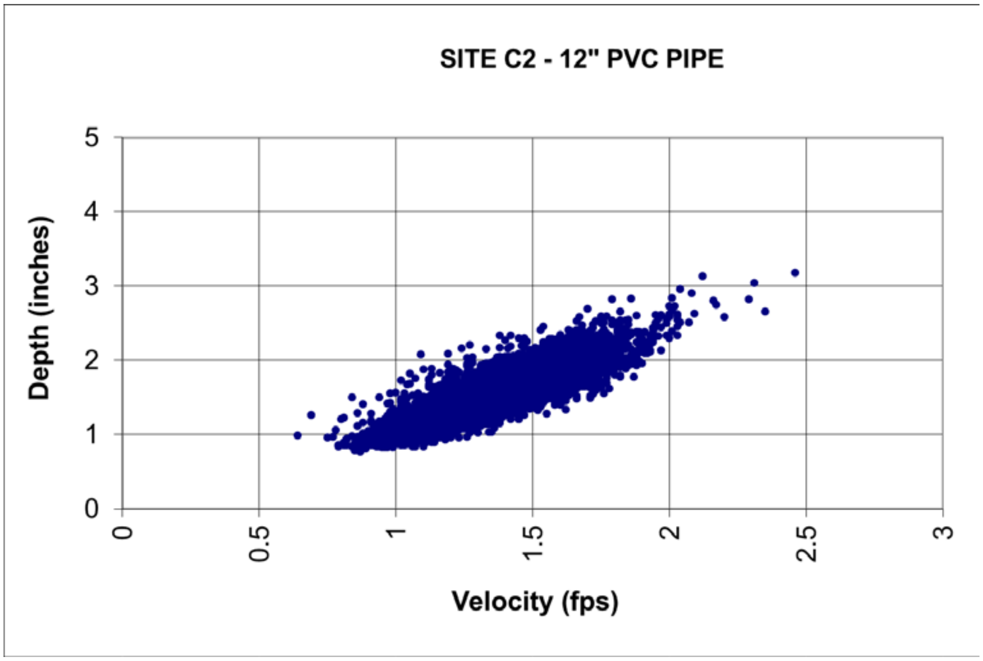
* *All of the report figures are found on fold-out pages in Appendix A*

"C" trunk line in the future. Some conclusions drawn from the data collected at this site are: The recorded flows range between 10 GPM and 180 GPM with a flow pattern that is very typical for an area that is largely residential (Graph 2-3).

- The peak gravity flows recorded during the weekends were higher than the weekday flows, which is typical.
- The overall peak flow at this site occurred on Saturday, December 7th because pumped flows from the Peterson Lift Station and from the Caine Dairy Lift Station both passed through this site at approximately the same time as the gravity peak flow. These conditions produced a peak flow of 180 GPM at this meter site. This peak was larger than the peak that was recorded on Thanksgiving. This is important to note for the master planning process because Nibley City needs to have a model that accounts for situations where small pumping peaks pass through the system at the same time. Collection system pipes need to be sized to accommodate these pumping peaks.
- Some peaks can be seen at this site from upstream pump stations. Some of the peaks are larger than others indicating that flows from both of the upstream lift stations were passing the meter site at the time the data point was recorded. Other peaks are smaller, indicating that flows were passing the meter site from only one of the upstream lift stations. The combined peaks from the upstream pump stations added about added 90 to 120 GPM of flow at this meter site. The peaks were separated by five to ten minutes. If the two peaks had hit this site at exactly the same time the gravity flows may have been increased by 125 to 155 GPM creating a total peak flow at this site of about 215 GPM.

The data collected at this site has good velocity to depth correlation as indicated by the tight scatter of points on the Velocity-versus-Level scatter plot in Graph 2-8.

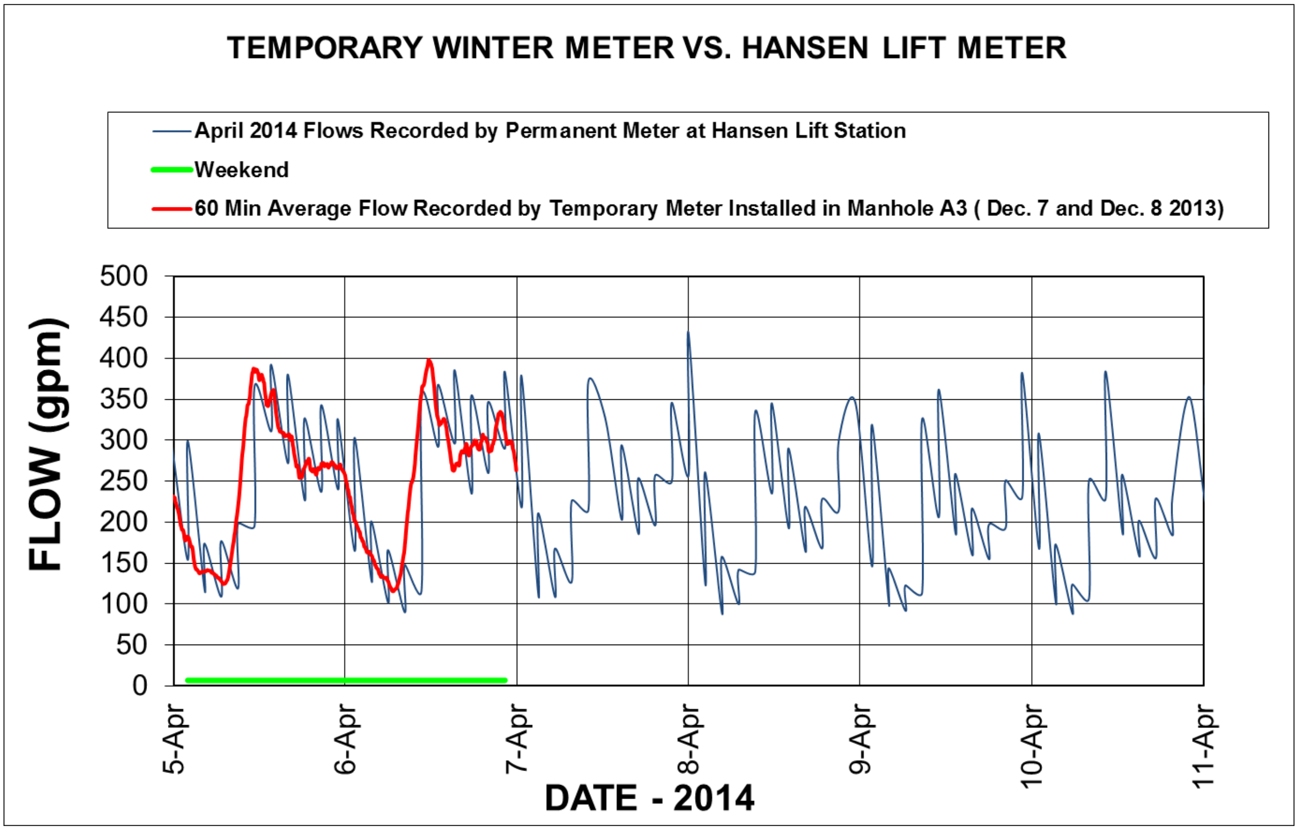
Graph 2-8: Site C2 Depth-versus-Velocity



2.4.4 Temporary Meter Flows Compared to Permanent Hansen Meter

The Hansen Lift Station has a flow meter that records the incoming sewer flows from the entire City. In the spring of 2014, the City installed a new SCADA system that allows City staff to monitor and review the City's flows. The meter was calibrated in March of 2014. Graph 2-9 compares the flows measured by the temporary meter installed in manhole A3 in the winter time with flows measured by the permanent Hansen Lift Station meter in April 2014.

Graph 2-9: Hansen Lift Station Flows-versus-A3 Temporary Meter Flows



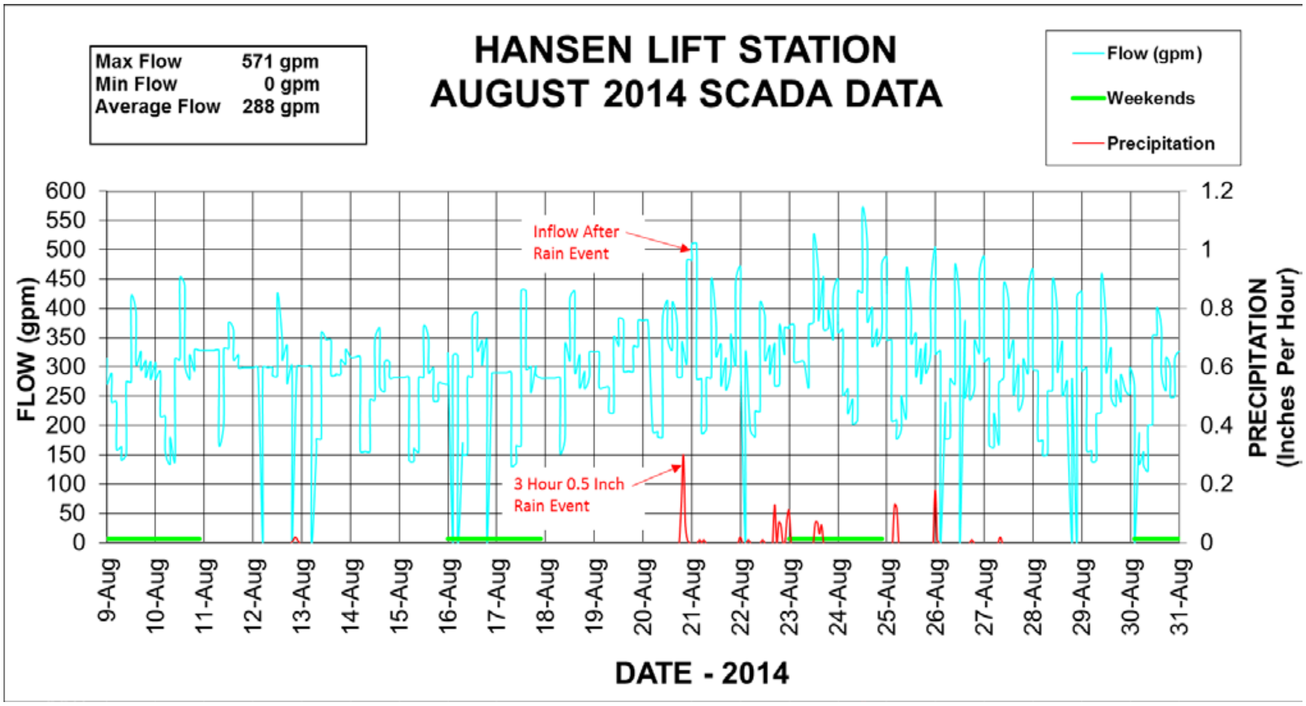
The flows recorded by the temporary meter at A3 do not include the flows from the "B" trunk line, but those flows are small. The peak winter hour flows from the "B" trunk line are most likely less than 40 GPM based on assumptions that were used to calibrate the model to match flows from the other meters.

2.5 Summer Infiltration Rates

Summer time flows are often different than winter flows in sewer collection systems due to seasonal changes in groundwater infiltration rates. In Nibley there are many irrigation canals that carry water only during the summer months. With so many canals that run close to sewer collection lines, there is potential to have irrigation water infiltrate into the sewer collection system.

Sewer flows recorded during summer months at the Hansen Lift Station were evaluated to estimate summer infiltration rates. The highest night time base flows that were recorded during the summer of 2014 occurred in the month of August. This is probably partly due to the fact that August was a fairly wet month in terms of precipitation. It is possible that some basement sump pumps push water into the sewer system during wet periods of time. Graph 2-10 shows the flows recorded during a week in August at the Hansen Lift Station.

Graph 2-10: Summer Flows at Hansen Lift Station



The night time flows that were recorded in August were close to 150 gpm including a week long period from August 18th through August 25th with night time flows around 200 gpm.

2.6 Inflow From Rain

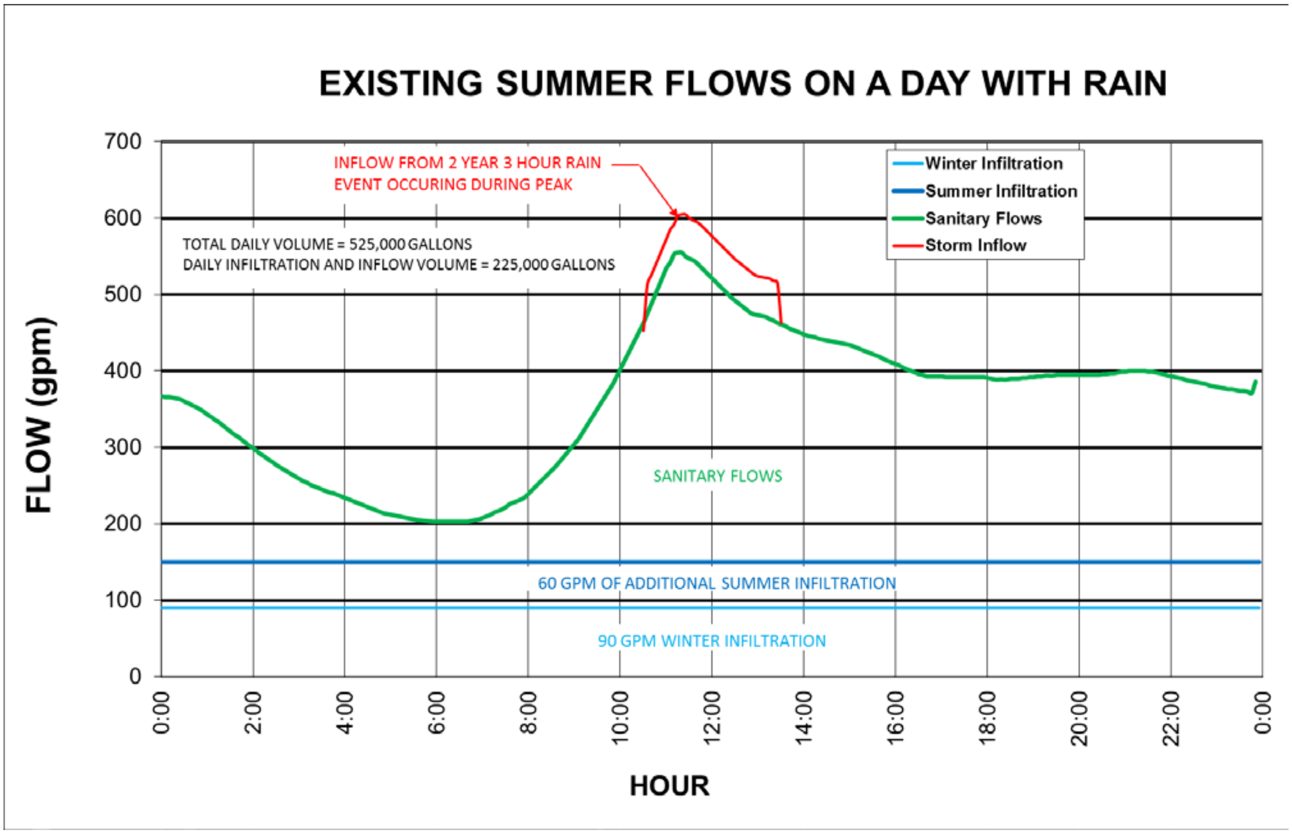
Flows in sanitary sewer systems often also increase as a result of rain storms. Collection systems need to be designed to convey daily peak sanitary flows (quantified using winter flow data) plus the peak seasonal infiltration and any inflow that may enter the system during a rain event.

Many rain events occurred in Cache Valley during the month of August 2014 (Graph 2-10). The Logan-Cache Airport has a permanent rain gauge that records precipitation on an hourly basis. Data from this rain gage was evaluated and graphed for the month of August to see when significant rain fall occurred. The largest event recorded during that time was more or less a 2-year, 3-hour storm that produced 0.5-inches of rain fall on August 20th between the hours of 6:00 p.m. and 10:00 p.m. During the storm, the city SCADA system at the Hansen Lift Station recorded an increase in flows of roughly 50 GPM.

2.7 General Flow Data Conclusions

Some general conclusions can be drawn from the flow data that was collected during the winter metering period and the summer data collected by the SCADA system at the Hansen Lift Station. These conclusions are listed below and illustrated in Graph 2-11.

Graph 2-11: Summer Flows on a Day with Rain



- **Winter Infiltration -** The amount of winter infiltration in the system is assumed to be equal to the amount of flow recorded at the temporary flow meter sites during the very early morning hours when most of the people in the city are asleep. Infiltration consists of groundwater that enters into the sewer system through open joint pipes, cracks in pipes, faulty service connections, leaky manhole joints and poor seals at the connections between pipes and manholes. Water from winter groundwater infiltration to the collection system accounts for approximately 90 GPM of flow in the collection system at the Hansen Lift Station.

- **Summer Infiltration Rate–** Infiltration increases in the summer by approximately 60 GPM for a total infiltration rate of 150 GPM at the Hansen Lift Station. The irrigation season usually starts in May and ends near the end of September.
- **Inflow From Rain –** Inflow is non-sanitary flow that enters the sewer collection system as a result of rain. This flow can enter the system through vented sewer lids, from sump pumps connected to the sewer system, from roof drains, or other connections. In order to estimate the effects of rain on the collection system flows, the sewer flows recorded by the permanent meter installed at the Hansen Lift Station were analyzed at times when significant rain events occurred at the weather station located at the Logan-Cache Airport. During a 2-year, 3-hour August 20, 2014 storm with 0.5 inches of precipitation, the Hansen Lift Station recorded an increase in flows of roughly 50 GPM.

A new rain gage in Nibley would provide more accurate rainfall information for Nibley City than the Logan-Cache Airport meter. The more localized data could be compared with the sewer flows recorded at the Hansen Lift Station to see how storms affect the flows. For example if a 10-year 4-hour storm was recorded, the flows at the Hansen Lift Station could be checked and the affects from that storm could be quantified.

- **Daily Volumes –**Daily flow volumes are estimated in Table 2-2 based on the flow data evaluation.

Table 2-2: Daily Volume Estimates with 2-year, 3-hour Storm

Daily Volume Estimates with 2-year, 3-hour Storm					
	Sanitary Daily Volume (Gallons)	I&I Daily Volume (Gallons)	Total Daily Volume (Gallons)	Volume per ERU (Gallons)	I&I Percentage of Total Volume
Winter Flows	300,000	130,000	430,000	280	30%
Summer Flows	300,000	225,000	525,000	342	43%

The daily volumes vary day to day depending on the season, weather conditions and other factors. The assumptions used to define an ERU are given in Section 2.8.6. Nibley should utilize the flow data that is now being collected at the Hansen Lift Station to further evaluate and to refine the daily volume estimates over time as more data is recorded.

- **Flow Patterns** - Nibley's gravity flow patterns are similar to other communities with weekends that produce higher peak flows than weekdays. The measured overall peak flow at the bottom of the system on Thanksgiving was slightly higher than the weekends that were recorded, however the difference was not significant.

2.8 LIFT STATIONS - THE THREE LIFT STATIONS THAT PUMP INTO THE COLLECTION SYSTEM DO HAVE SOME EFFECT ON PEAK FLOWS, AND PIPE CAPACITY AT THEIR POINTS OF ENTRY. HOWEVER, THESE PUMP PEAKS ARE SHORT IN DURATION AND DO NOT ADD LARGE VOLUMES OF FLOW TO THE SYSTEM. THE PEAK FLOWS FROM THE LIFT STATIONS ATTENUATE (REDUCE IN PEAK) FAIRLY QUICKLY AS THEY MOVE DOWN THROUGH THE COLLECTION SYSTEM. COMPUTER MODELING

A computer model was created using InfoSWMM 5.1 modeling software which is a product of Innovyze Incorporated. The model was created to simulate the existing system and flow conditions and to check the capacity of the system under projected future flow conditions. The model was calibrated to match the flow data that was collected by the flow meters. Further discussion of the hydrographs and model calibration is included in the following sections.

2.8.1 Existing System Key Modeling Assumptions

A computer model of a sewer system is based on assumptions that characterize the area and system components. The key assumptions used in the Existing System Model are as follows:

- **Model Building Units** - Current commercial, industrial, and residential units were counted using 2013 aerial imagery from Aero-Graphics Incorporated and dated November 24, 2013. These numbers were then reviewed with Nibley public works staff.

- **Model Population (5,977)** - The population used for the existing model is 5,977 based on the number or residential units multiplied by 3.8 people per dwelling unit. The number of people estimated per dwelling unit was provided by Nibley City.

  The population used for the model was compared to an estimated population that is based on 2010 census data and an assumed growth rate provided by the City Planner of 3.5% per year.

  - 2010 census population = 5,438

- Estimated 2013 city population = 6,029

The model population of 5,977 is slightly smaller than the estimated city population, but there are a few homes in the model study area that are not connected to the sewer system.

- **Model Sanitary Flow Per Capita (60 GPCD) -** The average wastewater flow (excluding I&I) was estimated to be 60 gallons per capita per day (GPCD) for typical residential units. This value is based on the flow monitoring results. This number was derived during the model calibration process to match the flows collected by the temporary flow meters.

I&I was added to the model based on contributing areas to match the flow data recorded by the temporary flow meters and by the permanent Hansen Lift Station meter. The total estimated amounts of I&I are graphed and explained in Section 2.7 and shown in Graph 2-11. I&I was added using units of gallons per contributing acre per day (GPAD).

- **Model Winter Infiltration (97 GPAD) -** Based on the temporary winter meter results, the winter night time flows were approximately 100 GPM near the Hansen Lift Station. It was assumed that infiltration adds a constant flow of 90 GPM during winter months. The entire current contributing service area of 1,326 acres generates approximately 97 GPAD for the flow of 90 gallons per minute.

- **Model Total Summer Infiltration (163 GPAD) -** The city started recording flow data at the Hansen Lift Station in the spring of 2014. The night time base flows increased from roughly 90 GPM during the winter to 150 GPM during the summer based on data that was recorded at the lift station through the summer of 2014. The entire current contributing service area of 1,326 acres generates approximately 163 GPAD during the summer months.

- **Model Inflow (Flow of 54 GPAD for a 3-hour Period) -** During a 2-year, 3-hour, August 2014 storm with 0.5-inches precipitation, the Hansen Lift Station recorded an increase in flow of roughly 50 GPM. Based on the current system service area of 1,326 acres, the average rate of inflow is 54 GPAD for a period of three hours. The 3-hour rain event is placed in the model around mid-day because that is when the peak sanitary flows occur on a weekend. This was done to account for rain inflow that may occur during peak flow times.

- **Model Total Summer I&I (217 GPAD)** - The total volume of I&I per contributing acre on a summer day that includes a 2-year, 3-hour rain event is approximately 217 gallons.

- **Non-Residential Flows –** Because peak flows occur on weekends, the models are set up to simulate weekends. Most commercial entities in Nibley are closed on weekends, so the only non-residential flows that are included are from the Peterson Lift Station and the Caine Dairy Lift Station. The model should be updated and adjusted appropriately as the character of development in the city changes in the future.

2.8.2 Model Development

The model input consists of three drawing layers; the system layer, the service area layer, and the parcel data layer. These three layers were created using ESRI ArcGIS 10.2.2 software and then were imported into the InfoSWMM software.

- **System -** The system layer contains a geometric map of the sewer system and a database that holds information about the sewer system, such as pipe length, pipe diameter, manhole rim elevation, and pipe invert (flow line) elevations. The system layer was built using survey data and other GIS data (pipe sizes etc.) provided by the City (Figure 1: Existing System*).

- **Service Areas -** The service area layer was created to split the City into smaller sewer drainage basins to determine where sewer flows are collected by the existing sewer system and where areas to develop in the future will be collected. This layer identifies where flows are added into the modeled collection system. The service areas were determined based on the current layout of the sewer system and area topography. Figure 3: Service Areas* shows the existing and future service areas used for the models and indicates which manholes receive the flows from each of the service areas.

- **Parcel Data -** The parcel data layer generates the sewer flows in the model. It contains the flow generating information such as population, contribution per capita, and land use. Each of the developed parcels was assigned to one of the following land use types and associated daily use pattern (diurnal curves):

    - Agriculture Preservation
    - Commercial

- Industrial
- Institutional and Public Lands
- Neighborhood Center –Mixed Use
- Neighborhood Commercial
- Park and Open Space
- Residential
    - Medium Density
    - Low Density
    - Rural

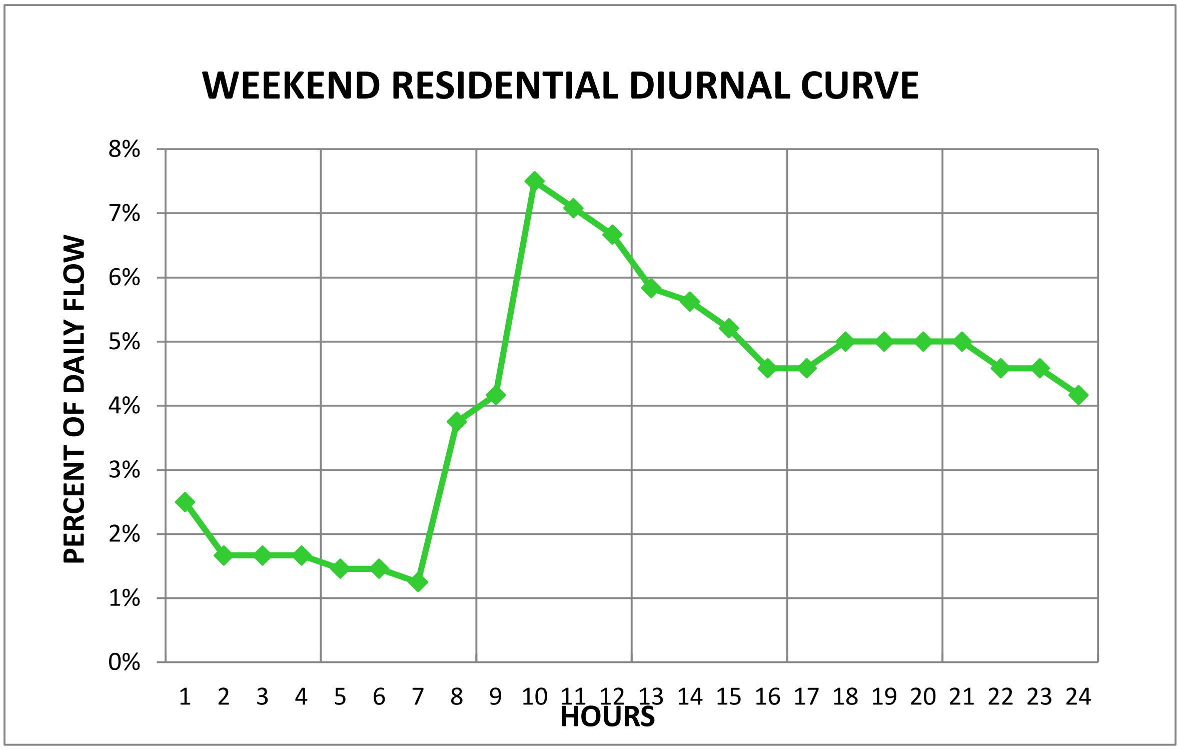
The land uses in the model are based on the planned future land uses that are shown in Figure 4: Land Use*. The undeveloped parcels do not contribute flows in the existing model.

2.8.3 Diurnal Flow Patterns

Sewer flows vary throughout the day. The shapes that are formed as a result of graphing flows verses the time of day are known as diurnal hydrographs or diurnal curves. Graph 2-12 below shows the weekend residential diurnal curve that was used in the model to match the shape of the metered flows.

** All of the report figures are found on fold-out pages in Appendix A*

Graph 2-12: Residential Diurnal Curve



The diurnal curve allows the modeling software to quantify the flow throughout the day for the various types of land use. The diurnal flow pattern shown in Graph 2-12 represents only the sanitary residential flows and does not include I&I flows.

2.8.4 2014 Winter Model Analysis

The computer model was calibrated to match existing winter flow conditions as recorded by temporary flow meters (Section 2.4). More specifically, the model was calibrated to match the flows that were recorded on Saturday, December 7th. This day was chosen because it produced the highest flow recorded at Site C2 and Site A3. It is prudent to calibrate sewer flow models to match days with high flows to help ensure that the collection system has adequate capacity now and in the future.

Calibration involved an iterative process of superimposing Site A3 and Site C2 metered flow graphs from December 7th over the model-generated diurnal flow curves. Then the flow generating model parameters (contribution per capita, infiltration etc.) were adjusted to match the metered flows.

** All of the report figures are found on fold-out pages in Appendix A*

Infiltration flows were then added to match the base flows that were present during the metering period. The amount of infiltration added is given in Section 2.8.1.

The model calibration process included adding the pump parameters from the four existing lift stations (Figure 1: Existing System*) to simulate the pumped flows within the system. The flows from the lift stations were calculated based on data collected by the city public works staff. The staff went to each lift station and recorded the dimensions of the lift station wet wells, the time that the pumps ran, and the amount of drawdown in the wet well over a period of time. Table 2-3 summarizes the flow data for each lift station.

** All of the report figures are found on fold-out pages in Appendix A*

Table 2-3: Existing Lift Station Data

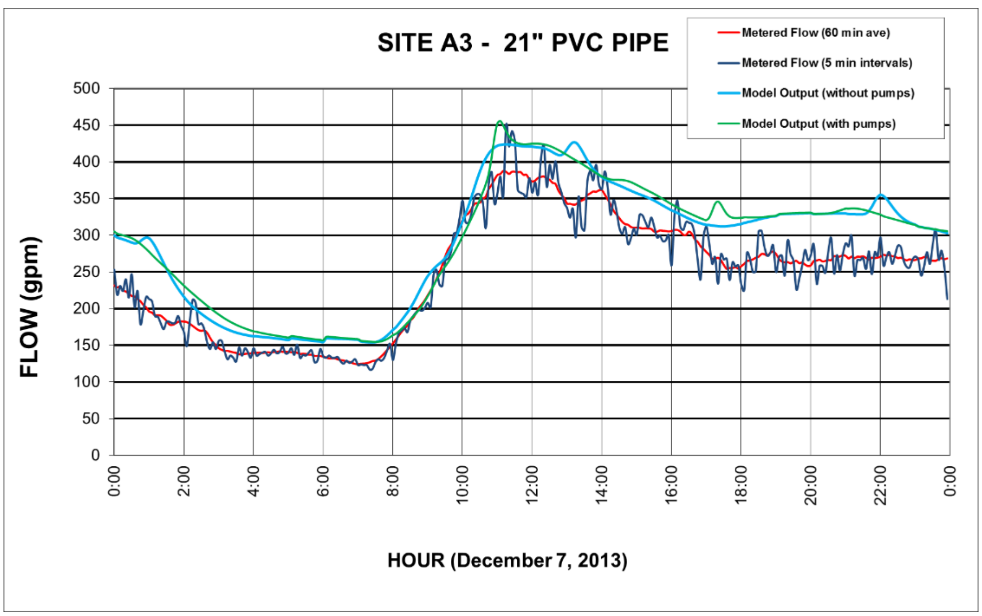
EXISTING LIFT STATION DATA							
Existing Lift Station Name	**Approximate Location**	***Wet Well Diameter (in)**	**Draw Down Depth (ft)**	****Time (min)**	**Wet Well Area (ft^3)**	**Wet Well Volume (gallons)**	**Flow (GPM)**
Scott Farm	3480 S. 780 W.	72	1	3.7	28.3	211	57
Caine Dairy	3600 S. HWY 89	90	1	2.8	44.2	330	118
Peterson	2690 S. HWY 89	96	1	1.9	50.3	376	194
Hansen	Heritage Drive just east of HWY 89	19'-8" X 13' Rectangle	3	4.4	767.1	5738	1314

*Dimensions taken from system record drawings.

**Times provided by Nibley City Staff.

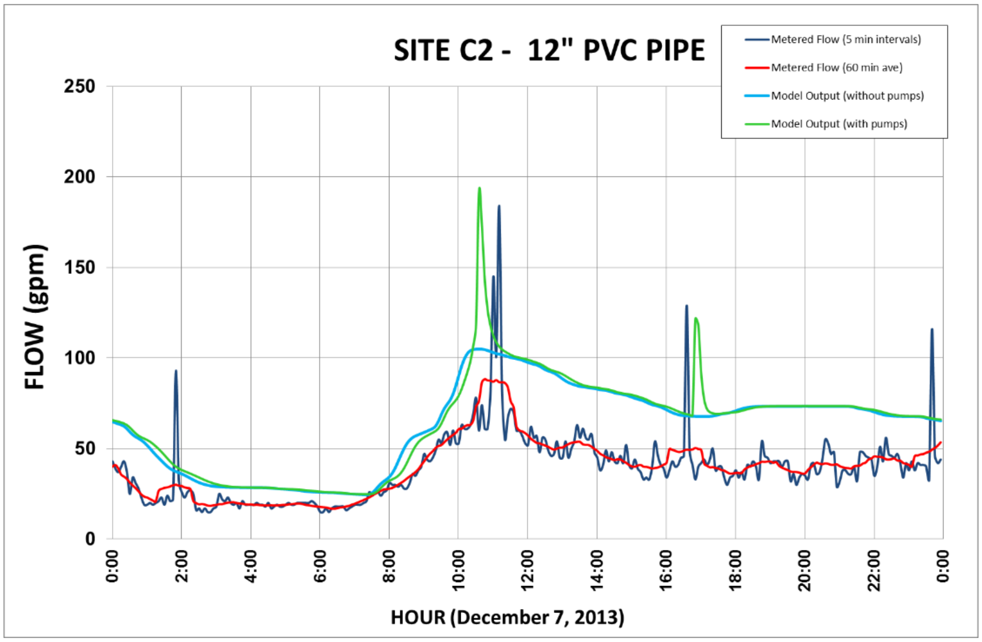
The model was ran multiple times and adjustments were made through an iterative process until the model flows matched the metered flows. Graph 2-13 shows the flows from the 2014 Winter Model compared to the metered flows from Site A3.

Graph 2-13: Site A3 2014 Winter Model Flows



Graph 2-14 shows the flows from the 2014 Winter Model compared to the metered flows from Site C2.

Graph 2-14: Site C2 2014 Winter Model

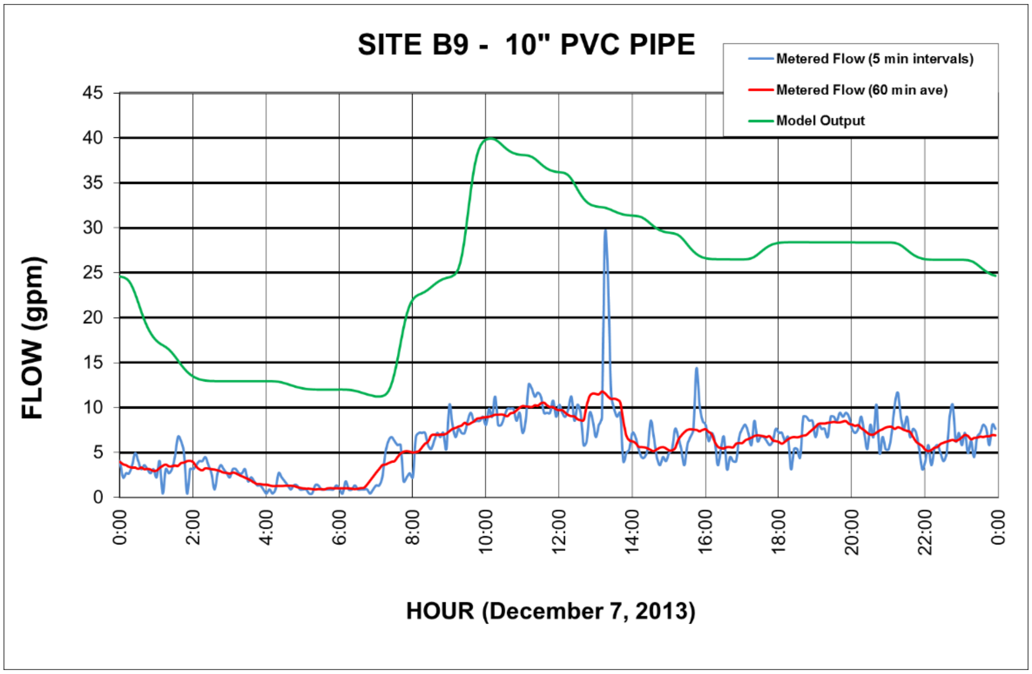


The flows from the model calibrated very closely to the measured flows from the meters at sites A3 and C2.

The flows measured by the temporary meter at site B9 were not large enough to give an accurate measurement during most of the meter period. However, many of the data points that were recorded by the meter when the flow depths were greater than one inch, correspond with the outputs of the model. The model flows for Site B9 are based on the model inputs and adjustments that were made to match the flows at sites A3 and C2. Graph 2-15 shows the flows from the 2014 Winter Model compared to the metered flows from Site B9.

** All of the report figures are found on fold-out pages in Appendix A*

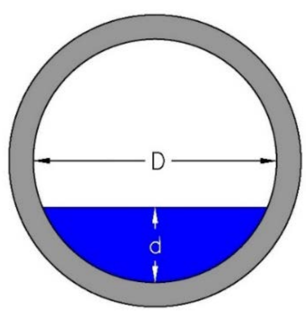
Graph 2-15: Site B9 2014 Winter Model



The flow spike recorded around hour 13:00 is probably more representative of actual flows at that time as the depths recorded then are actually deep enough to be read by the meter.

A quick way to display how well a collection system accommodates flows is by looking at the depth of flow in a pipe as a ratio of the pipe's inside diameter. The illustrated pipe shown in diagram 2-1 below represents a pipe flowing less than half full. A pipe that is full, or that has backwater from an over-capacity downstream pipe segment would have a d/D value of 1.0 or

Diagram 2-1: Depth of Flow (d) to Pipe Diameter (D) or d/D



greater. While a pipe flowing half full would have a d/D value of 0.5. Larger lines are able to handle more flows than are smaller lines, at equivalent d/D values, i.e., the larger lines have more reserve capacity per increment of d/D value. Figure 5: 2014 Winter d/D* shows the

** All of the report figures are found on fold-out pages in Appendix A*

existing depth of flow over diameter of pipe (d/D) for the analyzed sewer lines under 2014 winter conditions.

2.8.5 2014 Summer Model Analysis

The calibrated model is representative of winter sewer flows as metered during December of 2013. To create the 2014 summer model, additional flows from summertime infiltration were added. Inflow from a 2-hour, 3-year storm event were also added to the model. The 2014 summer model simulates the flows that could be present in the collection system at the peak time of day during a summer month and during a 2-hour, 3 year rain event. A very large rain event could produce higher flows than the flows in the existing model. Figure 6: 2014: Summer d/D* shows d/D for the analyzed sewer lines under 2014 summer conditions with the rain event.

Figure 7: 2014 Reserve Capacity* shows the reserve capacity in each of the existing pipes under 2014 summer flow conditions. These reserve capacities and other reserve capacity figures in this report are approximate based on the model results. They are given to help understand approximately how many more equivalent residential connections (ERU's) can be added upstream of each of the pipe segments as described below.

2.8.6 Peak Flow per Equivalent Residential Unit (ERU)

The peak flow per ERU was estimated to provide a tool that can be used to approximate how many more ERU's can be added upstream of a given pipe in the system. The actual peak flows vary throughout the system based on flow routing, so one peaking factor is not consistent throughout the collection system. The model should be maintained and updated as new development is proposed to verify that the system has adequate capacity.

In order to estimate the peak flow per ERU, an average residential lot size had to be assumed because the I&I is added to the model on a per acre basis. The assumed lot size used was two homes per gross acre. A residential area with one-third acre lots typically equates to an overall gross density of approximately two homes per acre because of the space the roadways occupy.

The following formula was used to determine the peak flow per average ERU.

** All of the report figures are found on fold-out pages in Appendix A*

Formula for Peak Flow Per ERU

$$\left(\frac{60\ Gal}{(Pers*Day)}*\frac{1\ Day}{24\ Hour}*\frac{1\ Hour}{60\ Min}*\frac{3.8\ Pers}{ERU}*1.8\ PF\right)+\left(\frac{0.068\ Gal}{Min*Ac}+\frac{0.04\ Gal}{Min*Ac}+\frac{0.038\ Gal}{Min*Ac}\right)*\frac{1\ Ac}{2\ ERU}=\mathbf{0.36}\frac{\boldsymbol{Gal}}{\boldsymbol{Min*ERU}}$$

UNIT ABBREVIATIONS

Gal = Gallons of flow	ERU = Equivalent Residential Unit
Pers = Person	PF = Peaking factor (Unitless)
Min = Minutes	Ac= Acres of contributing area

COLOR KEY

- (green) Sanitary Flows
- (yellow) Winter infiltration based on winter flow meter data
- (cyan) Additional infiltration in the summer based on Hansen Lift Station summer flow data
- (magenta) Inflow from 2-year 3-hour storm event based on flow spikes recorded at Hansen Lift Station meter in August 2014

2.8.7 Estimated Daily Contribution Per Capita

The contribution per capita in Nibley has been estimated based on the results of the calibrated model and the assumed density of two homes per acre. This was done to provide a comparison of the calibrated flows per capita as compared with assumed flows used for the design of the collection system. The approximate contribution per capita is 90 gallons per day. This number is calculated by adding the peak I&I assumed to come from one-half acre of developed land, to the estimated sanitary flow per home and dividing by the number of people per home. As shown in the formula below.

Formula for Flow Contrition per Capita

$$\left(\left(\frac{\mathbf{60\ Gal}}{\mathbf{Pers*Day}}*\frac{\mathbf{3.8\ Pers}}{\mathbf{ERU}}\right)+\left(\frac{217\ Gal}{(Ac*Day)}*\frac{1\ Ac}{2\ ERU}\right)\right)*\frac{\mathbf{1\ ERU}}{\mathbf{3.8\ Pers}}=\frac{\mathbf{90\ Gal}}{\mathbf{Pers*day}}$$

UNIT ABBREVIATIONS

Gal = Gallons of flow	ERU = Equivalent Residential Unit
Pers = Person	PF = Peaking factor (Unitless)
Min = Minutes	Ac= Acres of contributing area

COLOR KEY

- (green) Sanitary Flows per ERU
- (blue) People per ERU
- (purple) Summer Infiltration and Inflow (217 GPAD total see Section 2.8.1)

2.8.8 Existing Model Conclusions

The results of the existing 2014 collection system evaluation offer some conclusions:

1. Flows in the system increase in the summer as a result of increased infiltration, probably due to irrigation water.
2. Flows in the system increase during rain events as a result of inflow into the system. The volume of inflow and infiltration to the system is acceptable as compared with other collection systems in the state, but could be improved in new construction.
3. The actual measured flows per ERU are smaller than what was estimated for the design of the system. Each ERU contributes a peak flow of approximately 0.36 GPM. This is only an approximate general value and is given as a planning tool to help estimate how many more ERU's can be added to different parts of the system. The actual peak flows vary based on a number of variables including location in the system, and flow routing.
4. Based on the ERU evaluation, the contribution per capita in Nibley is approximately 90 GPCD including I&I.
5. The flows have a peaking factor of 1.8 when they enter the system, which reduces as the flows travel through the system.
6. All of the existing collection lines have reserve capacity to serve approximately 500 or more additional ERU's based on the stated assumptions.
7. All of the existing collection lines have enough capacity to serve for the next 10 years including the planned flows from Millville City.

3 MASTER PLAN & RELIEF ALTERNATIVES

3.1 INTRODUCTION

The master planning portion of the study involves applying future growth projections in the model to identify the future collection system improvements needed as the City grows. This master plan specifically considers the scenarios listed in Table 3.1.

Table 3-1: Future Time Frames Analyzed

Future Time Frames Analyzed	
Title	**Description**
2019	Projected 2019 flows during summer irrigation months and during a 3 year storm event
2024	Projected 2024 flows during summer irrigation months and during a 3 year storm event
2046	Projected 2046 flows during summer irrigation months and during a 3 year storm event. 2046 is the estimated year when all of the areas within the existing city limits will be developed to the current planned densities
2064	Projected 2064 flows during summer irrigation months and during a 3 year storm event. 2064 is the estimated year when all of the areas within the study area boundary (Figure 1) will be developed to the current planned densities

The master plan study area covers the area within the current city limits and includes some future annexation areas to the north and to the south of the current city limits outside of the city boundaries. The study area does not include any area west of Highway 89/91 except for areas that are currently within the City limits (Figure 1: Existing System*).

Build out within the city limits is defined as the future condition when all of the areas within the current city limits will be developed to the current planned densities (Figure 4: Land Use*). *Build out*, or *annexation build out* is defined as the future condition when all of the areas within the study boundary will be developed to the current planned densities.

The master plan models were utilized as tools for sizing future relief lines (lines that will be constructed to replace or supplement existing lines to relieve choke points) and future trunk lines (lines that will be

* *All of the report figures are found on fold-out pages in Appendix A*

extended to undeveloped areas of the city). The results of the master plan model identify conceptual alignments and required line sizes to accommodate future conditions within the study boundary.

3.2 Key Assumptions for Master Plan Models

The assumptions that are listed in Section 2.8.1 for the construction of the existing model were used for the future models. The following is a list of additional key assumptions used for future projections:

- The estimated future annual population growth rate is 3.5% as provided by City staff.
- All of the recommended improvements in the master plan are sized to convey the projected build-out flows for the study area and from Millville.
- Millville will contribute a peak flow of 950 GPM based on the following assumptions as listed on page 3 of the sewer system record drawings prepared by Sunrise Engineering:
    - Estimated Millville population: 5,465
    - Contribution per capita: 100 gallons per day
    - Peaking factor: 2.5
- The estimated build out population served by the collection system, excluding Millville, is 33,000 based on the planned densities given in the future land use map. It is estimated that the build out population will be reached in year 2064 based on the assumed growth rate.
- Existing lines that do not have enough capacity for future flows will be replaced. Future relief lines could also be new lines that run parallel to the existing lines to add capacity where needed. If parallel lines are installed and the existing lines are kept in service, the proposed new lines could be smaller.
- Ground elevations for future service areas taken from a Light Detection and Ranging (LIDAR) survey of the entire city that was completed by Aero-Gaphics Inc. in the fall of 2013.
- No flows will come from the agriculture preservation zone.
- The City staff provided the areas where growth will occur between now and 2019 (the next 5 years) and between 2019 and 2024. These areas are indicated in Figure 8: Projected Growth* along with the areas that have been assumed to develop by 2064 (build-out).

3.3 2019 Evaluation

A model scenario was created to evaluate the capacity of the existing sewer system at year 2019. Future growth was added to the existing model in areas inside the current city boundary that were

** All of the report figures are found on fold-out pages in Appendix A*

identified by City staff members as areas that may develop in the next five years (Figure 8: Projected Growth*).

Figure 9: 2019 d/D* provides an overview of the d/D values in the existing system with the projected 2019 flows. None of the existing pipes are backing up and no capacity improvements are needed between now and 2019 based on the assumptions used to build the model.

3.4 2024 Evaluation

A year 2024 scenario was created with growth (Figure 8: Projected Growth) placed in areas identified by City staff members to develop between now and 2024. This model includes future flows from Millville as was projected at the time the Nibley collection system was designed.

Figure 10: 2024 d/D* provides an overview of the d/D values in the existing system with the projected 2024 flows. None of the existing pipes are shown as backing up and no capacity improvements are needed prior to 2015 based on the assumptions used to build the model. Some of the trunk lines will be more than half full by year 2024 with the fullest pipe being located along the future alignment of 1600 West, just south of 2600 South.

Figure 11: Reserve Capacity* shows the projected reserve capacity in year 2024 in each of the pipe segments with the projected 2024 flows. Under this scenario all of the pipes can still serve more than 300 additional ERU's.

3.5 2046 Evaluation

A model scenario was built to identify how well the existing system will convey the flows from the area within the current city limits once it fully develops to the planned densities. Based on the assumed growth rate of 3.5% per year, it is estimated that the area within the current city limits will be built out by year 2046. This scenario does not include any of the areas outside of the current city limits, but does include the projected flows from Millville.

Figure 12: 2046 d/D* provides an overview of the d/D values in the system with the projected build out flows generated within the current city limits. The red d/D values identify pipes that are full or over full due to the backed up sewer flows under this scenario.

Figure 13: 2046 Reserve Capacity* shows the reserve capacity in the existing lines under this scenario in terms of the estimated number of additional ERU's can be added upstream.

** All of the report figures are found on fold-out pages in Appendix A*

Two of the existing trunk lines will exceed capacity before the area within the city limits is built out (Figure 13). The two locations in the existing system that are projected to exceed capacity are roughly defined as:

1. The South Trunk Line -This trunk line enters the Hansen Lift Station from the south. It will not have enough capacity starting at manhole C3 where the Peterson lift station flows enter the C-Line (Near the future 2700 South and Heritage Drive) north to the Hansen Lift Station (near Heritage Drive just east of HWY 89). This trunk line can accommodate the addition of roughly 775 future ERU's upstream including the flows from Millville.
2. Highway 165 from Hollow Road to 2900 South – This section of the A-Line goes along the east side of Highway 165 with many sections of the line running along the back of the properties that face out onto Highway 165. This trunk line can accommodate the addition of roughly 475 future ERU's upstream.

These two trunk lines will need to be upsized or have flows re-routed in the future if the areas upstream develop to the maximum densities allowed in the current land use plan.

3.6 2064 Evaluation (Build out)

A model scenario was created to identify conceptual upgrades to the existing system and future trunk lines and lift stations needed for year 2064 (Build out). Estimating the size of pipes that will be needed at build out is important because it provides a pipe size guide to follow as new pipes are installed or existing pipes are replaced. This guide helps prevent a situation where the City might upsize a pipe only to find out shortly thereafter that an even larger pipe is needed to accommodate future growth.

An existing ground surface layer was created in the model using the LIDAR survey data to master plan the areas that are currently undeveloped. The master planned pipe system was laid out to take advantage of the natural slope of the land and low-lying areas. The final decision on sewer service to these areas will be determined by Nibley City policy and land development activity.

The routes of the master plan lines may be slightly altered without affecting service depths or reducing pipe capacities. A detailed land survey will be required during design of the future pipes to ensure that they can connect to the existing collection system.

** All of the report figures are found on fold-out pages in Appendix A*

The future service areas were delineated based on natural and land use boundaries. The future service areas divide the undeveloped areas into parcels that drain naturally to the trunk lines.

Figure 14: Existing and Proposed Diameters* shows the recommended collection system with the existing pipe sizes and the sizes of any proposed lines needed to serve the area within the study area boundary when it is built out to the planned densities. This system routes most of the undeveloped area located south of the city to the west to 1500 West Street and then north through the south trunk line.

The proposed future trunk line upgrades (Figure 14: Existing and Proposed Diameters) are based on the assumption that undersized trunk lines will be replaced with larger trunk lines. During design of the new improvements the City may choose to add parallel lines to supplement the capacity of the existing trunk lines as needed.

The area south of the City and west of approximately 1500 West will need to be served by a regional lift station or by multiple smaller lift stations (Figure 14: Existing and Proposed Diameters). The same is true for the area north of 2600 South and east of the railroad tracks.

The collection system will work if built as laid out (Figure 14*) and if all of the model assumptions hold true in the future. Figure 15: Proposed* shows the d/D values in the build out system with all of the needed improvements made to the collection system.

The future improvements needed are outlined in Section 3.8. Large deviations from the master plan may affect line capacity and serviceability of some areas. The effects of changing the master plan should be thoroughly studied before allowing significant deviations.

3.7 Lift Station Evaluation

All of the existing lift stations are projected to have adequate capacity through build out with the exception of the Hansen Lift Station, located along Heritage Drive just east of HWY 89 (Figure 1: Existing System*). This lift station receives all of the sewer flows from the City. It will continue to receive increased flows as the City grows and will eventually need to be upgraded. It currently has two pumps that pump at 1,688 GPM each and has a vacant space allotted for a future third pump. Two pumps at a minimum are always required in lift stations to provide redundancy in case of a pump failure. When the peak flows in the system start to exceed the capacity of one pump (1,688 GPM) a third pump should be

** All of the report figures are found on fold-out pages in Appendix A*

added to maintain redundancy. Based on the model projections it is estimated that the third pump will need to be added around year 2030.

There is only one force main pipe that currently runs from the Hansen Lift Station to the Logan collection system. One force main is adequate to convey the flows and meets the standard of service. However, sometimes communities will install two force mains from lift stations to provide some redundancy and help avoid a sewer overflow if a force main is plugged or damaged. In the future, if the existing force main reaches the end of its serviceable life or if the capacity of the force main is reached, the City may consider installing a parallel line to provide some redundancy.

All of the pump stations will need to be maintained to continue to function properly. The City should continue to do regular maintenance on these lift stations and will eventually need to replace pumps and other equipment as the system ages.

Two new future regional lift stations are recommended in order to serve the entire *study* area. A summary of the existing and projected lift station*s* is given in Table 3-2.

Table 3-2: Lift Station Summary

LIFT STATION IMPROVEMENTS		
Lift Station Name	**Approximate Location**	**Projected Upgrades***
Existing - Scott Farm	3480 S. 780 W.	No upgrades currently projected. This is based on the assumption that the undeveloped areas to the south will be served by future trunk lines going to the west. Plan to discontinue use of this lift station in the future and route flows west through future gravity lines.
Existing - Caine Dairy	3600 S. HWY 89	No upgrades currently projected.
Existing - Peterson	2690 S. HWY 89	No upgrades currently projected.
Existing - Hansen	Heritage Drive just east of HWY 89	An additional pump will need to be added to the available slot in the lift station around year 2030.
Future - Northeast Regional	2200 S. Union Pacifice Rail Road	This new lift station will be needed to serve new development in the area between 2200 and 2500 South and Union Pacific Rail Road and Black Smith Fork River.
Future - Southwest Regional	3200 S HWY 89/91	This new lift station will be needed to serve new development in the area south and west of the current city limits.

*Upgrades based on model assumptions. Nibley City should regularly monitor the performance of each of the lift stations to identify capacity improvement needs before capacities are exceeded.

3.8 Future Capacity Improvement Projects

No capacity improvements need to be made to the existing collection system in the next 10 years. However, a few improvements will need to be made before build out and new system pipes and lift stations will need to be added to the system over time to serve areas that will develop in the future. Some opinions of probable cost have been prepared to assist in sewer planning.

3.8.1 Future Improvements to Existing System

Table 3-3 gives a prioritized list of capital improvements, along with associated costs, that may need to be made to the existing system prior to build out. An estimated number of additional ERU's that can be added upstream of each project is given in the table. The City should begin plans to make upgrades well before the estimated ERU limits are reached to avoid exceeding the capacity limits.

Table 3-3: Costs for Future Improvements to Existing System

<table>
<tr><th colspan="7">FUTURE IMPROVMENTS TO THE EXISTING COLLECTION SYSTEM</th></tr>
<tr><th>PROJECT DESCRIPTION</th><th>ESTIMATED ERU'S THAT CAN BE ADDED UPSTREAM</th><th>PIPE SIZE</th><th>UNIT</th><th>QUANTITY</th><th>AMOUNT</th><th>COST</th></tr>
<tr><td rowspan="4">HWY 165
Install a diversion and new 8"pipe to divert peak flows from the east side to the west side of HWY 165</td><td rowspan="4">475</td><td>8"</td><td>LF</td><td>1100</td><td>$ 158</td><td>$ 174,300</td></tr>
<tr><td>16" Bore</td><td>LF</td><td>125</td><td>$ 800</td><td>$ 100,000</td></tr>
<tr><td colspan="4">Engineering & Construction Contingency (40%)</td><td>$ 109,700</td></tr>
<tr><td colspan="4">PROJECT COST</td><td>$ 384,000</td></tr>
<tr><td rowspan="6">SOUTH TRUNK LINE
Replace the existing trunk line with larger pipes as shown in Figure 14 from 2700 S./Heritage Drive to the Hansen Lift Station</td><td rowspan="6">775</td><td>15"</td><td>LF</td><td>1530</td><td>$ 179</td><td>$ 273,870</td></tr>
<tr><td>18"</td><td>LF</td><td>3260</td><td>$ 203</td><td>$ 661,780</td></tr>
<tr><td>21"</td><td>LF</td><td>400</td><td>$ 275</td><td>$ 110,000</td></tr>
<tr><td>27"</td><td>LF</td><td>2750</td><td>$ 300</td><td>$ 825,000</td></tr>
<tr><td colspan="4">Engineering & Construction Contingency (40%)</td><td>$ 748,260</td></tr>
<tr><td colspan="4">PROJECT COST</td><td>$ 2,618,910</td></tr>
<tr><td rowspan="3">*1500 W. 3300 S.
Diversion
Install a diversion to send peak flows to the west</td><td rowspan="3">475</td><td></td><td>EA</td><td>1</td><td>$ 5,000</td><td>$ 5,000</td></tr>
<tr><td colspan="4">Engineering & Construction Contingency (40%)</td><td>$ 2,000</td></tr>
<tr><td colspan="4">PROJECT COST</td><td>$ 7,000</td></tr>
<tr><td rowspan="3">HANSEN LIFT STATION
Add a third pump to supplement the 2 existing pumps as planned on the collection system design plans</td><td rowspan="3">Estimated Year Needed: 2030</td><td></td><td>EA</td><td>1</td><td>$ 20,000</td><td>$ 20,000</td></tr>
<tr><td colspan="4">Engineering & Construction Contingency (40%)</td><td>$ 8,000</td></tr>
<tr><td colspan="4">PROJECT COST</td><td>$ 28,000</td></tr>
<tr><td colspan="6">TOTAL FUTURE TRUNK LINE COSTS</td><td>$ 3,038,000</td></tr>
</table>

*Future Southwest Regional lift station required prior to construction of this project.

All of the costs in table 3-3 are conceptual and based on 2014 values. A detailed cost analysis will need to be performed during the design of each capital improvement project prior to construction.

The HWY 165 improvements may never be needed if the owners of properties upstream do not all split their properties to the allowed planned densities. The City should re-evaluate the flows in the HWY 165 line before 300 more ERU's are connected upstream.

3.8.2 Future Trunk Lines to Serve Future Service Areas

As new development occurs outside of the areas that are currently developed, the City should have trunk lines installed that are large enough to serve all of the future development in the City as outlined in this master plan (Figure14: Existing and Proposed Diameters*). This will require that the City or developers pay the incremental cost difference for pipes that are larger than 8" in diameter. Over time, these "upsize" costs will be paid back as more units are connected to the trunk lines. The estimated costs to pay the incremental cost difference for future trunk lines larger than 8" in diameter are listed in Table 3-4. The time frame for the installation of these pipes is not known and will be driven by development.

Table 3-4: Estimated Cost for Future Trunk Lines

FUTURE TRUNK LINES TO SERVE FUTURE SERVICE AREAS				
FUTURE PIPE SIZE	**UNIT**	**LENGTH**	**[1]UNIT COST TO OVERSIZE**	**COST**
8"	LF	41,279	$ -	$ -
10"	LF	3,460	$ 5	$ 16,800
12"	LF	117	$ 10	$ 1,200
15"	LF	1,105	$ 21	$ 23,200
	TOTAL LENGTH	45,963		
ENGINEERING & CONSTRUCTION CONTINGENCY (40%)				$ 16,500
TOTAL FOR FUTURE TRUNK LINES				**$ 57,700**
[1]The difference between the cost of the needed pipe size and an 8" pipe.				

3.8.3 Future Pump Stations to Serve Future Service Areas

New lift stations will be required to serve the undeveloped areas that are outside of the current collection system service area. By following this master plan the City can have regional lift stations and limit the number of future lift stations needed. One regional lift station will be

* *All of the report figures are found on fold-out pages in Appendix A*

needed to serve the northeast corner of study area and another will be needed to serve the southwest corner (Figure 14: Existing and Proposed Diameters*).

The Northeast Regional Lift Station will need to include a pipe under the railroad tracks. The Southwest Regional Lift Station will need to have a force main to carry the flows to the Hansen Lift Station. Table 3-4 gives the estimated costs to construct the lift stations.

Table 3-5: Costs for Lift Stations to Serve Future Service Areas

FUTURE PUMP STATIONS TO SERVE FUTURE DEVELOPMENTS	
DESCRIPTION	**COST**
Construct New South West Regional Lift Station with Force Main	$ 350,000
Construct New North East Regional Lift Station With Force Main Under Rail Road Tracks	$ 300,000
ENGINEERING & CONSTRUCTION CONTINGENCY (40%)	$ 260,000
TOTAL FOR FUTURE LIFT STATIONS	**$ 910,000**
TOTAL	**$ 1,015,000**

4 CONCLUSIONS AND RECOMMENDATIONS

Based on the study and evaluation of the system it was found that no short term collection system improvement projects are needed. The following overall conclusions and recommendations are based on the results of this master plan:

4.1 Conclusions

The master plan conclusions are split below into the following three categories:

- **Existing Flow** - Conclusions related to the existing flows in the collection system
- **System Capacity** – Conclusions related to the capacity available in the system now and in the future
- **Future Service Areas** –Conclusions related to the approach to serve areas to develop in the future

4.1.1 Existing Flow Conclusions

1. Winter infiltration accounts for approximately 90 GPM of flow in the system.
2. Infiltration increases during the irrigation season by approximately 60 GPM for a total infiltration rate of 150 GPM during the summer.
3. Flows in the system increase by approximately 50 GPM during rain events as a result of inflow into the system from a 2-year 3-hour storm.
4. The daily contribution per capita in Nibley is approximately 90 gallons instead of the estimated 100 gallons used for the original design of the system.
5. The current volume of I&I in the system is significant, but is not considered excessive by EPA standards (Environmental Protection Agency, 1991).
6. Based on the flow meter data and the model calibration process, the peaking factor is approximately 1.8 instead of the estimated 2.5 factor that was used for design. The actual peaking factor in collection systems varies depending on the location in the system.
7. Each ERU contributes a peak flow of approximately 0.36 GPM. This is an approximate general value only and is given as a planning tool to help estimate how many more ERU's can be added to different parts of the system. The actual peak flows vary based on a number of variables including location in the system, and flow routing.

4.1.2 System Capacity Conclusions

1. No capacity upgrades need to be made to the existing collection system prior to year 2024 based on the master plan assumptions. This incorporates the planned flows from Millville City. Growth outside of the bounds of the 2024 model assumptions will require revisiting the model with the new data.

2. Based on the model assumptions, all of the existing collection lines can serve approximately 500 or more additional ERU's (Figure 7: 2014 Reserve Capacity*)

3. Some of the existing trunk lines will exceed capacity before 2046 if no improvements or flow routing changes are made (Figure 13: 2046 Reserve Capacity*). The two major areas that are projected to exceed capacity prior to year 2046 are roughly defined as:

    - <u>The South Trunk Line</u> from approximately 2700 South and Heritage Drive north to the Hansen Lift Station
    - <u>Highway 165</u> from Hollow Road to 2900 South

3. Some of the peak future flows collected in 1500 West from the undeveloped area south of the City may need to be split off to the west to avoid over filling the existing pipe in 1500 West. It is estimated the 475 ERU's can be added upstream of this location.

4. A pump will need to be added to the Hansen Lift Station around year 2030 for more capacity (routine maintenance of all lift stations needs to be ongoing).

4.1.3 Future Service Area Conclusions

1. The undeveloped area south of the current service area and east of 1500 West can be fed by gravity all the way to the Hansen Lift Station by connecting to the existing trunk line in 1500 West. This includes the area that is already served by the Scott Farm Lift Station.

2. At least two future regional lift stations will be needed to serve all of the study area (Figure 14: Existing and Proposed Diameters*).

4.2 Recommendations

The master plan recommendations are split into the same three categories as the conclusions.

4.2.1 Existing Flow Recommendations

1. Watch for any irrigation water that may be entering the sewer collection system from the ground surface through manholes. If any above ground irrigation water is entering the sewer system, take action to remove this source of inflow. Most of this summer infiltration probably happens below ground and may be difficult to mitigate.

2. Review flow data recorded by the SCADA system at times when large rain events occur to monitor and quantify the inflow volumes. Currently, the nearest 1 hour precipitation data is from a rain gage at the Logan-Cache Airport. Installation of a rain gage in Nibley could be considered. This would provide more accurate correlation of local precipitation in Nibley with inflow to the collection system as recorded by the flow meter at the Hansen Lift Station.

3. Continue to monitor I&I using the SCADA data from the Hansen Lift Station. If large increases in night time flows or flows after rain are noted, identify and eliminate the sources.

4.2.2 System Capacity Recommendations

1. Track the number of new ERU's added to the system to estmate when the capacities of certain pipes are being approached (Figure 7: 2014 Reserve Capacity and Figure 14: Existing and Proposed Diameters*).

2. Before new developments are permitted, update the existing sewer model to verify that adequate capacity is available. By inputting the new flows from the new developments the City will be able to require appropriate infrastructure upgrades and have a good understanding of the remaining capacity in the system.

3. Begin plans to design and construct capacity improvement projects well before a trunk line reaches full capacity. Many system managers plan to make capacity improvements around the time a trunk line reaches a d/D value of 0.75 if continued increases in flows are expected in that trunk line.

4. Require that Millville install a flow meter where Millville flows are added to the system. Communicate and coordinate with Millville staff anytime new flows are added from Millville and update the existing model with the new flows.

5. Although no capacity improvements to the existing system are expected for the next 10 years, begin planning a funding mechanism for long range collection system improvements. Monitor

how many ERU's are added upstream of the future problem areas (Figure 13: 2046 Reserve Capacity*). The following actions are proposed to address the future capacity deficiencies:

- The South Trunk Line from - Upsize the trunk line from approximately 2700 South and Heritage Drive, north to the Hansen Lift Station prior to adding 775 ERU's upstream.
- Highway 165 - Install a diversion and 8" pipe across HWY 165 Near Hollow Road and connect to the existing 8" pipe on the east side of HWY 165 prior to adding 475 ERU's upstream.
- 1500 West near 3350 South - Track the number of ERU's added up stream of the existing 8" pipe. A diversion will need to be installed near this point prior to adding 475 ERU's upstream of this location. The diversion will need to send some of the peak flows to the west to be pumped through the future Southwest Regional Lift Station. If the lift station is not built, upgrades to the existing line in 1500 West may be required with possible additional upgrades to the existing trunk line downstream.

6. Regularly monitor the performance of the Hansen Lift Station. Once both pumps in the lift station are frequently running at the same time (around year 2030), add a third pump.

4.2.3 Future Service Area Recommendations

1. Require an update to the existing sewer model to verify that there is adequate capacity prior to permitting new developments.

2. Coordinate with developers to serve the area south of the current service area and east of 1500 West by constructing a gravity collection system that routes flows to the existing trunk line in 1500 West to 3400 South. Once this new collection system is in place, discontinue use of the Scott Farm Lift Station. Route the flows from Scott Farm to the west through the new gravity collection system.Plan for regional lift stations in the approximate locations indicated (Figure 14: Existing and Proposed Diameters*). This will require extra coordination with developers during planning and development, but will greatly reduce future operation and maintenance costs. By having fewer regional lift stations instead of many smaller lift stations the city will have much less equipment to operate and maintain.

3. Require stringent requirements for new developments and enforce installation of tight sewer systems to minimize new sources of I&I.

** All of the report figures are found on fold-out pages in Appendix A*

4.2.4 Other Recommendations

1. Compare the level measurements that are being measured through the flume at the Hansen Lift Station with the actual flow depths shown on the staff gauge on a weekly basis. Record the measured levels and make adjustments to the level sensor as needed to match the actual flow depths.

2. Utilize flow data that is being recorded at the Hansen Lift Station over time to refine the daily flow volume estimations in the system (See Table 2-2).

3. The model and plan should be updated and verified with any significant changes to the system. The city should add model updates and checks to the development check list of items to be done by developers prior to development. Add the cost of updating the model to the fee schedule for new subdivisions or changes of land use requests.

** All of the report figures are found on fold-out pages in Appendix A*

REFERENCES

CRSA. (2007). *Nibley City General Plan.*

Environmental Protection Agency. (1991). *Sewer System Infrastructure Analysis and Rehabilitation.* Cincinnati, OH: United States Environmental Protection Agency, Office of Research and Developement.

SunriseEngineering. (2002). *Nibley Sewer Collection System Design.*