Village of Frankfort
Jackson Creek Lift Station

Downstream Sanitary Sewer Capacity Analysis

REL Project 23-R0659

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Appendices

1.0 Background Information

1.1 Jackson Creek Lift Station to West Pump Station

The Village of Frankfort (Village) identified that the gravity sanitary sewer trunk main downstream of the Jackson Creek Lift Station (JCLS) may be experiencing an appreciable amount of storm water and / or groundwater infiltration and inflow (I/I) into the wastewater collection and conveyance system. Robinson Engineering, Ltd. (REL) was retained to perform a capacity analysis on the gravity sanitary sewer downstream of the JCLS to the West Pump Station (WPS). The need for a capacity analysis stems from recent capacity improvements to the JCLS and the potential for future development.

The JCLS was originally constructed in 1996. The wet well and valve vault were configured to support two submersible pumps each with a four-inch diameter discharge line and three submersible pumps each with a ten-inch diameter discharge line. Two force mains, six-inch and sixteen-inch in diameter, were constructed from the JCLS to approximately 4,300 feet to the north. Plan and section views of the JCLS are in Appendix 1. Both force mains discharge into a manhole that connects to a fifteen-inch diameter gravity sanitary sewer north of Golden Gate Nursery, Inc. The JCLS valve vault is configured such that, depending on the valve settings, all the pumps can discharge to either or both of the force mains.

Initial construction for the JCLS included two, four-inch submersible pumps which initially discharged to the six-inch diameter force main. In 2005, the two submersible pumps were connected to the sixteen-inch diameter force main and the combined discharge for the two, four-inch submersible pumps was 1,201 gallons per minute (GPM). In 2022, a single eight-inch submersible pump with a capacity of 1,814 GPM was installed in the JCLS's wet well and was connected to the sixteen-inch diameter force main. If two additional eight-inch submersible pumps are installed, the lift station firm capacity is calculated to be 2,950 GPM; the firm capacity of a lift station is calculated with the largest pump out of service. The calculated 2,950 GPM flow includes flow if the two four-inch diameter pumps are connected to the six-inch diameter force main.

The fifteen-inch diameter gravity sewer that receives wastewater flow from the JCLS continues north along LaGrange Road (US Route 45/52) and heads west towards Elsner Road south of the Timber View RV Center. Turning north, the fifteen-inch diameter gravity sewer continues along Elsner Road and increases to an eighteen-inch diameter sanitary sewer north of Nebraska Street. North of Lincoln Highway (US Route 30), the sanitary sewer continues north along Cedar Lane and increases to twenty-one inches in diameter. The sanitary sewer heads east along Indiana Court and increases in size to twenty-four inches in diameter. East of Hawthorne Road, the sanitary sewer continues east and is located south of the former west wastewater treatment facility. The twenty-four-inch diameter gravity sewer combines with two twelve-inch, one eighteen-inch, and one additional twenty-four-inch diameter gravity sanitary sewers and discharges to the WPS. The WPS includes five pumps and discharges to the regional wastewater treatment plant.

1.2 2024 Temporary Flow Monitoring Report

REL subcontracted ADS Environmental Services (ADS) to assist with gathering wastewater flow data on the Village's sanitary sewer collection system. ADS provided five flow monitors and two rain gauges. The gravity sanitary sewer collection system from the JCLS to the WPS was divided into five consecutive flow basins and a flow monitor was installed to gather data for each basin. The study period began on March 14, 2024, and concluded on July 9, 2024, which totals 118 days. The flow monitors utilized an ultrasonic sensor for depth, a velocity sensor, and a pressure depth sensor. ADS provided an analysis and report, titled 2024 Temporary Flow Monitoring Report (ADS Report), that summarized their findings from the flow monitor and rain gauge data. The ADS Report is in Appendix 2.

The ADS Report provides insight into the amount of I/I entering the Village's sanitary sewer system. Inflow consists primarily of storm water runoff that enters a sanitary sewer collection system from direct connections including, but not limited to building downspouts, cleanouts, foundation drains, sump pumps, basement and area drains, and cross connections with storm sewer systems. Infiltration consists primarily of storm water and / or ground water entering a sanitary sewer system through defective system components including, but not limited to, defective sewer pipes, manholes, service connections, or other system appurtenances. Minor amounts of I/I are anticipated in any sanitary sewer system, however excessive I/I reduces capacity in the sanitary sewer system and can lead to sanitary sewer overflows (SSOs). A SSO is a discharge of untreated wastewater to the environment which can result in regulatory violations and public health issues.

1.3 Dry Weather Flows

Dry weather flows, which are observed during normal conditions and exclude wet weather events, were determined by ADS and provide a flow baseline for the sanitary sewer system. Typical wastewater flows follow a diurnal pattern with peak flow rates in the morning and evening. Wastewater flow rates in the sanitary sewer system typically drop during the middle of the day and during the middle of the night. Dry weather flows are used to determine the amount of infiltration into the wastewater collection system because wet weather events are excluded from the dry weather flow data set. The Illinois Environmental Protection Agency (IEPA) recommends a design average flow rate of 100 gallons per capita per day for new sanitary sewers in undeveloped areas; the IEPA recommended flow rate anticipates normal infiltration. The IEPA has also established suggested flow rates for various types of facilities, such as restaurants, hotels, and offices.

The Standard Specifications for Water and Sewer Construction (SSWSC) in Illinois include guidelines for testing new sanitary sewers. A new sanitary sewer can be tested using the infiltration method, which allows no more than 200 gallons of groundwater per inch of pipe diameter per mile to enter the sanitary sewer system each day. For example, a twelve-inch diameter sanitary sewer one mile in length would be able to receive up to 2,400 gallons of infiltration per day and still meet specifications (12-inch x 1 mile x 200 gallons per inch per mile = 2,400 gallons). The infiltration allowed by the SSWSC demonstrates that even new sanitary sewer systems have the potential to receive ground water through infiltration. A table with the lengths and sizes of sanitary sewers as well as the suggested allowable infiltration per the SSWSC within each basin is in Appendix 3.

Flow data is present where the flow monitors were installed, but several sub-basins / branch sewers provide incremental wastewater flow into the sanitary sewer system between the flow monitors. These sub-basins / branch sewers need to be accounted for because the flows from the sub-basins / branch sewers impact the available pipe capacity. In addition, flows for infill and new developments can be estimated based on the proposed land use and number of lots. Incremental flow values for new developments can be utilized to aid in determining whether the existing sanitary sewer system has adequate capacity to provide service or if system upgrades are required to handle additional wastewater volumes.

The majority of lots within this study area are zoned residential. Appendix 4 shows the breakdown of lots within each basin based on commercial, industrial, or residential zoning. Residential lots total 3,000 for the study area which is over 97% of the total lots. Since residential lots make up the majority of total lots in the study area, a method was needed to estimate the average flow contributed by each dwelling unit. Using just the number of lots would not produce an accurate flow contribution because approximately 446 manufactured housing units exist in the Gateway development on only three lots; the Gateway development consists of one residential and two agricultural zoned lots. In addition, a method was also needed to estimate the wastewater generated by the commercial and industrial lots. Some commercial lots are restaurants or department stores with more wastewater generation than a small medical or professional service office.

Appendix 5 shows how the estimated gallons per day per dwelling unit was calculated. The average dry weather flow from the ADS Report for each basin was reduced by the allowable infiltration leakage from Appendix 3 and further reduced by the estimated commercial and industrial flows. Water usage provided by the Village for certain commercial and industrial zoned lots was used to determine commercial and industrial lot wastewater generation. Commercial business categories included restaurants with a sanitary sewer flow of 2,600 gallons per day (GPD), office buildings with a sanitary sewer flow of 150 GPD, and department stores with a sanitary sewer flow of 1,100 GPD. The industrial zoned lots in the Village are not large wastewater generators with water usage less than a typical dwelling unit; industrial zoned lots were assigned 150 GPD per lot. One office district zoned lot contains an assisted living center, Cedarhurst of Frankfort, with an average water usage of 5,500 GPD.

The flow monitors were installed along the sanitary sewer collector main rather than separate wastewater collection system basins. Downstream flow monitors collected flow data that was also collected by upstream flow monitors. To determine the wastewater flow per dwelling unit for each of the five basins, the wastewater flow and number of dwelling units for each basin includes the wastewater flow and number of dwelling units from upstream basins. Basin 5 had the lowest calculated flow at 200 GPD per dwelling unit while Basin 3 had the highest calculated flow at 230 GPD per dwelling unit.

Pipe capacity data for the sanitary sewer system using the average dry weather flow can be found in Appendix 6. The two wastewater flow columns include data from the ADS Report in yellow highlighted cells, and calculated incremental flows for each sub-basin / branch sewer in blue highlighted cells. The calculated flow from the sub-basins / branch sewers is used to determine potential pipe capacity issues in sanitary sewer segments between flow monitors.

The ADS Report also used data from both dry conditions and rainfall events, combined with the rain gauges, to plot a regression line for each basin. The regression line is used to predict flows for various rainfall events that may or did not not occur during a monitoring period. Within Appendix C of the ADS Report, a regression graph is included for each of the five basins. ADS has provided predicted I/I flows for the 1-year, 1-hour storm event, the 5-year, 1-hour storm event, and the 10-year, 1-hour storm event. Pipe capacity data for each of the three storm events, calculated for each of the five basins, is included in Appendix 7.

2.0 Basin Evaluations

2.1 Basin 1 – JCFM01

A map with the five basins can be found in the ADS Report. Basin 1 includes the JCLS with its tributary area, Heritage Knolls Subdivision, and the commercial and industrial complex east of LaGrange Road and south of the Canadian National Railroad. Most of the land tributary to the JCLS is within the Village limits however the Gateway development is in unincorporated Will County. Basin 1 is approximately 1,456 acres in size, contains 674 manholes, 149,721 feet of gravity sanitary sewer between six and twenty-one inches in diameter, and 8,600 feet of sanitary sewer force main split equally between six and sixteen inches in diameter.

Both the American Society of Civil Engineers (ASCE) and the Water Environment Federation (WEF) recommend gravity sanitary sewers up to fifteen inches in diameter flow at a maximum of 50% capacity in dry weather conditions. Of the ten sanitary sewer pipe segments in Basin 1, along the Jackson Creek Interceptor, four are experiencing flows greater than 50% capacity in dry weather conditions, as seen in Appendix 6. Wet weather conditions result in pipes receiving wastewater flows greater than their hydraulic capacity. During the 1-year, 1-hour storm event, five pipe segments are over capacity with one additional pipe segment at 99% capacity. The number of pipe segments over capacity increases to eight for both the 5-year, 1-hour and 10-year, 1-hour storm events. In the 5-year, 1-hour storm event, several pipe segments would convey more than three times their capacity and one pipe segment is over four times its capacity in the 10-year, 1-hour storm event.

The ADS Report states that during dry weather, the flow monitor recorded a maximum depth of 7.12 inches which is approximately 50% of the pipe depth. The maximum depth recorded during wet weather events was 97.90 inches, which is nearly seven feet above the top of pipe. The ADS Report includes Scattergraphs for each of the flow monitor locations. The Scattergraphs indicate the velocity of the wastewater flow with the height of the wastewater using data points collected. When wastewater flow at flow monitor JCFM01 reached approximately 1.3 million gallons per day (MGD), the pipe began to surcharge.

The fifteen inch diameter sanitary sewer for Basin 1 has a maximum operational capacity of 1.75 MGD, but the system has a calculated capacity of 1.80 MGD. Once the flow reaches 1.3 MGD, the velocity decreases as the wastewater level rises. Once the pipe is surcharged, flow then increases despite surcharging being an undesirable condition in a wastewater collection system. Downstream limitations appear to prevent the sanitary sewers in Basin 1 from realizing calculated capacity.

2.2 Basin 2 – JCFM02

Basin 2 includes the Founders Place Subdivision, and the commercial and industrial complex west of LaGrange Road north of the Canadian National Railroad. Basin 2 includes all of Basin 1 plus an additional 64 acres, 32 manholes and 7,003 feet of gravity sewer between six and fifteen inches in diameter, and no sanitary sewer force main.

Of the eight sanitary sewer pipe segments along the interceptor in Basin 2, three are experiencing flows greater than 50% capacity in dry weather conditions, as seen in Appendix 6. Wet weather conditions result in pipes receiving wastewater flows greater than their hydraulic capacity. During the 1-year, 1-hour storm event, four pipe segments are over capacity with one additional pipe segment at ninety-seven percent capacity. The number of pipe segments over capacity increases to six and seven for the 5-year, 1-hour and 10-year, 1-hour storm events, respectively. In the 5-year, 1-hour storm event, three pipe segments convey more than two times their capacity and three pipe segments are over three times their capacity in the 10-year, 1-hour storm event.

The ADS Report states that during dry weather, the flow monitor recorded a maximum depth of 7.57 inches which is approximately fifty percent of the pipe depth. The maximum depth during wet weather events was twenty-two inches, which is a surcharge condition. The ADS Scattergraph for Basin 2 indicates the wastewater flow at flow monitor JCFM02 reached approximately 1.85 MGD when the pipe began to surcharge.

The fifteen inch diameter sanitary sewer for Basin 2 has a maximum operational capacity of 2.50 MGD, but ADS calculates the system's calculated conveyance is only 1.60 MGD. Once the flow reaches 1.85 MGD, the velocity increases very little as the pipe continues to surcharge. The surcharged sanitary sewer is able to convey flow greater than anticipated because of the additional pressure generated by the rising wastewater with available downstream capacity.

2.3 Basin 3 – JCFM03

Basin 3 includes all of Basins 1 and 2 plus the Sutton Dale and Yankee Ridge Subdivisions with no commercial or industrial zoned lots. Flow monitor JCFM03 adds approximately 163 acres 93 manholes, and 18,233 feet of gravity sanitary sewer between eight and eighteen inches in diameter, and no sanitary sewer force main.

Of the five sanitary sewer pipe segments along the interceptor in Basin 3, two sanitary sewer segments are fifteen inches in diameter and the remaining three segments are eighteen inches in diameter. The fifteen-inch sanitary sewer segment is below 50% full during dry weather conditions, and the eighteen-inch sanitary sewer segments are below 75% full during dry weather conditions, as seen in Appendix 6. Both the ASCE and WEF recommend gravity sanitary sewers over fifteen inches in diameter flow at a maximum of 75% capacity in dry weather conditions. Wet weather conditions result in a pipe receiving wastewater flow greater than its hydraulic capacity. During the 1-year, 1-hour, 5-year, 1-hour, and 10-year, 1-hour storm events, only one pipe segment is over capacity. One additional pipe segment is over 90% capacity for the 10-year, 1-hour storm event.

The ADS Report states that during dry weather, the flow monitor recorded a maximum depth of 8.04 inches which is approximately forty-five percent of the pipe depth. The maximum depth during wet weather events was twenty-nine inches, which is a surcharge condition. The ADS Scattergraph for Basin 3 indicates the wastewater flow at flow monitor JCFM03 reached approximately 2.5 MGD when the pipe began to surcharge.

The eighteen-inch diameter sanitary sewer for Basin 3 has a maximum operational capacity of 2.5 MGD, but the system has a calculated capacity of 3.20 MGD. Once the flow reaches 2.5 MGD, the velocity increases very little as the pipe continues to surcharge. Despite the surcharge condition, a downstream restriction appears to limit sanitary sewer pipe flow at the flow monitor in Basin 3 to only seventy-eight percent of calculated flow.

2.4 Basin 4 – JCFM04

Basin 4 includes Basin 1, Basin 2, Basin 3, as well as the Prairie Crossings, Settler's Pond, Cardinal Lake, Brookridge Creek, Brookridge Commons, Brookside Brookside 2 Subdivisions, and Hickory Creek Church. In addition, a multi-family complex, the Frankfort Township Office Complex, all of which are unincorporated, are tributary to Basin 4. Basin 4 includes sixty-six commercial lots, which is the most commercial lots of any of the five basins. Basin 4 adds approximately 327 acres, 211 manholes, 43,955 feet of gravity sanitary sewer between six and eighteen inches in diameter, and no sanitary sewer force main.

Of the eight sanitary sewer pipe segments along the interceptor in Basin 4, none are greater than 75% full in dry weather conditions, as seen in Appendix 6. Wet weather conditions result in pipes receiving wastewater flows greater than their hydraulic capacity. During the 1-year, 1-hour storm event, two pipe segments are over capacity with another pipe segment at ninety-two percent capacity. During the 5-year, 1-hour storm event, three pipe segments are over capacity with another three pipe segments at or above eighty percent capacity. The number of pipe segments over capacity is three for the 10-year, 1-hour storm event with an additional three pipe segment at over ninety percent capacity. For the 5-year, 1-hour and 10-year, 1-hour storm events, two pipe segments are conveying more than two times its calculated capacity.

The ADS Report states that during dry weather, the flow monitor recorded a maximum depth of 6.60 inches which is approximately thirty-one percent of the pipe depth. The maximum depth during wet weather events was just over eighteen inches, which is within design guidelines. The ADS Scattergraph indicated the pipe that contained flow monitor JCFM04 did not surcharge at any point during the study.

The eighteen inch sanitary sewer for Basin 4 has a calculated capacity of 4.40 MGD. However, data points on the ADS Scattergraph indicate maximum flow around 3.0 MGD which is approximately sixty-eight percent of expected capacity. Despite the sanitary sewer pipe not surcharging, conveyance of wastewater did not increase substantially with rising wastewater levels. Pipes in Basin 4 convey current flow rates, but downstream restrictions may limit maximum operational capacity.

2.5 Basin 5 – JCFM05

Basin 5 includes Basins 1-4, as well as the Butternut Creek Woods, Charmaine, Lincoln Meadows, New Frankfort Settlement, Tanglewood, and Connecticut Hills Subdivisions with no commercial or industrial zoned lots. Basin 5 adds approximately 313 acres, 222 manholes, 38,319 feet of gravity sanitary sewer between eight and twenty-four inches in diameter, and 3,873 feet of sanitary sewer force main.

Of the thirteen sanitary sewer pipe segments along the interceptor in Basin 5, two are greater than 75% full in dry weather conditions, as seen in Appendix 6. Wet weather conditions result in pipes receiving wastewater flows greater than their hydraulic capacity. During the 1-year, 1-hour and the 5-year, 1-hour storm events, three and four pipe segments are over capacity, respectively. The number of pipe segments over capacity increases to five for the 10-year, 1-hour storm event. In the 1-year, 1-hour storm event two sanitary sewer pipe segments are conveying more than two times their calculated capacity. In the 5-year, 1-hour and 10-year, 1-hour event, a pipe segment is four and four and one-half times capacity, respectively.

The ADS Report states that during dry weather, the flow monitor recorded a maximum depth of six inches which is approximately twenty-five percent of the pipe depth. The maximum depth during wet weather events was fifty-four inches, which is a surcharge condition with wastewater flows two and one-half feet over the top of the pipe. The ADS Scattergraph indicates that when wastewater flow at flow monitor JCFM05 reached approximately 4.75 MGD, the pipe began to surcharge.

The twenty-one and twenty-four-inch diameter sanitary sewer for Basin 5 have a maximum operational capacity of 4.75 MGD, but the system's calculated conveyance is 8.00 MGD. Once the flow reaches 4.75 MGD, the velocity decreases as the pipe continues to surcharge. A second grouping of points in the scattergraph indicates wastewater flow that does not surcharge under lower flow conditions. The two groupings of data points may be due to the WPS, located four sanitary sewer pipe segments to the east of the flow monitor, cycling between various pumps turning on and off.

3.0 Basin Findings

3.1 Basin 1

The maximum gravity sanitary sewer during dry weather conditions at flow monitor JCFM01 was at fifty percent of pipe depth, which is the maximum recommended for sanitary sewers up to fifteen inches in diameter. Based on calculated pipe data, as noted in Appendix 6, four pipe segments are over fifty-percent capacity during dry weather. Storm events during the monitoring period were less than one-year storm events, meaning storms of that magnitude will typically occur more than once per year. These storms surcharged the monitor manhole such that the sanitary sewer had nearly seven feet of wastewater over the top of the pipe. The storm data indicates there is inflow due to quick spikes in flow shortly after storm events. Infiltration does also exist because wastewater flow rates took several days to return to normal after storm events.

The rapid surcharging of the sanitary sewer indicates downstream sewers may not be able to handle the sudden inflow or there is a restriction in the sanitary sewer pipes. Flow monitor JCFM02 indicates a surcharge condition but not to the extent flow monitor JCFM01 indicates a surcharge condition. The sanitary sewer pipe size is the same in Basins 1 and 2 and the flow monitors were only seven pipe segments apart, so the amount of surcharging should be similar at both flow monitors. It is possible additional head loss is also realized due to the multiple flow direction changes at manholes between flow monitors JCFM01 and JCFM02.

Significant surcharging at flow monitor JCFM01 is indicative of a downstream obstruction or bottleneck issue. Surcharging in Basin 1 begins at 1.3 MGD so only seventy-two percent of the calculated pipe capacity upstream of flow monitor JCFM01 is available to convey wastewater. Even during dry conditions, the pipe capacity for four pipe segments is less than recommended. Sizing of the sanitary sewer pipe in Basin 1 should be increased to convey existing flows and may need to be further increased to account for any future developments tributary to this basin.

The JCLS has two force mains with adequate capacity to convey up to 4.2 MGD with the addition of two eight-inch submersible pumps and the use of both the six-inch and sixteen-inch force mains. Any increase in the pumping rate from the JCLS will increase wastewater flows and may require additional capacity in the downstream sanitary sewer system. Despite having capacity for additional development, the two force mains have experienced significant deterioration since being installed twenty-eight years ago. Previously, the six-inch diameter force main failed under Laraway Road though it has been repaired and put back into service. The Village has repaired several pipe failures on both the six-inch and sixteen-inch diameter force mains over the past five years. Upon inspection of both force mains made during the repairs, it is evident that the remaining life of both force mains is very short.

3.2 Basin 2

The average gravity sanitary sewer during dry weather conditions at flow monitor JCFM02 is fifty-three percent of pipe depth, which is just above the maximum recommended for sanitary sewers up to fifteen inches in diameter. However, three pipe segments are calculated at over fifty percent capacity during dry weather flow. The storms during the reporting period surcharged the manhole with flow monitor JCFM02 such that the sanitary sewer had nearly ten inches of wastewater over the top of the pipe. The storm data indicates there is inflow due to spikes in wastewater flow though with a greater delay than in Basin 1. Infiltration contributes to sanitary sewer wastewater flow more in Basin 2 than in Basin 1 due to the longer time for sanitary sewer flows to return to dry weather condition flows.

The storm event data indicates four pipe segments are over capacity with another pipe segment at ninety-seven percent capacity for the 1-year, 1-hour storm event. During the 5-year, 1-hour storm event, six pipe segments are over capacity with an additional pipe segment at ninety-nine percent capacity. During the 10-year, 1-hour event, the number of pipe segments over capacity increases to seven. Flow monitor JCFM02 indicated a surcharge condition but not to the extent flow monitor JCFM01 indicated a surcharge condition. The sanitary sewer pipe size is the same in Basins 1 and 2, so the amount of surcharging should be similar at both flow monitors. Flow monitor data indicates that Basin 2 conveyed the I/I, but under surcharge conditions. If there is an obstruction in the sanitary sewer system between these two flow monitors that is removed or remediated, additional surcharging may be experienced in Basin 2.

The flow monitor in Basin 2 measured surcharging of only seven inches over the top of pipe, but the flow data also shows that above approximately 2.0 MGD, surcharging increased with little velocity increase. The lower surcharging in Basin 2 compared to Basin 1 may be due to the larger diameter sanitary sewer two pipe segments downstream of flow monitor JCFM02. The existing sanitary sewer pipe is smaller than recommended during dry weather flow and upstream obstructions may be preventing additional surcharging within Basin 2. The sanitary sewer pipe is undersized for current flows and will need to be further increased to account for proposed developments tributary to this basin.

3.3 Basin 3

The gravity sanitary sewer during dry weather conditions at flow monitor JCFM03 is forty-five percent of pipe depth, which is below the maximum recommended for sanitary sewers larger than fifteen inches in diameter. The storms during the reporting period surcharged the monitor manhole such that the sanitary sewer had nearly a foot of wastewater over the top of the pipe. The storm data indicates infiltration accounts for a calculated sixty-two percent of the wastewater flow. Infiltration contributes to sanitary sewer wastewater flow more in Basin 3 than in Basins 1 and 2.

Despite the sanitary sewer pipe segments conveying the wastewater flow during dry weather conditions, pipe segments become surcharged during storm events. During the 1-year, 1-hour storm event, 5-year, 1-hour storm event, and the 10-year, 1-hour storm event, one pipe segment is over capacity. Flow monitor JCFM03 shows a surcharge condition after 2.5 MGD flow is realized with the wastewater elevation rising with little increase in velocity. Flow monitor data indicates that Basin 3 conveyed the I/I, but under surcharge conditions and can convey only seventy-eight percent of the calculated capacity of 3.20 MGD.

The flow monitor for Basin 4 did not report surcharging during dry or wet weather events which indicates an obstruction or bottleneck may be present between flow monitors JCFM03 and JCFM04. The sanitary sewer pipe is sized for current dry weather flows but is over capacity for even the 1-year, 1-hour wet weather events. The sanitary sewer pipe will need to be upsized to handle additional development or flow tributary to this basin.

3.4 Basin 4

The gravity sanitary sewer during dry weather conditions at flow monitor JCFM04 is thirty-one percent of pipe depth, which is below the maximum recommended for sanitary sewers larger than fifteen inches in diameter. Within the study reporting period, the twenty-one inch diameter gravity sanitary sewer did not surcharge at the flow monitor. The storm data indicates there is inflow due to spikes in flow and infiltration that persisted for several days after a wet weather event. Infiltration accounts for a calculated sixty-three percent of the wastewater flow in Basin 4. Infiltration contributes to sanitary sewer wastewater flow more in Basin 4 than in Basins 1, 2, or 3.

The wet weather pipe capacity calculations indicate that two and three sanitary pipe segments were over capacity during the 1-year, 1-hour and 5-year, 1-hour storm events, respectively. Three pipe segments are over capacity during the 10-year, 1-hour storm event with an additional three pipe segments over ninety percent capacity. Flow monitor JCFM04 did not surcharge, but above flows of 4.60 MGD, wastewater levels rose with no increase in velocity. Flow monitor data indicates that Basin 4 conveyed the I/I, but at higher flowrates sanitary sewer wastewater levels rise due to downstream limitations. The sanitary sewer pipe is sized for dry weather flow but several pipe segments are above capacity during wet weather events. Development tributary to this sanitary sewer will require additional capacity to properly convey wastewater flows.

3.5 Basin 5

The average gravity sanitary sewer during dry weather conditions at flow monitor JCFM05 is twenty-five percent of pipe depth, which is below the maximum recommended for sanitary sewers larger than fifteen inches in diameter. Within the study reporting period, the twenty-four inch gravity sanitary sewer surcharged by approximately thirty inches which is two and one-half feet over the top of pipe. The storm data indicates there is inflow due to spikes in flow, however the inflow for Basin 5 is less than the other four basins. Infiltration persisted for the longest period of the five basins after a wet weather event. Infiltration accounts for a calculated eighty percent of the wastewater flow in Basin 5 which is the highest percentage of any of the five basins.

During dry weather flow, the sanitary sewer flow depth at the flow monitor is within recommended design guidelines. During the 1-year, 1-hour storm event, four pipe segments were over capacity with another pipe segment over ninety percent capacity. Three pipe segments are over capacity during the 5-year, 1-hour storm event with one pipe segment at ninety-one percent capacity. Five pipe segments are over capacity during the 10-year, 1-hour storm event.

The storm event data indicates a divergence in velocity and wastewater height with flows greater than approximately 2.0 MGD. In the upper set of data points, flows reach 3.5 MGD and the pipe surcharges to a point approximately thirty inches over the top of pipe. Velocities remain consistent as the wastewater height rises. In the lower set of data points, wastewater flows reach around 2 MGD while velocities decrease. Flow monitor JCFM05 was five manholes upstream of the WPS which also receives wastewater flows from additional sanitary sewers including two twelve-inch, one eighteen-inch, and one additional twenty-four-inch diameter pipes. Either the WPS or the additional flows from the other sanitary sewer pipes significantly impact the conveyance from Basin 5; the operational capacity from Basin 5 is twenty-three percent of calculated capacity.

4.0 Conclusion

4.1 Jackson Creek Lift Station

The JCLS can convey additional wastewater by installing two more eight-inch pumps. Increasing capacity at the JCLS without upgrades to the downstream collection and conveyance system will result in additional surcharging and may result in possible SSOs. In addition, the existing six-inch and sixteen-inch diameter force mains have experienced failures and need to be replaced.

REL recommends that both the six-inch and sixteen-inch diameter force mains be replaced prior to any other improvements at the JCLS.

4.2 Gravity Sanitary Sewer System

The trunk main of the gravity sanitary sewer system along the interceptor within the study area includes forty-four pipe segments, of which nine are over capacity during dry weather flow. During a 1-year, 1-hour storm event, fifteen pipe segments, a third of the pipe segments, are over capacity. During the 5-year, 1-hour and 10-year, 1-hour storm events, the number of pipe segments over capacity increases to twenty-two and twenty-four, respectively. A majority of the trunk main in this study area would need to be replaced, possibly with a larger diameter pipe, to meet even current dry weather wastewater flows.

Of the approximately 11,400 feet of gravity sanitary sewer trunk main in this study area, segments totaling 4,860 feet have portions greater than twenty feet in depth. Installation costs for utility lines increase substantially at a depth greater than fifteen feet. An alternative to upsizing the trunk line would be to install force mains from the JCLS to the WPS. The longer force mains would increase pipe friction losses so the JCLS ultimate pumping capacity will be less than the current capacity if the pumps and motors are not upgraded. The average dry weather flow at flow monitor JCFM01 was 0.490 MGD while the average dry weather flow at flow monitor JCFM05 was 0.790 MGD. Basin 1 accounts for approximately 59% of the wastewater flow in this study area.

REL recommends that the Village televise the sanitary sewer pipe segments between flow monitors JCFM01 and JCFM02 because of the surcharging differences that occurred between these monitors.

REL recommends that the Village televise the sanitary sewer pipe segments between flow monitors JCFM03 and JCFM04 because of the surcharging differences that occurred between these monitors.

Inflow typically receives more attention than infiltration in wet weather events. However, groundwater infiltration reduces the capacity of a wastewater collection system twenty-four hours a day, seven days a week. Groundwater infiltration is not measured directly by flow monitors but is estimated using empirical methods. The ADS Report used the Stevens-Schutzbach Method to determine the amount of groundwater infiltration into each basin. The estimated groundwater infiltration in Basin 1 is calculated to be fifty-four percent of the total average dry weather wastewater flow. Basin 2 has the lowest estimated infiltration at sixteen percent of total average dry weather wastewater flow. Basins 3, 4, and 5 have calculated groundwater infiltration as a percentage of total average dry weather wastewater flow at sixty-two percent, sixty-three percent, and eighty percent, respectively. Groundwater infiltration is a significant contributor to the average dry weather wastewater flows in the study area.

Based on wet weather regression results, the Net rainfall derived infiltration and inflow (RDII) per inch of rainfall are reported for each basin for a projected 1.00-inch storm event, and the results are summarized in Table 9 of the ADS report. The Net RDII volumes are computed by subtracting the Gross RDII volume of any upstream flow monitor basin from the Gross RDII volume measured at the outlet of each flow monitor basin. This process identifies and isolates RDII to the basin sizes shown. Normalized Net RDII is then calculated by dividing the Net RDII volume by the associated basin size. These results provide an overview of where the most significant wet weather RDII is coming from.

Before replacing existing sanitary sewer pipes with larger capacity sanitary sewer pipes, an I/I investigation can be used to determine if removing I/I will be more cost effective than sanitary sewer pipe replacement.

REL recommends an I/I investigation in Basins 1, 2 and 4. Basin 1 has the largest wastewater flow of any basin so a reduction in I/I will have the most impact to the trunk main in this study area. Basin 2 has the highest Net Rainfall Dependent Infiltration and Inflow (RDII) (Gallons/Linear Foot/inch) followed by Basin 4 which has the second highest Net RDII (Gal/LF/in)..

4.3 West Pump Station

Based on data from flow monitor JCFM05, the WPS may be a factor as to why Basin 5 can only convey twenty-three percent of the calculated wastewater flow. Divergent data points during the reporting period may indicate pumps turning on and off but may also indicate inadequate wet well capacity. The WPS should have adequate wet well capacity such that wastewater is not backing up and surcharging within the collection system. It is also possible the additional sanitary sewer lines combining near the WPS are a contributing factor in causing sanitary sewer surcharging and the reduction in calculated pipe capacity.

The Village should investigate the multiple sanitary sewer mains near the WPS to determine why the operational capacity of the main at flow monitor JCFM05 is significantly lower than the calculated capacity. The additional ten-inch, twelve-inch, and three twenty-inch diameter sanitary sewers should be investigated to determine whether the collection and conveyance system or the lift station is restricting wastewater capacity at this location. This could include flow monitoring on the other interceptor sewers tying into the WPS as well as lift station drawdowns, instantaneous flow measurements and reviewing pump curves.