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Please accept the attached document for filing in the above-referenced docket. Feel free to call me at 615.252.2363 if you have any questions.

Sincerely,

BRADLEY ARANT BOULT CUMMINGS, LLP

By: ______________________
Henry Walker

HW/mf
Enclosures

cc: Karen Stachowski

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ENGINEERING REPORT

CARTWRIGHT CREEK

SEWER SYSTEM REHABILITATION EFFECTIVENESS

Prepared for:
Cartwright Creek, LLC
18 September 2020

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EXECUTIVE SUMMARY

Cartwright Creek, LLC owns and operates a sewage collection and treatment system in Williamson County, Tennessee. In a statewide study of all NPDES municipal wastewater systems (Kurz, 2016a); this system was identified as having a level of 78% annual I/I. That represents a significant amount of leakage and the system was ranked number 211 out of 238 systems measured (indicating a severe condition compared to other Tennessee systems). The current customer base should only require less than half of the rated 0.25 mgd flow capacity of the treatment facility. However, the daily influent flow to the treatment facility exceeded the plant capacity on an average of 296 days per year over the past three calendar years. The excessive flow conditions were caused by clear water I/I (inflow and infiltration) and RDI/I (Rainfall derived I/I) entering the collection system. Data in MORs (Monthly Operating Reports) provided to TDEC, in 2012, 2017, and 2018 showed that about 75% of the total annual flows treated by the Cartwright Creek facility was clear water from I/I. To correct this problem, the Owner perceived this as a “chicken and egg” situation where they needed to add new customers to generate revenue to pay for major sewer rehabilitation and remediation to decrease excessive flows. However, they could not add new flows before achieving I/I reduction to avoid exacerbating the existing problem conditions.

The Owner developed a plan to conduct temporary flow and rainfall monitoring at four locations in the collection system. The first round of monitoring was conducted in May and June of 2017 and was intended to establish a baseline of flow conditions and to help make decisions to prioritize parts of the system for sewer rehabilitation work. Basin 46 was identified as the worst area. Even during dry weather, there was more 200,000 gpd of constant infiltration. The baseline monitoring was followed by CCTV inspection in October 2017 and January 2018 that focused on priority areas and identified leaking defects. A project was conducted from September 2019 to June 2020 that rehabilitated 20 manholes and lined 15 pipe segments (total of 3,352 LF). The lining work represented 6.9% of the all the public sewer system pipes (48,292 LF). A second round of flow and rainfall monitoring (at the same locations used in 2017) was initiated in June 2020 for two months to measure the effectiveness of this phase of rehabilitation.

All of the temporary monitoring results were analyzed using the “Linear Regression 24-Hour Rainfall” method (Kurz, 2003 & 2012, and Kurz et al, 2013b). This analysis generated values for ADDWF-7 (Average Daily Dry Weather Flow-7-Day), Annual I/I, and 24-hour and Peak-hour RDI/I projections for various 24-hour rainfall events for each monitoring location. A comparison of the analytical results in 2020 to results from 2017 showed a reduction of 244,000 gpd representing a reduction of 59% of the ADDWF-7 for about 95% of the collection system. (About 2,600 LF of the 15-inch trunk line immediately upstream of the treatment facility was not included in the monitoring.) The annual I/I and the 24-hour RDI/I levels were also reduced by more than 60%. However, the projected Peak-hour RDI/I for a 5-year, 24-hour rainfall event (4.5 inches) showed little change. Additionally, two of the basins (96F and 97) showed reductions for some of the I/I parameters, although no pipe-lining work was conducted in those basins (2 manholes were rehabilitated in basin 96F). The original assessment did not justify a high priority level of concern for rehabilitation in those two basins. Therefore, any variation in I/I parameters for those two monitors must be attributed to a level of variability that is typical for monitoring equipment in sewers. Finally, the Analyst observed that the rehabilitation work clearly improved hydraulic flow characteristics where liners were applied in the vicinity of monitored pipelines.

The measured reduction of I/I and RDI/I following the sewer rehabilitation work is a basis for cautious optimism. However, it is important to recognize that both of the monitoring projects in the Cartwright Creek system were conducted during the dry weather season. The Analyst's experience with hundreds of similar before-after monitoring comparisons in other systems in Tennessee has shown that monitoring during dry season periods (even ones with very large rainfall events) almost always underestimated the true levels of I/I and RDI/I (those levels that are critical for understanding the impact on system capacity). Additionally, short monitoring periods (less than 6 months) generally resulted in a degraded estimate for annual I/I. Finally, the peak-hour RDI/I is projected to exceed the plant capacity if the system experiences more than an inch of rainfall in 24 hours. One of the recommendations from this study is that a follow-up flow and rainfall monitoring project be conducted during the wet season (with high groundwater, low evapotranspiration conditions) to better assess I/I and system capacity.

Currently, the Cartwright Creek system is not under a moratorium from TDEC that would stop or limit adding new customers and additional wastewater flows. However, the Owner has prudently regulated new connections to the system to avoid exacerbating high flow conditions and negative impacts on the collection system and treatment facility. In its latest permit renewal, TDEC-DWR commented that the influent wastewater was being "very diluted by inflow and infiltration" and that this affected the facility's ability to comply with monthly average per cent removal requirements (TDEC, 2019). One of the recommendations of this report is that the Owner continue its policy and not allow new connections beyond a prudent fraction of the amount of ADDWF-7 flow reduction measured in this study.

Additional I/I reduction is needed and is reasonably achievable with properly planned and targeted sewer rehabilitation. Typical projects in Nashville and Brentwood required that 20% to 30% of the system piping be rehabilitated to achieve a consistent 50% or greater reduction of annual I/I and RDI/I during wet weather conditions. So far in Cartwright Creek, only 6.9% of the system has been rehabilitated. As an example, during the 2020 temporary study monitoring at monitor location 46, a 1-inch rainfall in 24 hours is projected to produce a peak hour RDI/I flow rate of 0.28 mgd (in addition to the base flow). Even though the meter at manhole 46 does not represent the entire system, this RDI/I flow exceeds the rated capacity of the treatment plant. Now that system hydraulics have been improved and gross sources of leakage have been removed, then further inspection should reveal remaining sources of these flows. Additionally, the possibility (indeed, likelihood) of leakage in service laterals should be investigated.

The Cartwright Creek treatment facility influent flow is monitored by a "strap-on" flow meter on the pipe from the pump that discharges into the plant tanks. The Operator reported that this meter was failing in 2019 and 2020. Therefore, the daily influent values are not trustworthy for that period. However, the meter was repaired this month. Accurate influent flow data is needed for proper plant operation, for compliance with NPDES permitting requirements, and for long-term I/I monitoring.

Finally, a modern, tipping bucket type rain gauge and recording meter should be procured and installed near the centroid of the collection system (or at the treatment facility if there is no other secure location). It is impossible to make reliable estimates about I/I and RDI/I without rainfall information. The MOR analyses included with this report used data from private rain gauges near Franklin, Tennessee. However, it was clear during the analysis process that using those remote measuring locations led to difficulties for understanding the rainfall conditions in the Cartwright Creek system.

PURPOSES

The purposes of this report are to:

- Document and explain the effectiveness of sewer rehabilitation work to reduce I/I and RDI/I, and improve capacity in the Cartwright Creek sewage collection system. This point responds to the request by George Garden in his letter to Bruce Meyer (14 September 2018).
- Provide a basis for the Owner to make sound policy decisions about accepting new service connections.
- Establish and justify standardized, reproducible procedures for measuring critical I/I and RDI/I parameters in this collection system based on sound engineering judgment and extensive published research.
- Report and describe the results from flow and rainfall monitoring that will establish and function as a baseline for measuring the effectiveness of future sewer rehabilitation projects in this system.
- Identify any operational or facility deficiencies that degrade efforts to manage I/I.

INTRODUCTION

Cartwright Creek, LLC owns and operates a public sewage collection and treatment system in Williamson County, Tennessee. The system serves about 550 customers (500 residential and 45 light commercial). The system includes a wastewater treatment facility which is rated at 0.25 mgd in its NPDES Permit. The treatment facility operates with an extended air, activated sludge process, with tertiary filtration and treated effluent chlorination/dechlorination. (TDEC, 2019) There are 48,292 LF of pipe in the collection system ranging in age from about 20 to 45 years old. "During the driest period in the past 12 years (2006-2018) . . . the lowest flow was about 150,000 GPD." "But, during average weather, (the system) averages around 250,000 to 300,000 GPD." (Meyer, B., 2018)

This facility and collection system operates under NPDES Permit # TN0027278. The Permit was renewed on 31 Dec 2019 and expires on 30 November 2021. In the Permit Rationale section, TDEC stated: "A review of the DMR summary from September 2016 through September 2019 inclusive indicates that this facility does not always meet minimum technology-based effluent limits in terms of CBOD5 and TSS monthly average percent removals. The data also suggests this is due to influent waste water being very diluted by inflow and infiltration." The ADDWF-7 (Average Daily Dry-weather Flow- 7-day) averaged about 0.164 over the past three calendar years. However, the daily influent flow to the treatment facility exceeded the plant capacity on an average of 296 days per year over the past three calendar years.

<u>2013 I/I Study (for calendar year 2012)</u>

At the request of TDEC, an I/I study was conducted by G. Kurz (2013a). That study was based on the MORs (Monthly Operating Reports) for calendar year 2012. For 2012, the study found:

> ***"The average flow for the lowest 7-day period was 0.24 mgd. However, based on the high level of dilution of influent BOD, the pounds load of influent BOD, and a projection from the population (and commercial base) served, the true sanitary base flow is estimated to be less than 0.15 mgd. If true, then the annual I/I for the calendar year 2012 was about 129 million gallons (representing 70% of the total flow handled at the treatment plant). This figure is conservative since it does not include any SSO volumes upstream of the POTW influent meter. This average does not begin to depict the potential problems experienced by the plant during peak flow periods. This estimate of annual I/I was corroborated by calculating the amount of***

dilution of influent BOD represented by the estimated annual I/I. Elimination of I/I in the system would result in an average BOD influent concentration of 303 mg/l. That number is representative of (**or similar to**) measurements of BOD levels in grinder pump systems with no I/I. Using an O&M rate of $2.00/1,000 gal, this level of I/I has a cost of ~ $260,000 annually. The peak RDII (rainfall dependent I&I) is estimated to be about 0.7 mgd for a 4.5" (5 year return) rainfall event. "

METHODOLOGY

Flow and Rainfall Monitoring

Cartwright Creek LLC, contracted with Utility Technologies to provide flow and rainfall monitoring services for the temporary, before-after monitoring studies in 2017 and 2020. Utility Technologies also provided mapping and manhole inspection services in May 2016.

In 2017, Utility Technologies reported that: "A total of 235 manholes (including four pump station wet wells) were identified during the study (an earlier study in 2016). Of these, 217 manholes were inspected and GPS readings taken. Eighteen manholes could not be located, were buried, or could not be accessed. A complete (and badly needed) map was developed through this effort but little actual I/I was identified."

Additionally: "In May 2017, Cartwright Creek again contracted with Utility Technologies to perform a temporary flow monitoring study. The system was divided into four basins, and each basin was monitored with the goal of isolating and quantifying any I/I particular to that basin." The monitored manholes and basins are shown in Figure 1 and listed in Table 1 with basin sizes.

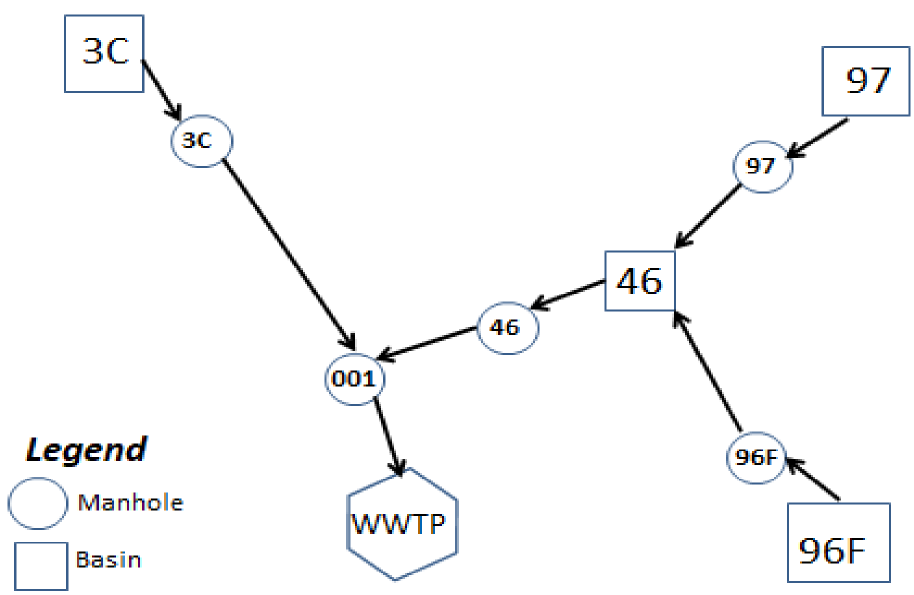

Figure 1. Cartwright Creek Basins and Monitoring Manhole Schematic.

Table 1. Cartwright Creek flow monitoring study basin sizes.

Monitored Manhole	Pipe Diameter (in)	Basin Size (LF)
3C	8	10,751
46	15	14,224
97	10	10,284
96F	12	10,438
Unmonitored near WWTP	n/a	2,595
	TOTAL:	**48,292**

(Table created by Utility Technologies, 2017)

In 2017 and 2020 ISCO meters were used for the sewer flow monitoring. These meters measured depth and velocity and calculated the sewage flow rates based on the continuity equation. A tipping bucket type rain gauge with recording device was installed inside the fence of the treatment facility. Reports by Utilities Technologies (2017 & 2020) included documentation of the locations and site conditions for each installation. Additionally, the data were provided in Excel format which facilitated analysis. Overall, the meters performed reliably. However, the velocity sensor at manhole 46 in the summer of 2020 failed after 6 August 2020 which resulted in the loss of 5 days of data at that location. For this study, that loss was not critical.

Analysis of Flow and Rainfall Data

For this study, inspection and comparison of the hydrographs and gross statistics that describe flow and rainfall gave some insight about flow and I/I reduction related to the sewer rehabilitation work. However, such visual comparison is not adequate or appropriate for calculating objective, numerical measures for various flow, I/I and RDI/I parameters. As part of analyzing data from hundreds of flow monitors deployed in Nashville, Brentwood, Chattanooga, and Jackson Tennessee, in the Washington Suburban Sanitary Commission, and in Kansas City, Kansas; a system was developed and published in 2003 (Kurz, et al). Described as the "Linear Regression 24-Hour Rainfall" method, it was copyrighted in 2012 (Kurz & Burgett). This method was used to evaluate before-after monitoring results in Nashville and Brentwood Tennessee and those communities documented over 3.6 billion gallons of I/I removed annually. In aggregate, those programs documented about 50% reduction of annual I/I, 24-hour RDI/I, and Peak-hour RDI/I (Kurz et al, 2004 & 2012b). This method also calculates the statistical confidence interval for all projected RDI/I values. This feature should be useful for designers who wish to include a factor of safety in their rehabilitation designs and projections of I/I removal.

Analysis of MORs

The Cartwright Creek NPDES Permit requires submission of MORs (Monthly Operating Reports) to the Tennessee Division of Water Resources. These reports record daily measurements of flows and other operating information collected on a frequency specified in the permit. A summary of results from an analysis for calendar year 2012 was shown above in the Introduction section. For this report, MOR data were also analyzed for calendar years 2017, 2018, and 2019. Year 2020 through July was evaluated as a partial year with the last 5 months of calendar year 2019.

The MORs for Cartwright Creek were analyzed using the "Municipal Annual I/I and RDI/I Analysis Spreadsheet" developed by G. Kurz (2016b) in the course of the statewide municipal I/I study in 2016. This method is accepted by TDEC. The reports for each year are included in Appendix C of this report.

Comparison of Daily Flows

The temporary flow monitoring did not include a meter location to isolate the basin that included most of the trunk line directly upstream of the treatment facility. This represented 2,595 LF of pipe downstream of manhole 46 and manhole 3C. A logical approach would be to assume that the difference between the daily sum of the upstream temporary meters and the daily readings at the treatment plant influent would represent any I/I contribution from that reach of trunk line. The results from making that comparison are shown in Figures 2 and 3.

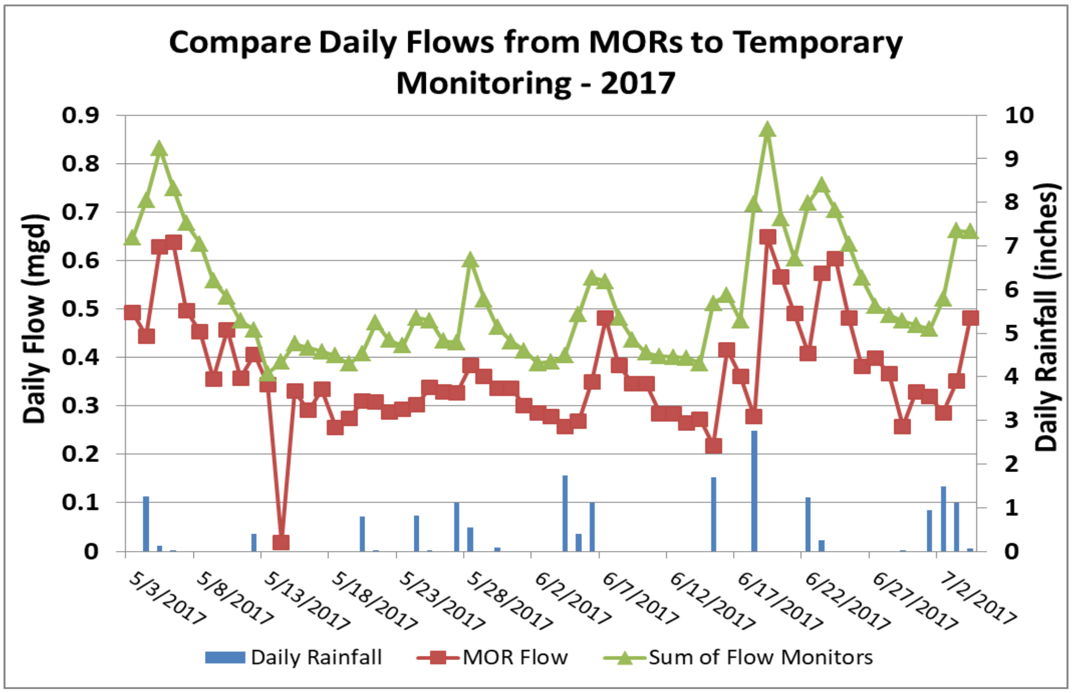

Figure 2. Sum of Temporary monitors averaged 0.154 mgd greater than plant influent meter.

In 2017, the sum of the upstream meters was always greater than the values reported by the plant influent meter and averaged about 0.154 mgd. By inspection of the graph in Figure 2, the difference appeared to be fairly consistent for the duration of the temporary monitoring period. However, in the summer of 2020, the average difference decreased to 0.053 mgd and the difference each day shown in the graph in Figure 3 appeared to become erratic.

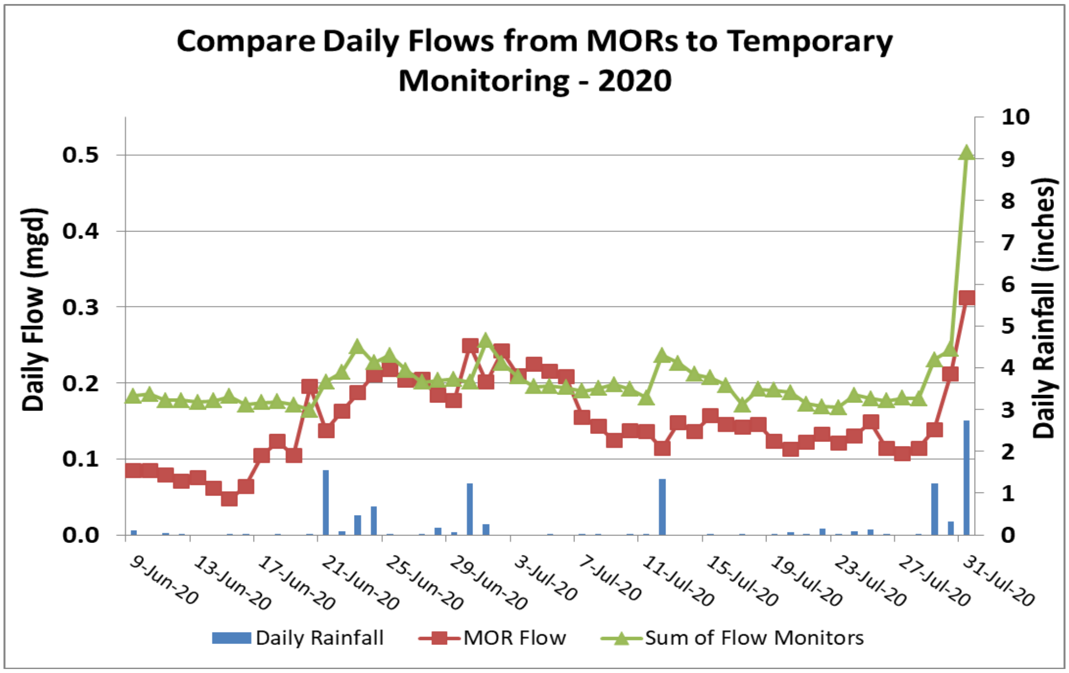

Figure 3. Sum of Temporary monitors averaged 0.053 mgd greater than plant influent meter.

The logical question in this situation is: "Which meters are reading correctly and what readings can be trusted for calculations?" For this report, primacy was given to the data generated by the ISCO meters used in the temporary monitoring. These meters were calibrated by the technicians when installed. Also, the Operator of the treatment plant reported that there were problems with the plant influent meter beginning in 2019. In any case, the negative difference in the measurements made the values unusable for calculating I/I in the trunk lines. Therefore, the parameters and characterization of flow, I/I RDI/I and measures of rehabilitation effectiveness are all based on a summary of the temporary metered flows. In this case, that means adding the results from the monitor at manhole 46 to the results from basin 3C.

SEWER REHABILITATION

A plan for conducting sewer rehabilitation was developed by IDG (INFLO Design Group LLC) in 2018. The project included lining 15 pipe segments by CIPP (Cured-in-Place Pipe) and rehabilitating 20 manholes. Rehabilitation was conducted from September 2019 to June 2020. Additionally, a set of plans by IDG (2019) were reviewed which included "General Project Notes" and "Cured in Place Pipe Procedure". (As-built plans were not available for review.)Service laterals connected to segments to be lined were to be inspected as part of the project and short segments of liner (4 to 6 LF) to stop leaks at the junction of the pipes were to be installed as determined by the engineer. There were 33 service laterals connected to pipes designated for CIPP lining.

Table 2 shows how the rehabilitation work was planned to be allocated in the four monitored basins and in the 15 inch trunk line downstream from the monitored areas. The total amount of lining work treated 6.9% of public sewers in the Cartwright Creek collection system. At the end of the project, the second round of flow and rainfall monitoring was initiated in June 2020 to measure the effectiveness of this phase of rehabilitation.

Table 2. Cartwright Creek 2019-2020 sewer rehabilitation.

Monitored Manhole	Basin Size (LF)	Manholes rehabilitated	Number of pipe segments rehabilitated	Length of rehabilitated pipe (LF)	% Rehabilitation
3C	10,751	2	1	176	1.6%
46	14,224	12	10	2,236	15.7%
97	10,284				0.0%
96F	10,438	2			0.0%
Unmonitored near WWTP	2,595	4	4	940	36.2%
TOTAL:	**48,292**	20	15	3,352	6.9%

RESULTS

The results shown in Table 3 summarize for the Cartwright Creek system the reduction of the ADDWF-7 and I/I parameters by combining the results from the monitor at manhole 46 with the results from basin 3C, and comparing the values calculated in 2020 to the results calculated in 2017. The technical reports on the analysis performed for each monitoring location for the before-after monitoring periods are included in Appendix A (for 2017) and Appendix B (for 2020).

Table 3. Comparison of I/I parameters calculated from the before-after temporary flow monitoring.

All monitored areas *

	2017	**2020**	**change**	**% change**
7-day ADDWF (mgd)	0.417	0.173	0.244	59%
AM low hour (mgd)	0.315	0.090	0.225	72%
RDI/I 24-hr, 5-year (mg)	1.283	0.479	0.804	63%
RDI/I pk-hr, 5-year (mgd)	2.053	1.628	0.425	21%
Annual I/I (MG)	144.5	47.0	97.429	67%

* Estimated by adding results from Monitors 46 and 3C.
(represents 94.6% of the system and was 5.3% rehabilitated)
Does not include 2,595 LF of trunk lines or unknown overflow locations.
System length includes 2,595 LF of unmonitored trunk line

Most of the rehabilitation work was conducted in basin 46 and most of the flow and I/I reduction was observed in that basin as shown in Table 4. However, the values for the overall system in Table 3 and Table 4 should be used carefully considering the following points:

- Both of the before-after monitoring periods were conducted during dry season conditions (low rainfall and high evapotranspiration). Experience has shown in Tennessee that RDI/I values are affected by these conditions. In the wet season, they are usually greater than during the dry season. It is important to identify the “worst case” conditions. Therefore, measurements during the wet season are the most useful.

- As discussed later, some flow and I/I values were observed to decrease in basins which did not receive any rehabilitation pipe lining work. This means that there is a possibility that some of the reduction that was observed was due to the variation in dry weather conditions.
- The numbers in Table 3 were calculated for an aggregate of the results for the flow monitor locations used in the two studies. However, those studies did not include about 5% of the total system contributing to the treatment facility because some of the trunk lines were not monitored. I/I in those pipes will increase the overall values. Some CIPP liners were installed on the trunk lines, which will likely reduce the additional unknown I/I impact (downstream of manhole 3C and manhole 46) on the treatment facility.

Basin 46 was experiencing significant dry weather infiltration in 2017. This was clearly illustrated by inspection of the ADDWF-7 hydrograph in Figure 4 which showed that the AM low flow rate (0.302 mgd) was 80% of the ADDWF-7.

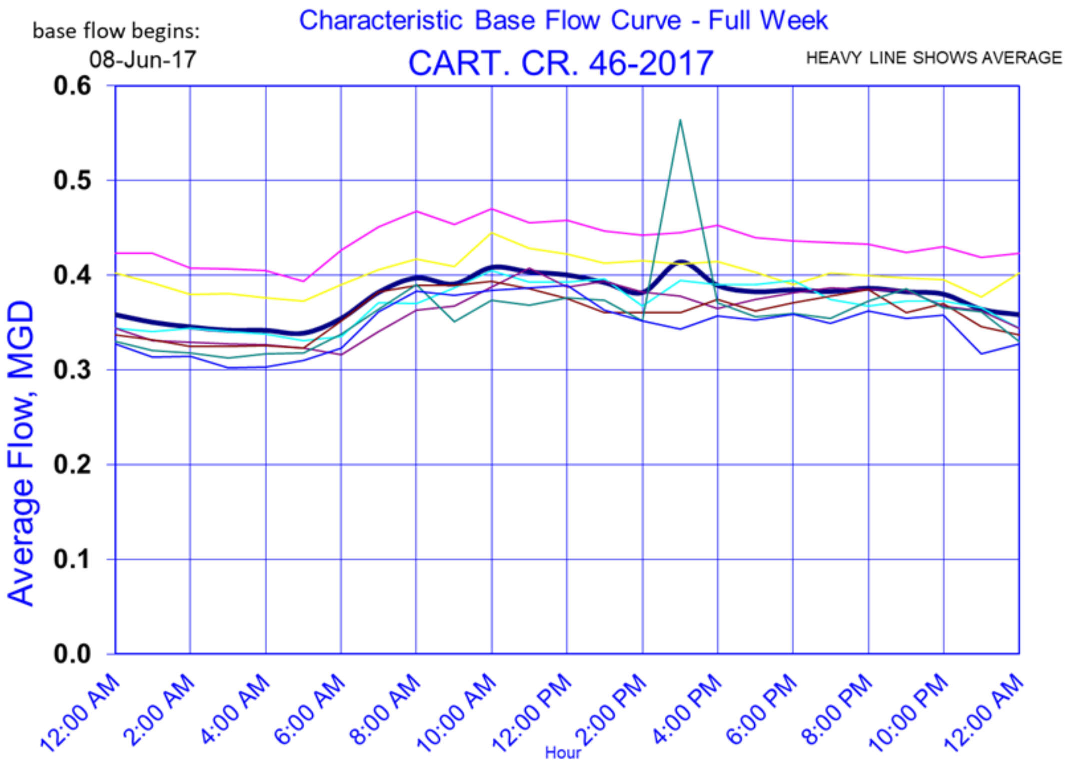

Figure 4. Monitor 46 ADDWF-7 hydrograph before rehabilitation average 0.377mgd.

Following lining in that basin, in 2020 the AM low flow rate dropped to 0.085 mgd and represented 54% of the ADDWF-7 shown in the hydrograph in Figure 5.

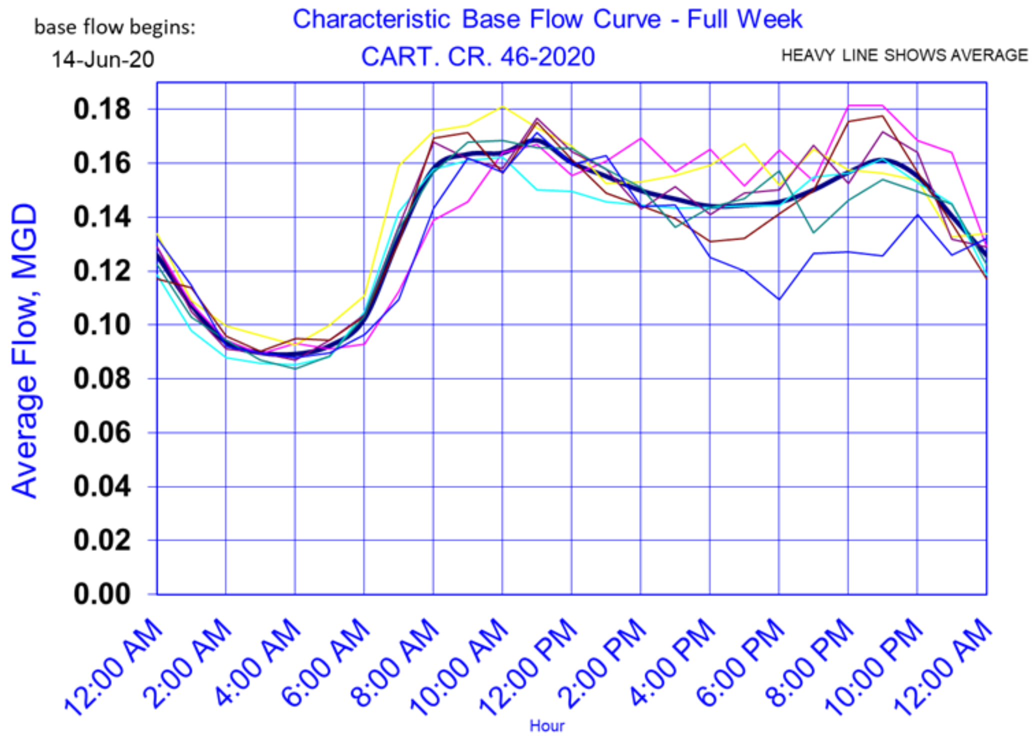

Figure 5. Monitor 46 ADDWF-7 hydrograph after rehabilitation average 0.137 mgd.

The results for Monitor 46, 96F and 97 were combined mathematically to estimate the results for Basin 46 as shown in Table 4.

Table 4. Comparison of I/I parameters calculated from the before-after temporary flow monitoring in Basin 46.

Basin 46 *

	2017	2020	change	% change
7-day ADDWF (mgd)	0.320	0.097	0.224	70%
AM low hour (mgd)	0.275	0.074	0.201	73%
RDI/I 24-hr, 5-year (mg)	0.726	0.224	0.501	69%
RDI/I pk-hr, 5-year (mgd)	**	NA	**	NA
Annual I/I (MG)	113.8	35.4	78.375	69%

* Basin 46 contribution calculated by subtracting results of monitors 96C and 97 from monitor 46 (represents 29.5% of the system and was 15.7% rehabilitated)

** Value obtained by subtraction was negative since most of the peak hour flow came from 96F

Unexpectedly, some of the flow and I/I parameters also decreased in the two upstream basins which did not receive CIPP lining (although 2 manholes were rehabilitated in basin 96F). The changes are shown in Table 5 and Table 6.

Table 5. Comparison of I/I parameters calculated from the before-after temporary flow monitoring at Monitor 96F.

Monitor 96F

	2017	2020	change	% change
7-day ADDWF (mgd)	0.038	0.018	0.020	53%
AM low hour (mgd)	0.020	0.007	0.013	64%
RDI/I 24-hr, 5-year (mg)	0.280	0.184	0.096	34%
RDI/I pk-hr, 5-year (mgd)	1.771	1.113	0.658	37%
Annual I/I (MG)	14.9	4.9	9.966	67%

Table 6. Comparison of I/I parameters calculated from the before-after temporary flow monitoring at Monitor 97.

Monitor 97

	2017	2020	change	% change
7-day ADDWF (mgd)	0.019	0.023	-0.004	-19%
AM low hour (mgd)	0.008	0.003	0.005	60%
RDI/I 24-hr, 5-year (mg)	0.079	0.033	0.045	58%
RDI/I pk-hr, 5-year (mgd)	0.096	0.075	0.020	21%
Annual I/I (MG)	8.2	1.7	6.508	79%

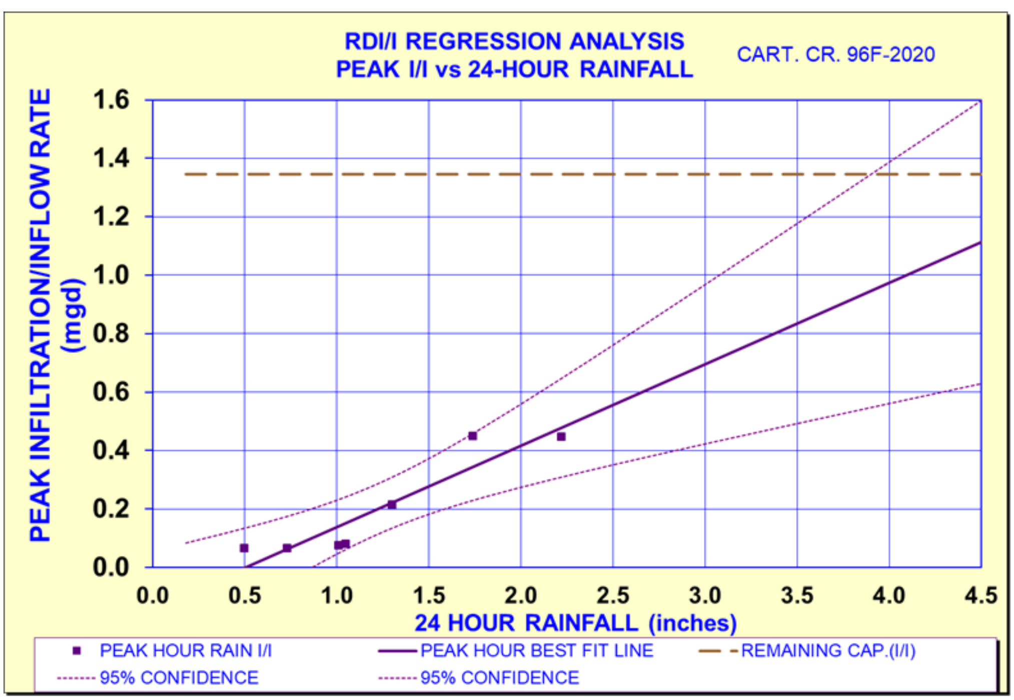

Figure 6. Projected Peak-hour RDI/I for a range of rainfall events up to 4.5 inches in 24 hours.

The peak-hour projected RDI/I did not significantly decrease in the system following sewer rehabilitation. After reviewing the results for this parameter at all the monitoring locations, the Analyst concluded that most of the peak-hour I/I originates in basin 96F. Therefore further investigations for inflow sources should focus in that basin. The graph in Figure 6 shows that there is a significant amount of RDI/I in 96F measured in the summer of 2020.

Improved Hydraulic Characteristics

All raw depth and velocity data are subjected to a scattergraph analysis to determine the true capacity of the monitored segment (in contrast to a theoretical capacity based on estimates of hydraulic slope and roughness). In addition to quantifying the capacity, the scattergraph usually reveals a qualitative impression of flow characteristics. For example, the scatter of data points in 2017 for the meter at manhole 46 (Figure 6) showed poor characteristics (backed up flow beginning when the pipe was only at about half capacity). Monitoring data should ideally fall on (or have a slope similar to) the Mannings curves (shown here with constant and variable "n" versions).

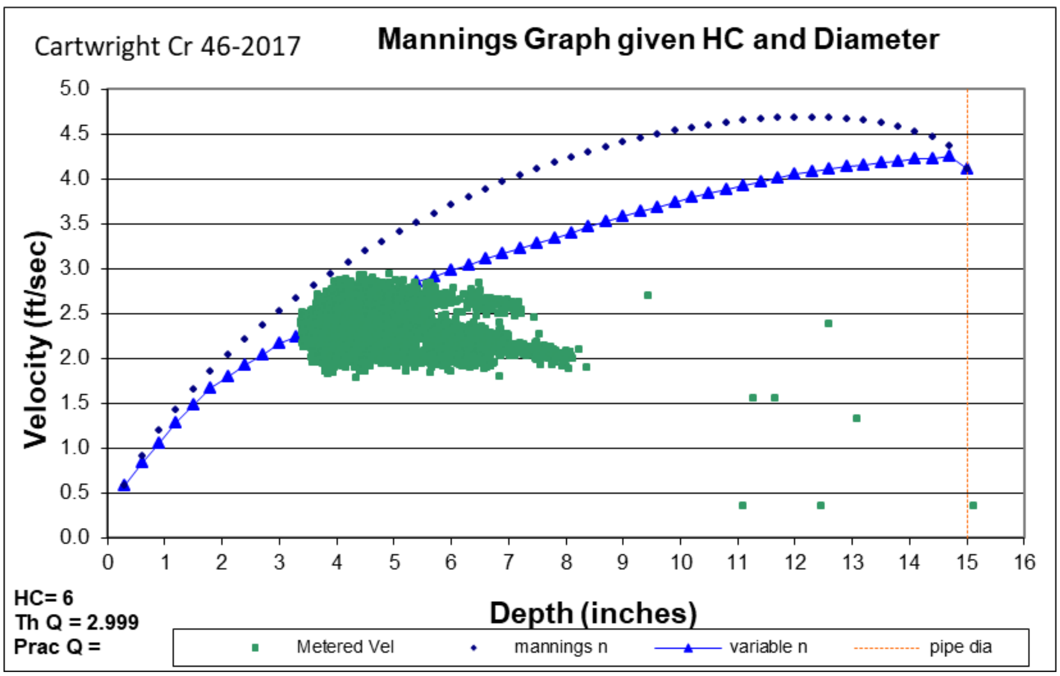

Figure 6. Scattergraph of velocity vs depth for monitor 46 in 2017.

However, after lining in 2020, the scatter of data was much tighter than observed in 2017 as shown in Figure 7. Also, no backed up flow was observed. Finally, the graph of the actual data points observed in 2020 represent a typical Mannings curve with an offset (sometimes referred to as a "dead dog" effect). The most important points observed in 2020 are that there was no hindered flow, and that the data points were in a tight linear form. This shows that the meter was working well and that the pipe was operating efficiently through the range of observed depths (up to 9.5 inches in a nominal 15 inch pipe).

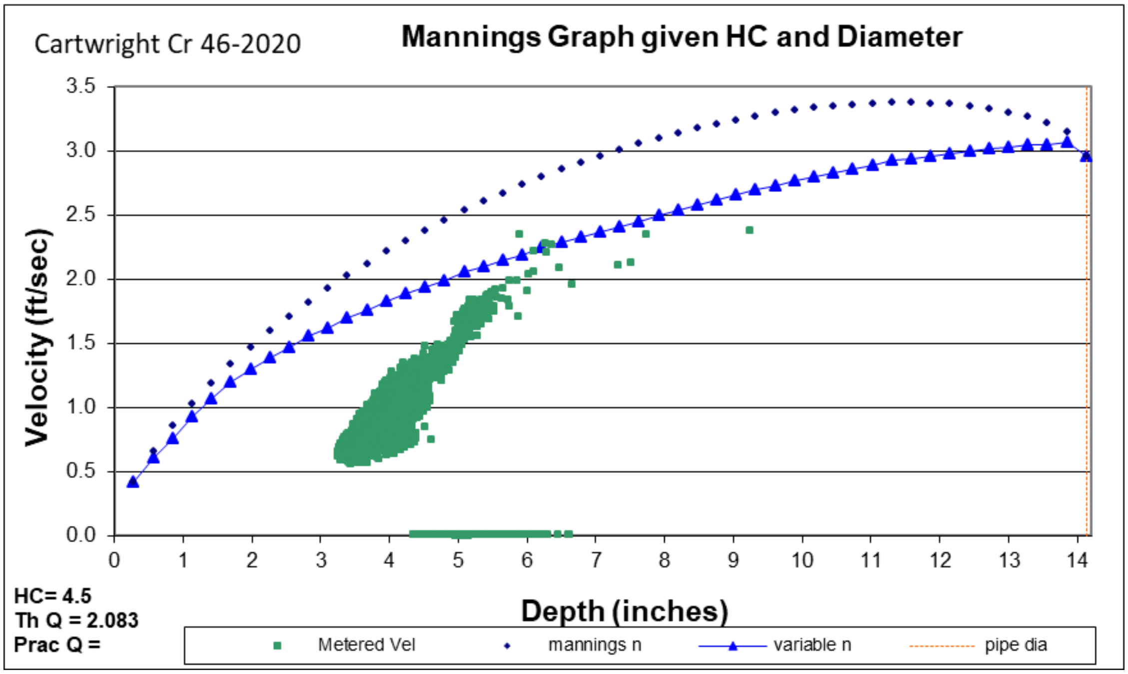

Figure7. Scattergraph of velocity vs depth for monitor 46 in 2020.

CONCLUSIONS

- The shape of the ADDWF-7 hydrograph for meter 46 during the 2017 temporary monitoring showed evidence of more than 200,000 gpd dry weather infiltration. This was significantly reduced after rehabilitation in 2020. The ADDWF-7 at this meter was reduced from 0.377 to 0.137 mgd following rehabilitation. The ADDWF-7 for the monitored system was reduced to 0.173 mgd which is below the rated capacity of the treatment facility.
- Since the two upstream basins that were not rehabilitated showed some decrease of flow and I/I related parameters, then all of the reductions measured in the basins that were treated should not be solely attributed to the rehabilitation work.
- The projections and graphs of peak-hour RDI/I changed very little from 2017 to 2020. This suggests that there are likely inflow locations which need to be investigated and corrected. Smoke testing may be helpful for this purpose. Basin 96F showed the greatest level of peak-hour RDI/I (1.113 mgd) projected for a 5-year, 24-hour rain event of 4.5-inches. An investigation to find inflow sources is recommended to begin with that basin.
- The lack of an on-site or local rain gauge severely limits the reliability of RDI/I analytical results based on data in MORs for long-term monitoring.
- Failure (or deterioration) of the influent meter at the treatment facility eliminated most of the value of the flow data in 2019 and all of 2020 for the purpose of I/I and RDI/I analysis. The increasing BOD concentrations give some indirect indications of I/I reduction in the spring and summer of 2020. The meter was repaired in September 2020, and the readings compare well with the measurements made by the plant effluent meter.

RECOMMENDATIONS

- Procure and operate a tipping bucket type rain gauge with a recorder for monitoring rainfall in 15 minute increments. The gauge should be located in a place that reasonably represents the centroid of the Cartwright Creek sewage collection system.
- Have the treatment facility influent flow meter inspected and calibrated by a person trained to evaluate similar equipment. In particular, the calibration should include calibration of the actual flow (not just calibration of the electronics). An engineer should evaluate the location of the existing meter and the results from the inspection and make recommendations for either accepting the existing location and equipment or recommending new equipment and configuration to obtain reliable influent flow information. This recommendation may have a lower priority now that the meter has been repaired.
- Cartwright Creek should conduct another round of flow and rainfall monitoring during the next wet season at the four locations previously monitored and the data analyzed using the same methods as the studies in 2017 and the summer of 2020 to assure a proper comparison. Since the two previous monitoring studies were conducted during generally dry weather conditions (low groundwater and high evapotranspiration from active vegetation and trees), then the results from a wet-season study should provide a true baseline of infiltration and RDI/I conditions to act as a baseline for future rehabilitation planning and decisions.
- Conduct smoke testing to locate possible inflow sources in Basin 96F.
- Consider using short-term, incremental depth/flow meters (eg. ITracker) to isolate defective line segments during wet weather to detect inflow.
- Conduct additional sewer rehabilitation. A long-range plan should be based on rehabilitating an additional 15% of the system (about 7,200 LF) using the rehab experience in Nashville and Brentwood as a guide. Any rehabilitation plan should focus first on stopping migration of groundwater and should work on priority areas. That means taking a “system approach” by conducting lining, manhole rehabilitation, and lateral rehabilitation to stop migration of water in a particular area.
- If new sections of undeveloped land are opened for development, then the Owner may want to consider using individual grinder pumps at the new homes. Discharging to a low pressure system of collector pipes would eliminate adding new I/I. However, a plan would be needed for maintaining the grinder pumps for those customers.

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APPENDIX A

2017 Analysis Reports

APPENDIX B

2020 Analysis Reports

APPENDIX C

MOR Analysis Spreadsheets