MEMO

Date: July 2, 2014

To: The City of Dublin

From: Taymour El-Hosseiny, Ph.D, PE

Subject: Capacity Analysis for the North Fork Indian Run Sub-trunk

Copies: Craig Bohning

1. Purpose

The purpose of this memo is to provide a discussion on capacity analysis for the North Fork Indian Run (NFIR) sub-trunk sewer operated and maintained by the City of Dublin, OH. The capacity analysis evaluates impacts of projected discharges from future development using dynamic hydraulic modeling (PCSWMM) for the following scenarios:

a. Proposed changes in land use from a golf course to a housing development at a site currently operated by Riviera Country Club (approximately 170 acres).

b. Build-out of possible developable open space tributary to the North Fork Indian Run sub-trunk sewer. The available open space for future development is approximately 460 acres including the Riviera site.

2. Background

The Davidson Phillips proposes to change the land use of a site currently operated as a golf course to residential housing units (the golf course is currently operated by the Riviera Country Club). Sanitary wastewater from the new housing units would discharge into the North Fork Indian Run (NFIR) sub-trunk sewer. Due to changes in land use, the City of Dublin, OH has requested Davidson Phillips to provide capacity assurance that the NFIR sub-trunk sewer has adequate capacity to convey collected wastewater at current and build-out conditions without a negative impact on current sewer services and would not impose limitations on future development.

Exhibit 1 illustrates a layout of the NFIR sub-trunk sewer and location of the proposed site development. This study is a planning level analysis, where it is early to decide where the exact tie-in location of the new development into the NFIR. Moreover, since the NFIR sub-trunk sewer is the center of this study, small diameter sewers are not included in the analysis.

Therefore, this study focuses on the capacity assurance of the NFIR sub-trunk sewer only where detailed tributary sewers are considered beyond the scope of this memorandum.

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In 2011, the City of Dublin conducted a study to evaluate the capacity of its sub-trunk sewers located within the Bridge Street Corridor[1]. The study used computer modeling of the sewer system (XP SWMM) and the following are important findings related to the NFIR:

a. Field observations shows evidence of surcharge at manhole # 3121located under I-270.
b. Capacity deficiency in the NFIR is predicted at build-out condition if no reduction in current infiltration/inflow (I/I) rates would be implemented based on available flow monitoring data.
c. In the 2011 Annual Report by the City of Dublin to Ohio EPA, the City reported water-in-basement (WIB) at 7753 Crawley Drive, which is located in the NFIR basin. The report indicated that the WIB incident occurred on 12/5/2011 was caused by excessive Infiltration/Inflow due to wet weather flow.

3. Study Area:

Exhibit 1 illustrates 3,740 acres tributary area to the NFIR sub-trunk sewer where it shows currently developed and future available open space for development as agreed with the City of Dublin[2]. The western border of the tributary area is bounded by Highland-Croy Road, the southern border is Bridge Street, and the northern border is tributary boundary between the NFIR and the Deer Run sub-trunk sewers. Figure 1 depicts land development status of the 3,740 acres tributary to the NFIR sub-trunk sewer, which can be characterized as follows:

- Existing Development: 2,430 acres are currently developed (70% of the total area) as: Single family 67%, multi-family 9%, commercial 14%, and schools 9% (figure 2 illustrates land use of the existing development).
- Future Development: 460 acres (13% of the total area) are available for future development as either mixed residential low density near Brock Road or current large lots that may be subdivided into residential subdivision.
- Parks: 580 acres (17% of the total area) are designated as parks and open space.

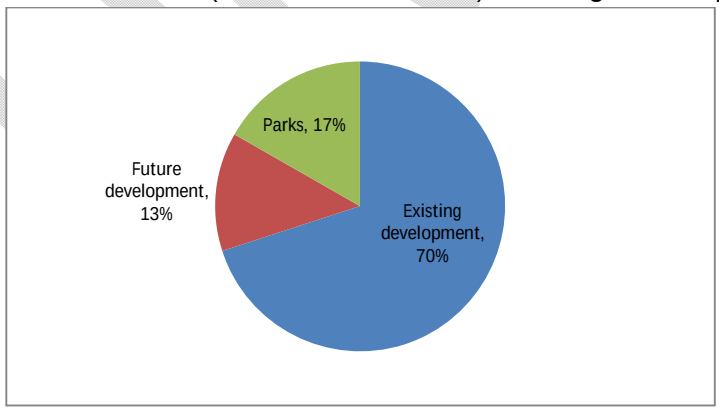

Figure 1: Land Development Status of Tributary Area to the North Fork Indian Run

[1] City of Dublin, 2011, Bridge Street Corridor, Sanitary Sewer System Modeling, EMH&T
[2] E-mail from Barbara Cox dated 3/26/2013. NFIR Future Tributary area

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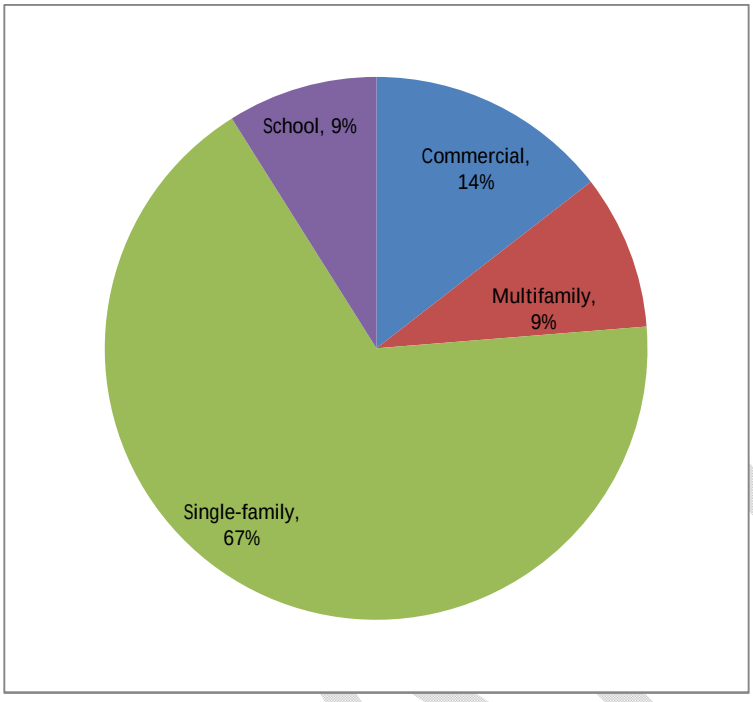

Figure 2: Land Use Classification of Current Tributary Area to the North Fork Indian Run

4. Flow Monitoring Program:

Four (4) flow meters were installed at key locations to characterize tributary flow. Exhibit 2 illustrates locations of the installed flow meters where data was recorded for approximately 2 month between 3/7/2013 to 4/29/2013. Table A-1 in Appendix A lists the installed flow meter and pictures of the installation. Table 1 is a description of the installed flow meters, measured water depth of average dry weather flow (DWF), and ratio of Average DWF to the sewer diameter.

Table 1: Summary Characteristics of Installed Flow Meters in the North Fork Indian Run Sub-Basin

Flow meter ID	MH#	Location	Description	Sewer Diameter, Slope Inch, %	Average DWF Depth Inch	Ratio of DWF to Diameter %
FM1	2515	Near Kilgour Place and Indian Run Falls Park	Outfall of the North Fork Indian Run sub-trunk sewer	24, 0.38%	9.64	40%
FM2	3472	Tenbury Dr and	Northern area to the NFIR: Brandon Sections 1, 2 and	15, 0.2%	5.47	36%

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Flow meter ID	MH#	Location	Description	Sewer Diameter, Slope Inch, %	Average DWF Depth Inch	Ratio of DWF to Diameter %
		Worsley Pl	3, Bristol Commons, Ashnaugh outfall, Muirfield village			
FM3	775	Finnegan Ct and Earlsford Dr	Southern area to the NFIR: Avery Rd Sewer, Dublinshire, Windham Village, Westbury, Park Place, Bishop Crossing	18, 0.3%	3.45	19%
FM4	1508	Avery Rd and Balmoral Dr	North area of NFIR: Shannon Glen, Belvedere, Tartan West, Tartan Ridge	24, 0.23%	4.2	17%

DWF: Dry Weather Flow

During the monitoring period, four (4) rainfall events were used on model calibration (all of them are less than 1-yr). Table 2 lists the highest recorded flow during the monitoring period due to a rainfall event occurred on 3/18/2013. The total rainfall for this event was 0.9-inch with a duration of 6-hours which can be classified as 2-month, 6-hr storm. Table 2 lists maximum recorded water depth and ratio to the sewer diameter where FM2 recorded 96% full due to the 2-month storm. The City of Columbus, Division of Sewerage and Drainage (DOSD) provided Rainfall data recorded at rain gauge RG1 which is installed at 5800 Post Rd, Dublin OH (Coffman Park).

Table 2: Highest Recorded Wet Weather Flow between 3/7/2013 and 4/29/2013

Flow meter ID	MH#	Sewer Diameter	Max Water Depth (3/18/2013)	Ratio of max water depth to sewer diameter
		in	in	%
FM1	2515	24	14.8	61%
FM2	3472	15	14.4	96%*
FM3	775	18	4.09	22%
FM4	1508	24	5.12	21%

* Sewer reached 96% full due to 2 month storm

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5. Modeling Analysis

A dynamic hydraulic model was developed for this study to evaluate the capacity of the NFIR sub-trunk sewer employing PCSWMM 2012 software and SWMM engine 5.0.022. The model has two principle components:

1. Detailed physical characteristics of the NFIR acquired from the City of Dublin sewer records and GIS. The information includes sewer invert elevation, top-of-casting elevation, sewer diameter, sewer slopes, and sewer offsets.
2. Flow estimates for dry and wet weather flow based on land use, acreage, house counts, per capita wastewater allowance 100 gal/day, diurnal hourly variations during the day, and Infiltration/Inflow (I/I) rates using flow monitoring data.

Sewer model scenarios were developed to perform the following tasks:

1. Calibrate the sewer model to observed flow data for an accurate simulation
2. Evaluate the capacity of the NFIR and identify locations with capacity deficiency
3. Propose alternatives to eliminate identified deficiency (if any)

Table 3 is a summary of the developed model scenarios for the NFIR illustrating the purpose of each scenario, rainfall used to generate wet weather flow as a Level-of-Service, and a brief description of the model component.

Table 3: Summary of Model Scenarios for the NFIR Sub-trunk Sewer

	Purpose	Scenario	Rainfall	Comments
1	Model Calibration	Current conditions	Historical	Continuous simulation between 03/7/2013 thru 4/29/2013 (53 days duration). Use current tributary area and current I/I
2	Capacity deficiency ID	Build-out	Design storm, 25-yr, 6-hr	Event model: Ultimate tributary area with no improvements
3	Alternative Analysis	Build-out solution, Alternative 1	Design storm, 25-yr, 6-hr	Event Model: Augmentation relief sewer at the same grade as NFIR to increase the capacity of the deficient capacity sewer segments
4		Build-out solution, Alternative 2	Design storm, 25-yr, 6-hr	Event Model: Replace and upsize deficient capacity sewer segments of the NFIR
5		Build-out solution, Alternative 3	Design storm, 25-yr, 6-hr	Event Model: Storage equalization tank to shave peak flow and return back stored flow to the NFIR
6		Build-out solution, Alternative 4	Design storm, 25-yr, 6-hr	Event Model: Parallel relief sewer 1-ft above existing sewer to convey excess flow above the capacity of the deficient capacity sewer segments

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5.1. Model Calibration:

Figure 3 is a graphical comparison between model results (computed) and recorded flow data at flow meter FM1 (MH# 2515) for dry and wet weather flow. The illustration is for a selected period pulled from the continuous simulation to demonstrate the largest response during the monitoring period (March 18, 2013). Table 4 lists computed and observed peak flow and corresponding. For more detailed comparison of the other flow meters, refer to the digital sewer model in the attached CD using PCSWMM.

Table 4: Computed and Observed Peak Flow at Monitored Locations

Flow meter ID	Peak flow		Difference
	Computed	Observed	
	cfs	cfs	%
FM1	6.55	6.42	2.0 %
FM2	3.43	3.90	12.0 %
FM3	0.71	0.65	7.6 %
FM4	0.85	0.82	4.0 %

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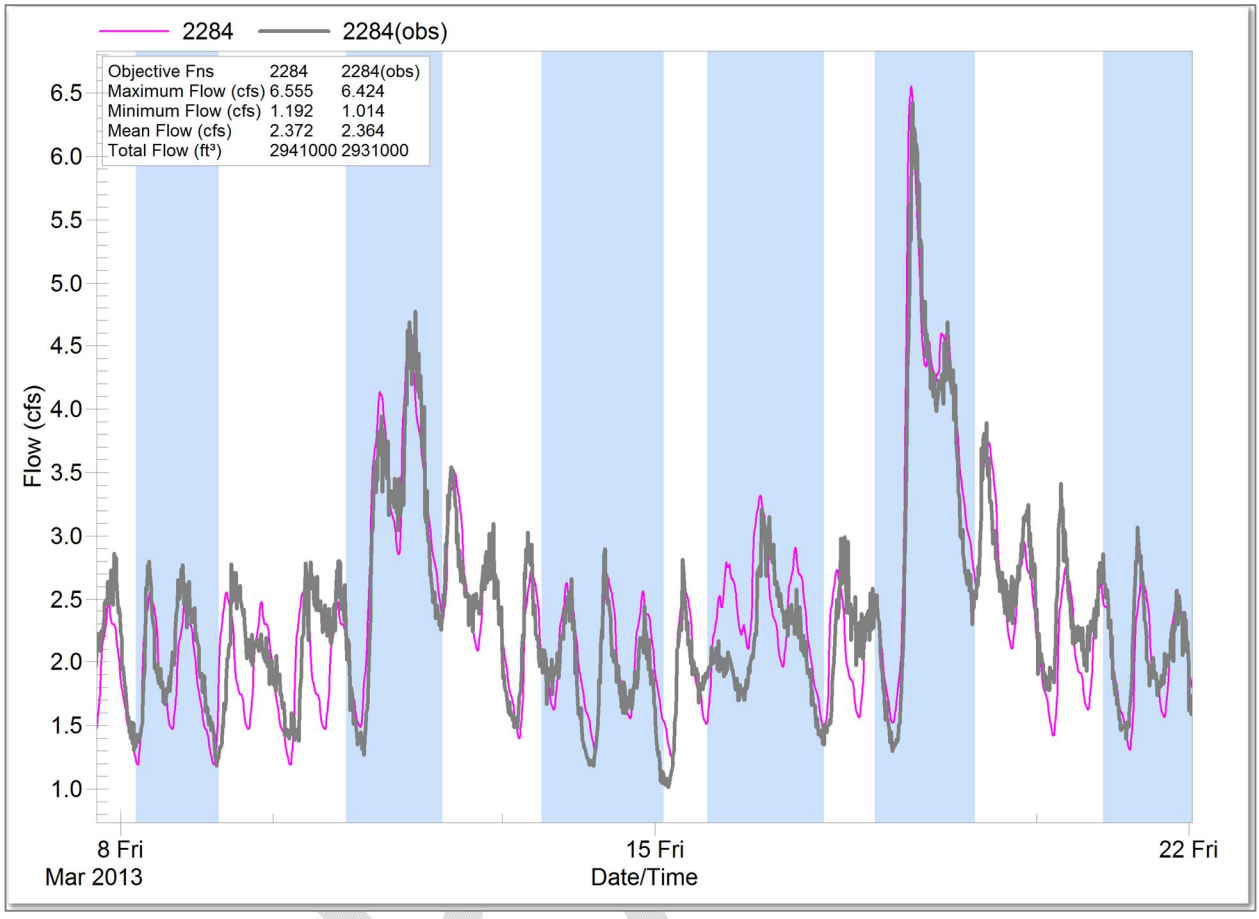

Figure 3: Comparison between Computed and Recorded Flow Data at FM1

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5.2. Capacity Analysis:

Capacity analysis is determined assuming:

1. Build-out conditions of possible developable land tributary area to the NFIR
2. Model parameters for build-out are acquired from the calibrated model at current conditions
3. Level-of-service at 25-yr, 6-hr design storm to generate wet weather flow

Exhibit 3 illustrates a summary of findings after running the Build-out conditions model for the NFIR sub-trunk sewer

1. Segment 1: Adequate capacity is predicted in the sewer segments from the north end of NFIR at Mckitrick Rd (MH# 5562) until the intersection of Earlington/DublinShire (MH# 2121) near Brandon Woode Park.

2. Segment 2: Surcharge conditions are anticipated in manholes between Earlington/DublinShire from MH# 2121 until MH# 2517 located at the John Sells school yard near Bridge Street due to: a) mild slope installation of the NFIR (24-inch at 0.38%) and, b) increased infiltration/ Inflow (I/I) rates from tributary areas to FM2 (MH#3472).

3. Segment 3: Adequate capacity is available in sewer segments between MH#2517 and the sub-trunk sewer outfall at Dublin Rd. The identified adequate capacity is due to 38-ft drop in elevation from 827.00 to 789.00. The receiving sewer is 36-inch at 0.74% slope.

4. Overflow is predicted from the following manholes:
   a. MH# 2496 located at the intersection of the NFIR and I-270 (Figure 4)
   b. MH# 2847 located at the back yard of houses near the intersection of Tenbury Dr. and Reddington Dr. (Figure 5)

   Figure 6 is a longitudinal hydraulic profile of the NFIR illustrating sewer invert, sewer crown, top-of-casting, and estimated maximum hydraulic grade line using the 25-yr design storm. Potential overflow is predicted at manholes located at low elevations.

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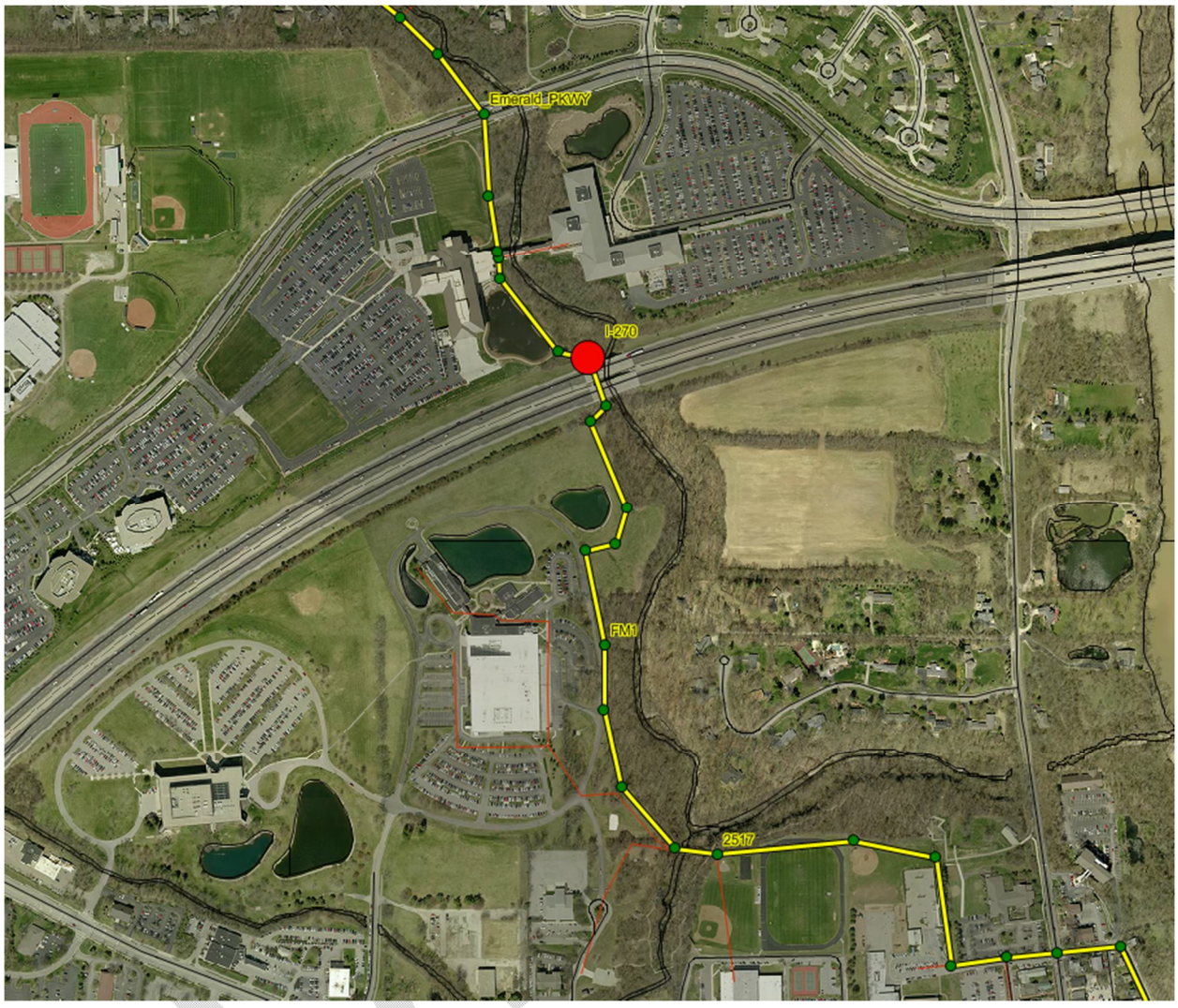

Figure 4: Identified Manholes with Potential Overflow under I-270

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Figure 5: Identified Manhole with Potential Overflow Using 25-yr storm

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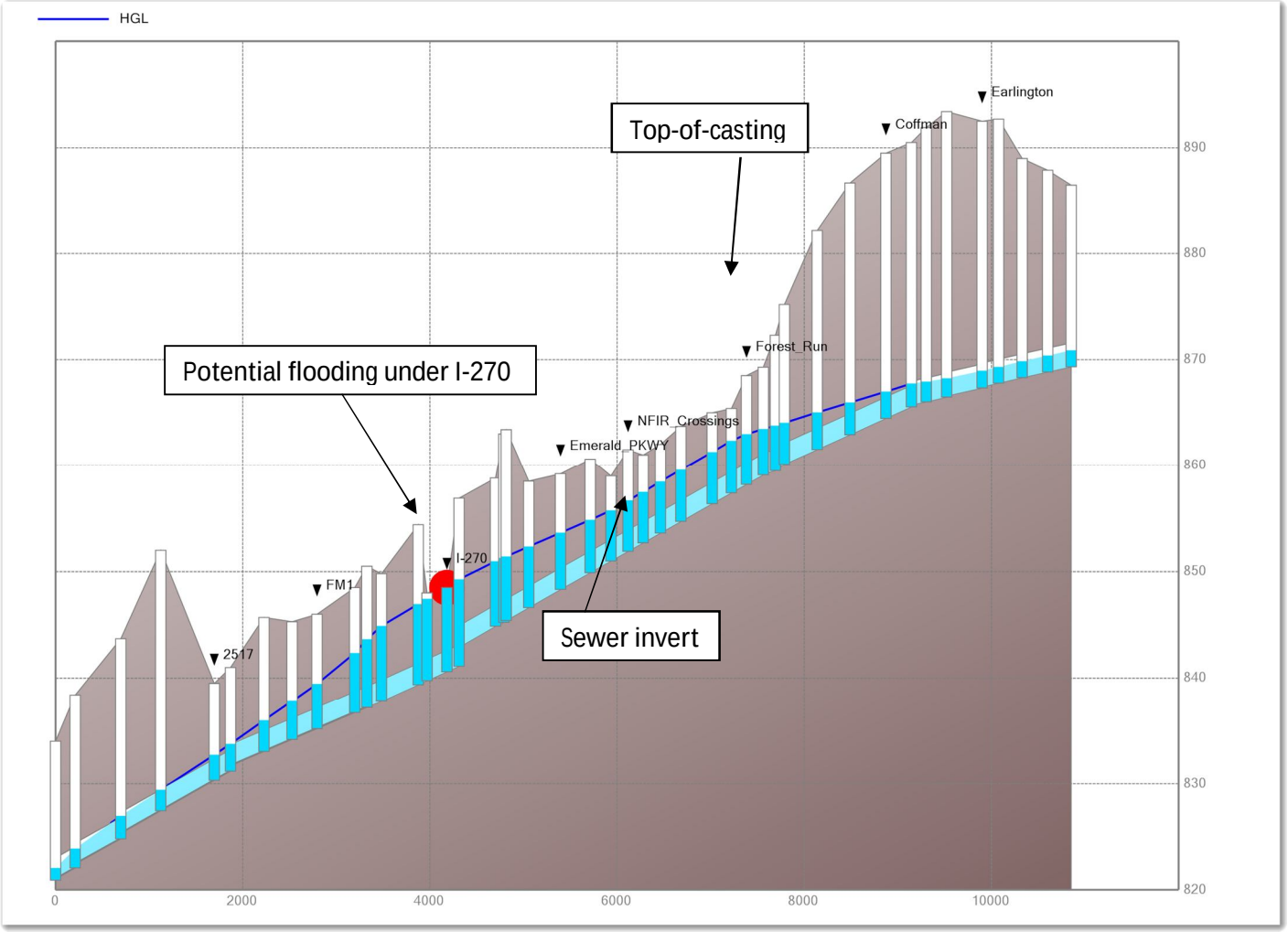

Figure 6: Hydraulic Profile of the Surcharged Segment for the North Fork Indian Run

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5.3. Alternative Analysis

Four technologies are considered viable to alleviate identified capacity deficiency for the NFIR as follows:

1. Replace and up-size
2. Augmentation relief sewer
3. Storage
4. Source control

5.3.1. Alternative 1: Replace and Up-size:

This alternative proposes to replace and upsize deficient capacity sewer segments. The proposed improvement would increase the capacity of sewer segments from MH# 2521 to MH# 2512, and between MH# 2491 to MH# 2847.Table 5 lists proposed improvements and potential increase in capacity. Potential overflows are eliminated due to increase in conveyance.

Table 5: Proposed Upsized Sewer Segments to Increase Capacity Conveyance in the NFIR

Segment	Length	Manhole		Sewer Size		Sewer Slope		Capacity	
		From	To	From	To	From	To	From	To
	ft	#	#	inch	inch	%	%	cfs	cfs
1	2,038	2521	2512	24	30	0.38 %	0.38 %	13.90	25.00
2	136	2845	2847	8	12	0.88%	0.88%	1.13	3.34
3	682	2491	2845	15	24	0.028%	0.028%	1.07	3.78

5.3.2. Alternatives 2 & 3: Augmentation Relief Sewer:

Two alternatives are explored under this category to augment capacity to the NFIR as follows:

1. Construct an **Express Sewer** to relief deficient capacity segments to be laid at the same grade as the existing sub-trunk sewer. Exact alignment is not dot determined at this stage but can be flexible depending on easement availability.

2. Construct a **Parallel Relief Sewer** at the same alignment as the existing sub-trunk sewer laid 1-ft above the crown of the identified sewer segments.

Alternative 2, Express Sewer: This alternative proposes: a) augmentation capacity to the sub-trunk sewer; and b) upsize sewer segments near Brand Rd / Earlington PKWY.

a) The augmentation sewer would be 18-inch diameter, 1,935-ft long; at slope 0.5-0.3%. Alignment is open at this planning stage. The proposed invert of the relief

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sewer would be offset 1-ft higher than the sub-trunk sewer to be active only during wet weather flow. The proposed sewer will extend from MH# 1849 and MH# 2510

b) Upsize of sewer segments near Brand Rd / Earlington PKWY is required to mitigate potential overflow from those segments. Table 6 lists proposed improvements and potential increase in capacity

Table 6: Proposed Express Sewer Installed Parallel to the NFIR

Segment	Length	Manhole		Sewer Size		Sewer Slope		Capacity	
		From	To	From	To	From	To	From	To
	ft	#	#	inch	inch	%	%	cfs	cfs
1	1,935	2521	2512	N/A	18	N/A	0.5-0.3 %	N/A	8.1
2	136	2845	2847	8	12	0.88%	0.88%	1.13	3.34
3	682	2491	2845	15	24	0.028%	0.028%	1.07	3.78

Alternative 3: Parallel Relief Sewer

This alternative proposes: a) the construction of a parallel sewer lay 1-ft above the existing sewer; and b) upsize sewer segments near Brand Rd / Earlington PKWY.

a) The proposed relief sewer would be 18-inch laid at the slope as the existing sub-trunk sewer from MH# 2521 to MH# 2512. The estimated length is 2,038-ft. The relief sewer will receive excess flow above the capacity of the NFIR during wet weather flow.

b) Upsize of sewer segments near Brand Rd / Earlington PKWY is required to mitigate potential overflow from those segments. Table 7 lists proposed improvements and potential increase in capacity.

Table 7: Proposed Parallel Relief Sewer Laid 1-ft above the Crown of the NFIR

Segment	Length	Manhole		Sewer Size		Sewer Slope		Capacity	
		From	To	From	To	From	To	From	To
	ft	#	#	inch	inch	%	%	cfs	cfs
1	2,038	2521	2512	N/A	18	N/A	0.38%	N/A	6.4

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Segment	Length	Manhole		Sewer Size		Sewer Slope		Capacity	
		From	To	From	To	From	To	From	To
	ft	#	#	inch	inch	%	%	cfs	cfs
2	136	2845	2847	8	12	0.88%	0.88%	1.13	3.34
3	682	2491	2845	15	24	0.028%	0.028%	1.07	3.78

5.3.3. Alternative 4: In-line Storage

This alternative proposes: a) construction of an online storage replacing the existing sewer; and b) upsize sewer segments near Brand Rd / Earlington PKWY.

a) The proposed online sewer would be 60-inch to replace and be laid at the slope as the existing sub-trunk sewer from MH# 2521 to MH# 2510. The estimated length is 1,000-ft. The relief sewer will store excess flow above the capacity of the NFIR during wet weather flow and release it gradually.

b) Upsize of sewer segments near Brand Rd / Earlington PKWY is required to mitigate potential overflow from those segments. Table 8 lists proposed improvements and potential increase in capacity.

Table 8: Proposed online Storage to Alleviate Identified Capacity Deficiency in the NFIR

Segment	Length	Manhole		Relief Sewer Size		Sewer Slope		Capacity	
		From	To	From	To	From	To	From	To
	ft	#	#	inch	inch	%	%	cfs	cfs
1	1,000	2513	2511	24	60	0.30 %	0.30 %	12.3	14.2
2	136	2845	2847	8	12	0.88%	0.88%	1.13	3.34
3	682	2491	2845	15	24	0.028%	0.028%	1.07	3.78

5.3.4. Source control

Source control (i.e., I/I reduction) was not explored in this analysis due to lack of data for its effectiveness. The City of Dublin is currently implementing a lining program for several sewer segments and assessing its effectiveness in flow reduction. Solid results require a holistic approach to address all sources of public and private sources. At the time of writing this memo, effectiveness of the lining program is under evaluation.

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Appendix A

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Table A-1: Installed Flow Meters in the North Fork Indian Run Sub-Trunk Sewer

Flow meter	MH ID	Sewer size	Installation water depth	From / To	Picture of Installation
FM1	2515	24-inch	9.5-inch	3/7/2013 – 4/29/2013	
FM2	3472	15-inch	5.5-inch	3/7/2013 – 4/29/2013	
FM3	775	18-inch	2.5-inch	3/7/2013-4/29/2013	
FM4	1508	24-inch	3.5-inch	3/7/2013-4/29/2013	

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