GPD GROUP

December 18, 2024
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2024041.51

To: Brad Kosco, PE, PS – City of Hudson

From: GPD Group

Cc:

No. of Pages: 12 (not including attachments)

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Technical Memorandum: Darrow Road Park Basin Hydrologic & Hydraulic Study

Purpose

The purpose of this technical memorandum (TM) is to summarize GPD Group's work on the Darrow Road Park Basin Hydrologic and Hydraulic Study, which evaluates the capacity of the existing system and explores storage improvements on the Darrow Road Park property.

Existing Condition

GPD Group performed a hydraulic and hydrologic analysis on the project area using PCSWMM (Version 7.6.3610) and GeoHECHMS software. PCSWMM utilizes the EPA's Storm Water Management Model (SWMM) as the computational engine. SWMM version 5.2.3 was used within PCSWMM. GeoHECHMS is a software tool created by CivilGEO, utilizing HEC-HMS as its computational engine. HEC-HMS, a program developed by the U.S. Army Corps of Engineers, is designed for conducting hydrologic analyses.

GPD utilized a PCSWMM model previously developed during past projects with the City. The model was updated to include a channel extending from Middleton Road to a 27-inch culvert under Edgeview Drive, which outlets to Darrow Road Park. Additionally, a 30-inch culvert on Edgeview Drive, also discharging to Darrow Road Park, was incorporated. These updates were based on client-provided survey data and OGRIP LiDAR data. The subcatchments were redelineated based on topography to align with the newly added sewers and channel. The existing conditions model is shown in **Figure 1**.

PCSWMM and GeoHECHMS models were set up to generate inflow hydrographs for evaluation in a hydraulic model. Soil information and land cover data were obtained from the USDA Natural Resources Conservation Service (NRCS) Web Soil Survey and National Land Cover database within the GeoHECHMS software to determine the Curve Numbers within the watershed. The soils are predominantly composed of different types of silty loam, which have poor drainage characteristics. The watershed's land use is a mix of urban areas and forested land. See **Table 1** below for a breakdown of the drainage areas, SCS Curve Number values and the time of concentration calculated within the GeoHECHMS model and carried over to the PCSWMM model.

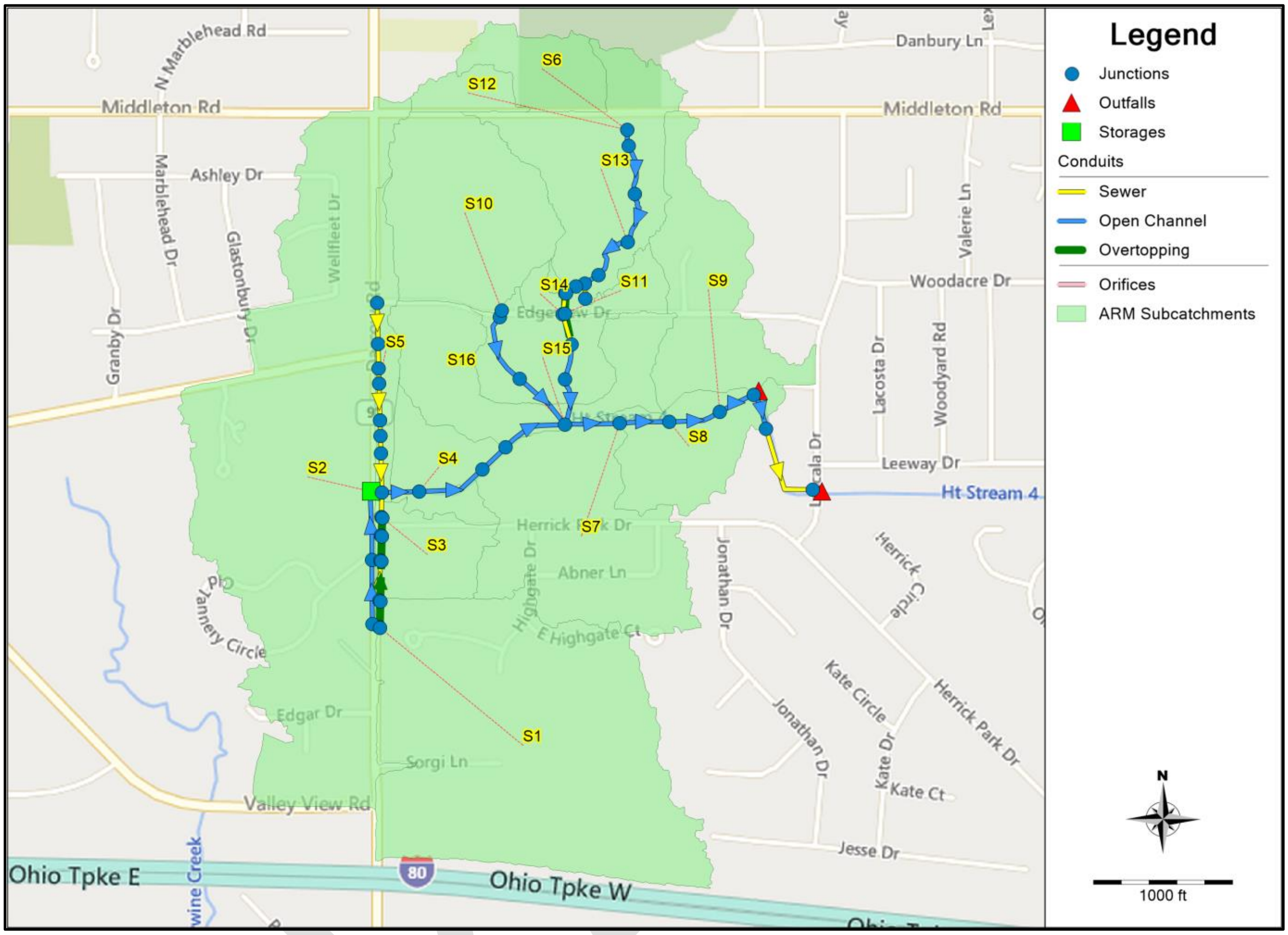


Figure 1: PCSWMM Model Schematic

Table 1: GeoHECHMS Sub-basin Data

Subcatchment	Area (acres)	Slope %	Flow Length (ft)	Computed CN	Time of Concentration (min)
S1	86.567	1.9	3027.2	83.37	53.72
S2	105.323	2.8	3006.7	84.41	43.15
S3	10.802	1.0	1133.9	84.07	37.77
S4	10.351	1.6	1218	85.74	38.01
S5	6.593	4.1	2142.3	85.5	26.92
S6	9.993	2.4	1298.1	85.18	56.03
S7	37.758	0.9	2463.4	84.37	32.87
S8	16.37	1.4	1585.57	83.9	23.94
S9	24.923	3.9	1298.59	85.56	36.15
S10	30.986	4.6	1808.91	84.46	25.8
S11	4.755	3.3	1148.38	84.98	28.61
S12	4.532	2.8	962.14	85.24	24.71
S13	29.013	3.4	2161.7	83	24.62
S14	1.627	8.3	382.49	79.86	19.75
S15	13.562	2.2	949.09	88.06	28.78
S16	21.418	2.6	1743.62	87.22	30.78

Lastly, the rainfall data from *National Oceanic and Atmospheric Administration Atlas 14* was applied to a 24-hour, SCS Type II curve and input into PCSWMM. The rainfall data is provided in **Table 2** and the subcatchment runoff generated in PCSWMM using Alternative Runoff Method (ARM) subcatchments is summarized in **Table 3**. It should be noted that the August 8, 2024 event that caused widespread flooding in the city was between a 500-year and 2000-year event based on total rainfall over 24-hours. The ARM subcatchment option in PCSWMM allows for the use of runoff methods that differ from the SWMM5 non-linear reservoir routing method for subcatchments. The SCS dimensionless unit hydrograph approach within the ARM subcatchments was used for this analysis.

Table 2: Recurrence Intervals and 24-Hour Rainfall Depths

Recurrence Interval	24-hr Rainfall Depth (in)
1-year	2.04
2-year	2.44
5-year	3.04
10-year	3.53
25-year	4.24
50-year	4.84
100-year	5.49
500-year	7.21
2000-year	9.26*

*2000-year value estimated by extrapolating NOAA Atlas 14 precipitation data

Table 3: PCSWMM Peak Subcatchment Runoff (cfs)

Subcatchment	100YR	50-YR	25-YR	10-YR	5-YR	2-YR	1-YR
S1	193.55	162.30	133.86	100.84	78.71	52.94	36.95
S2	281.59	237.31	196.80	149.55	117.82	80.50	57.10
S3	31.31	26.36	21.84	16.56	13.02	8.86	6.27
S4	31.14	26.39	22.03	16.93	13.47	9.37	6.78
S5	24.52	20.79	17.36	13.34	10.62	7.38	5.34
S6	84.12	70.84	58.70	44.55	35.05	23.89	16.93
S7	51.78	43.58	36.09	27.35	21.48	14.61	10.32
S8	99.20	84.13	70.29	54.06	43.04	29.97	21.74
S9	30.66	25.93	21.60	16.53	13.10	9.05	6.51
S10	115.22	97.26	80.82	61.61	48.64	33.42	23.85
S11	16.83	14.24	11.86	9.08	7.19	4.97	3.56
S12	17.57	14.88	12.41	9.53	7.57	5.26	3.79
S13	106.71	89.54	73.94	55.80	43.63	29.39	20.52
S14	6.16	5.11	4.16	3.06	2.34	1.51	1.01
S15	51.23	43.84	37.03	28.98	23.47	16.85	12.57
S16	76.33	65.10	54.76	42.59	34.27	24.33	17.96

Proposed

The proposed analysis consisted of creating additional storage at Darrow Road Park via either a constructed basin or grading a berm to trap floodwater in the park. Additionally, several of the culverts and ditches on Edgeview Drive were evaluated to determine their existing capacity and size necessary to convey the 25 and 100-year events.

Storage Analysis

GPD developed a conceptual layout for a basin on the Darrow Road Park property (**Storage Alternative 1)**. PCSWMM was used to evaluate its impact on the peak flows exiting Darrow Road Park for the 10-yr, 50-yr and 100-yr design storm. The existing condition model was updated to reflect the proposed conditions by adding the basin, as shown in **Figure 2**. Located on the Darrow Road Park property, the basin has an invert elevation of 1042.5 feet and a top elevation of 1048.5 feet. Positioned north of the Darrow Road Park stream, it is generally parallel to the stream with dimensions of approximately 882-feet in length and 290-feet in width. This basin is designed to receive flows from a watershed area of approximately 94.5-acres. The max storage volume for the 10-yr, 50-yr, and 100-yr design storm is summarized in **Table 4**. The basin as currently drawn has a total storage volume of approximately 31 acre-feet and so the footprint could be reduced in size and still provide benefit.

Table 4: Storage Basin Max Volume

Storage Name	Storage Basin		
	10-yr	50-yr	100-yr
	Max Volume (ac-ft)	Max Volume (ac-ft)	Max Volume (ac-ft)
SouthernParkBasin	9.41	14.49	16.78

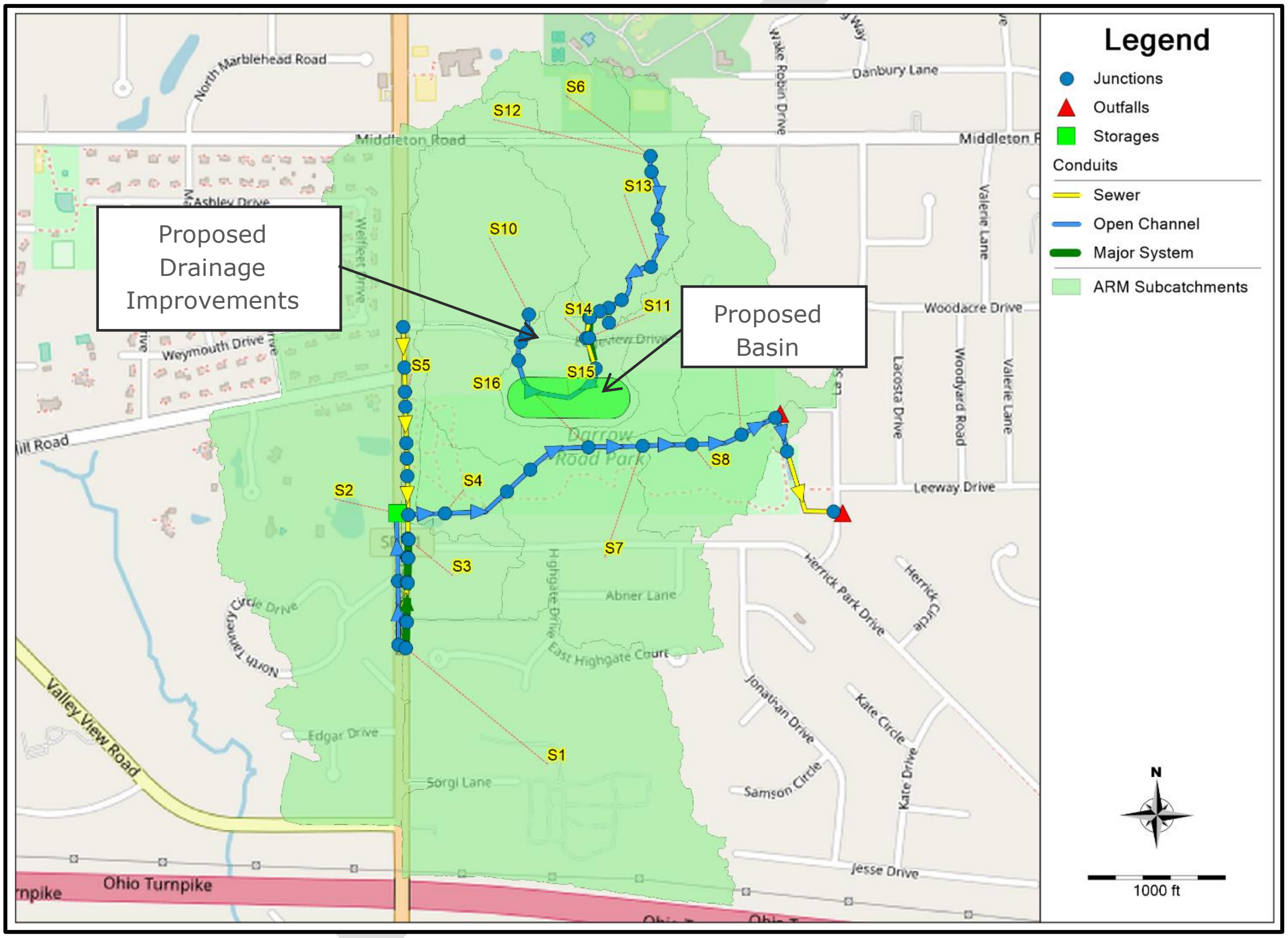


*Figure 2: Proposed PCSWMM Schematic (**Storage Alternative 1**)*

GPD also evaluated two options of raising the berm at the downstream end of the stream near Tamarisk Court by 1-ft to 1040.1 (**Storage Alternative 2**) and 2-ft to 1041.1 (**Storage Alternative 3**) to minimize flow overtopping the channel and flowing through the properties on Tamarisk Court and store water in the floodplain. For the option that raised the berm by 2-ft, the culvert inlet capacity was also reduced to by placing an orifice at the opening to maximize storage. The location is shown in **Figure 3.**

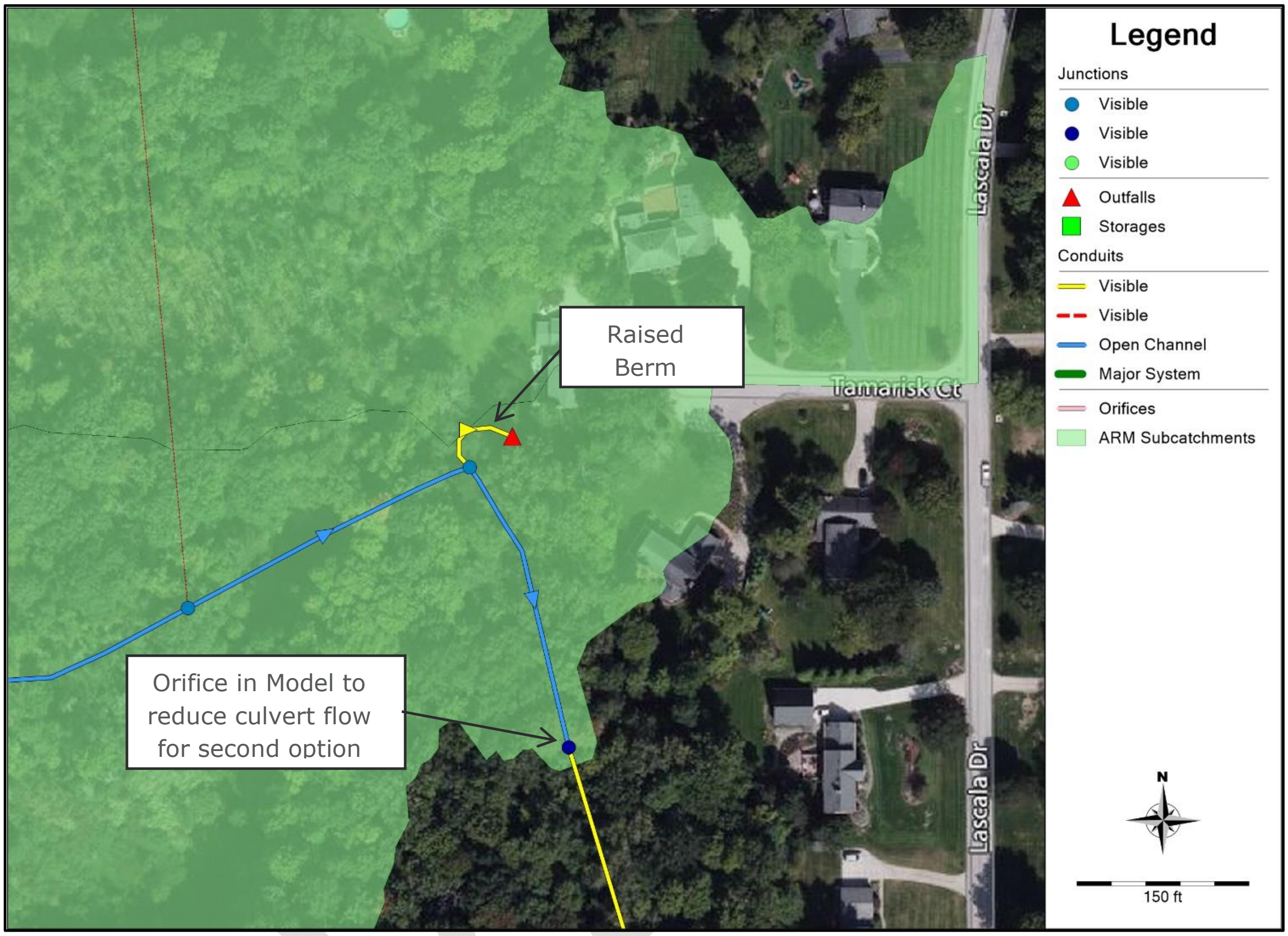


*Figure 3: Stream Berm Location (**Storage Alternative 2 & 3**)*

Edgeview Drive Culverts

The Edgeview Drive analysis focused on the 30-in and 15-in culverts and associated ditches as shown in **Figure 4**. The capacity of the existing culverts and ditches are discussed in the following paragraphs. The capacities were estimated based on the survey data provided by the City of Hudson and record drawings available from the city's online GIS database. There was not enough definition in the provided survey to determine the size of the existing roadside ditches tributary to the 15-inch culvert and therefore the existing capacity could not be determined.

Figure 4: Edgeview Drive Drainage Elements

30-inch Culvert System

The existing 30-inch culvert can carry the 5-year storm before flow start to cross the road and continue downstream. The upstream ditch is V-shaped based on the provided survey data and has a depth of approximately 2-ft before it starts to spread to the west. At 2-ft deep the channel has a top width of approximately 13-ft. The upstream ditch has the capacity to carry the 2-year storm before flow starts leave the channel and spread out. The downstream channel is also V-shaped with a depth of approximately 1-ft and top width of approximately 10-ft. It also can carry up to approximately the 2-year storm. The reason the downstream channel has the same capacity as the upstream channel is due to the Manning's assigned to the channels. The upstream channel appears to have some rock and vegetation on the banks and so a Manning's of 0.045 was assigned. The downstream channel is primarily lawn and so a Manning's of 0.035 was assigned.

15-inch Culvert System

Survey completed by the City of Hudson confirmed that the size of the culvert is 15-inch and the downstream invert was determined, however, the upstream structure has a concrete lid with a side window and therefore the upstream invert could not be determined. GPD utilized the slope from the record plans available in the city's online GIS database to determine the existing capacity. The existing 15-inch can carry the 10-year storm without surcharging the culvert.

Results

Storage Analysis

The existing conditions model was compared to the Alternative 1 basin model to evaluate improvements in the Hydraulic Grade Line (HGL) at the downstream end of the Darrow Road Park stream. **Table 5** provides a summary of the maximum HGL at the downstream end of the stream for the 10-yr, 50-yr, and 100-yr storm. The basin reduces the HGL by a maximum value of approximately 4-inches for the 100-year near the culvert entrance. The reduction in HGL occurs throughout the entire stream reach in the park and converges to existing elevations at the Darrow Road culvert. Table 1**Table 6** provides a summary of the peak flow at the outlet of the model. The basin reduces the peak flow by 18.9-cfs, 24.6-cfs, and 26.1-cfs for the 10-year, 50-year, and 100-year storm events, respectively. The minimal reduction in peak flow was investigated further, and it appears to be a function of flow timing in the watershed. The 94.5-acre watershed that would flow into the proposed basin is approximately 23% of the overall watershed size (414.6-acres) at culvert inlet on the eastern edge of the park. The peak of the hydrographs coming from the 94.5-acres from the north is into and mostly through the system before the majority of the watershed from the south is flowing through the stream. Therefore, the storage basin is only providing minimal reduction in peak flow downstream.

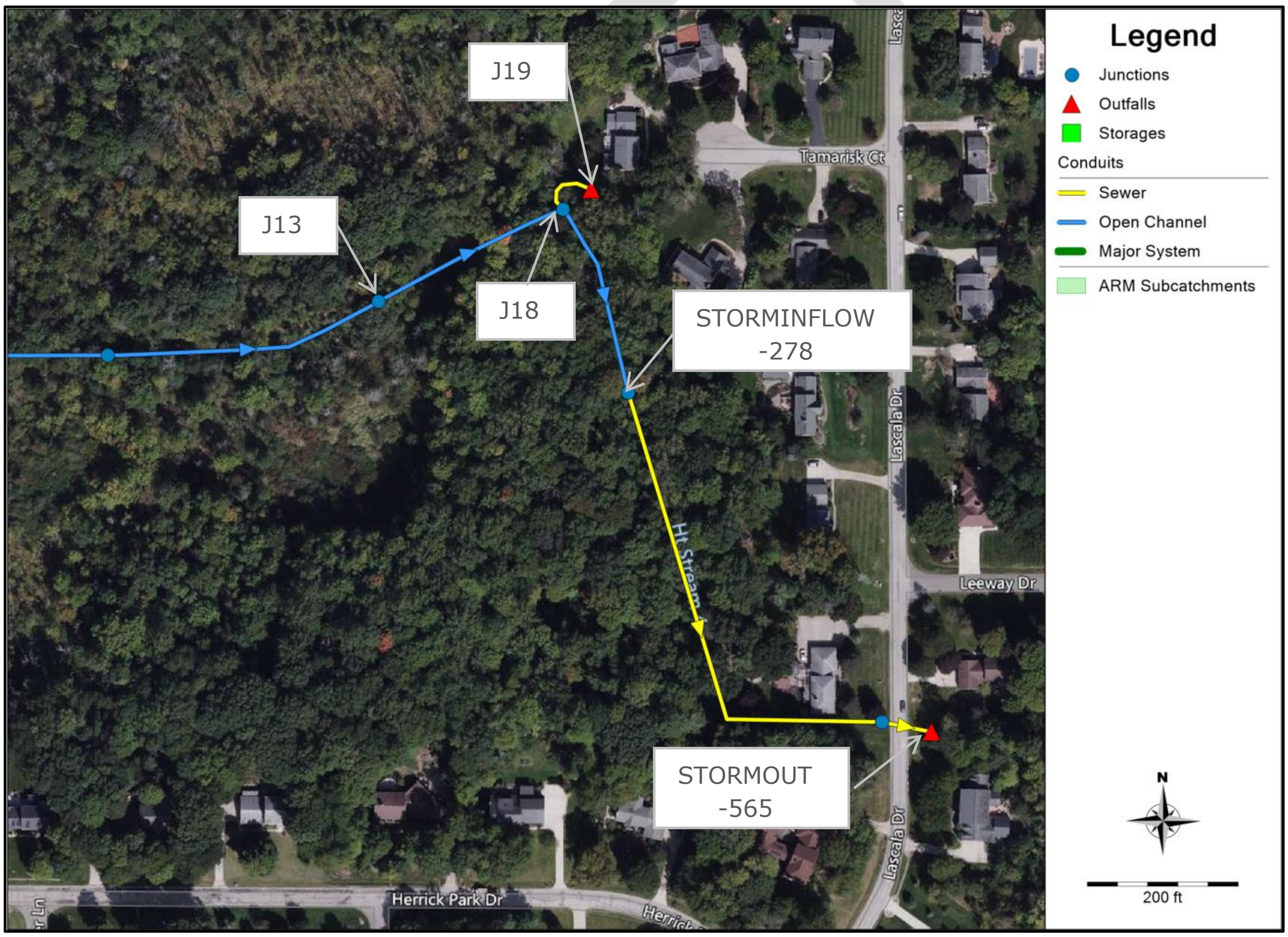


Figure 5: Results Locations

Table 5: Existing Conditions vs Alternative 1 Max HGL

Name	Invert Elev. (ft)	Existing Conditions			Alternative 1 - Storage Basin					
		10-yr	50-yr	100-yr	10-yr		50-yr		100-yr	
		Max. HGL (ft)	Max. HGL (ft)	Max. HGL (ft)	Max. HGL (ft)	Δ	Max. HGL (ft)	Δ	Max. HGL (ft)	Δ
J13	1035.56	1039.2	1039.88	1040.12	1039.05	-0.15	1039.62	-0.26	1039.8	-0.32
J18	1035.5	1038.87	1039.65	1039.92	1038.7	-0.17	1039.38	-0.27	1039.6	-0.32
STORMINFLOW -278	1035	1038.53	1039.5	1039.81	1038.27	-0.26	1039.18	-0.32	1039.5	-0.31

Table 6: Existing Conditions vs Alternative 1 Peak Flow Rates

Outfall Name	Existing Conditions			Alternative 1 - Storage Basin					
	10-yr	50-yr	100-yr	10-yr		50-yr		100-yr	
	Max Flow (cfs)	Max Flow (cfs)	Max Flow (cfs)	Max Flow (cfs)	Δ	Max Flow (cfs)	Δ	Max Flow (cfs)	Δ
STORMOUT-565	145.52	219.66	242.51	126.67	-18.85	195.03	-24.63	216.38	-26.13

The HGL and peak flow rates were also analyzed for raising the storage berm 1-ft. Raising the berm increased upstream HGL for the 50 and 100-year events. The increase in HGL only continued approximately 900-ft upstream of the culvert, at which point the HGL converged with existing condition. However, this modification significantly reduced overflow volume rate to the Tamarisk Court, nearly eliminating it, but did not reduce the flow downstream. However, the flow at the culvert outfall increased due to the overflow over the berm and into the neighborhood being eliminated. This would potentially increase the flood risk downstream along Leeway Drive and connecting streets. A summary of results for the 10-year, 50-year, and 100-year storm events is provided in **Table 7** and

Table 8.

Table 7: Existing Conditions vs Alternative 2 HGL

Name	Invert Elev. (ft)	Existing Conditions			Alternative 2 - 1-ft Raised Berm Storage					
		10-yr	50-yr	100-yr	10-yr		50-yr		100-yr	
		Max. HGL (ft)	Max. HGL (ft)	Max. HGL (ft)	Max. HGL (ft)	Δ	Max. HGL (ft)	Δ	Max. HGL (ft)	Δ
J13	1035.56	1039.2	1039.88	1040.12	1039.2	0.00	1039.9	0.02	1040.3	0.18
J18	1035.5	1038.87	1039.65	1039.92	1039.9	0.05	1039.8	0.15	1040.1	0.18
STORMINFLOW -278	1035	1038.53	1039.5	1039.81	1038.5	-0.03	1039.6	0.10	1040.1	0.19

Table 8: Existing Conditions vs Alternative 2 Flow Rates

Outfall Name	**Existing Conditions**			**Alternative 2 - 1-ft Raised Berm Storage**					
	10-yr	**50-yr**	**100-yr**	**10-yr**		**50-yr**		**100-yr**	
	Max Flow (cfs)	**Max Flow (cfs)**	**Max Flow (cfs)**	**Max Flow (cfs)**	**Δ**	**Max Flow (cfs)**	**Δ**	**Max Flow (cfs)**	**Δ**
STORMOUT-565	145.52	219.66	242.51	145.52	0.00	229.71	10.05	260.68	18.17

The HGL and peak flow rates were also analyzed for raising the storage berm 2-ft and providing some type of control at the culvert inlet. This control was modeled as a 5-ft orifice at the inlet of the 6.5-ft diameter culvert. This scenario increased upstream HGL for the 50 and 100-year events. The increase in HGL continued approximately 1650-ft upstream of the culvert (halfway between the culvert entrance and Darrow Road), at which point the HGL converged with existing condition. At Darrow Road, the water surface for the 100-year is the same between the existing condition and Alternative 3 scenario. This modification significantly reduced overflow volume rate, nearly eliminating it, and reduced the flow downstream. The flow at the culvert outfall decreased due to the orifice control in the model, thus likely reducing the risk of flooding downstream for Leeway Drive and connecting streets. A summary of results for the 10-year, 50-year, and 100-year storm events is provided in **Table 9** and **Table 10**.

Table 9: Existing Conditions vs Alternative 3 HGL

Name	**Invert Elev. (ft)**	**Existing Conditions**			**Alternative 3 - 2-ft Raised Berm Storage**					
		10-yr	**50-yr**	**100-yr**	**10-yr**		**50-yr**		**100-yr**	
		Max. HGL (ft)	**Max. HGL (ft)**	**Max. HGL (ft)**	**Max. HGL (ft)**	**Δ**	**Max. HGL (ft)**	**Δ**	**Max. HGL (ft)**	**Δ**
J13	1035.56	1039.2	1039.88	1040.12	1039.8	0.60	1040.7	0.82	1041.1	0.98
J18	1035.5	1038.87	1039.65	1039.92	1039.8	0.93	1040.7	1.05	1041.1	1.18
STORMINFLOW -278	1035	1038.53	1039.5	1039.81	1039.7	1.17	1040.7	1.20	1041.1	1.29

Table 10: Existing Conditions vs Alternative 3 Peak Flow Rates

Outfall Name	**Existing Conditions**			**Alternative 3 - 2-ft Raised Berm Storage**					
	10-yr	**50-yr**	**100-yr**	**10-yr**		**50-yr**		**100-yr**	
	Max Flow (cfs)	**Max Flow (cfs)**	**Max Flow (cfs)**	**Max Flow (cfs)**	**Δ**	**Max Flow (cfs)**	**Δ**	**Max Flow (cfs)**	**Δ**
STORMOUT-565	145.52	219.66	242.51	112.84	-32.68	148.51	-71.15	158.6	-83.91

The proposed basin or 1-ft raising of the berm do not appear to significantly reduce the peak flow downstream of Darrow Road Park. The 1-ft raising of the berm protects the residential properties that are currently flooded in large events but has no other benefit and actually increases peak flow downstream by approximately 7% for the 100-year. The 2-ft raising of the berm coupled with some type of flow control at the culvert inlet appears to have a significant reduction in peak flow, almost 35% for the 100-year, while not appearing to impact surrounding properties with the increase in water surface contained within the park.

Edgeview Drive Analysis

30-inch culvert: 25-year Improvements

To carry the 25-year storm at 2-ft of depth, the upstream ditch would need to be trapezoidal channel with a 3-ft bottom width with 2:1 side slopes; the Manning's from the existing condition of 0.045 was maintained. The culvert would need to be increased to a 42-inch to carry the 25-year without overtopping the road. The downstream ditch would need to be a trapezoidal channel with an 6-ft bottom width with 2:1 side slopes; the Manning's from the existing condition of 0.035 was maintained. The depth for the downstream ditch would need to be approximately 1.5-ft deep.

30-inch culvert: 100-year Improvements

To carry the 100-year storm at 2-ft of depth, the upstream ditch would need to be trapezoidal channel with a 4-ft bottom width with 2:1 side slopes; the Manning's from the existing condition of 0.045 was maintained. The culvert would need to be increased to a 3-ft by 5-ft box culvert to carry the 100-year without overtopping the road. The downstream ditch would need to be a trapezoidal channel with an 8-ft bottom width with 2:1 side slopes; the Manning's from the existing condition of 0.035 was maintained. The depth for the downstream ditch would need to be approximately 1.5-ft deep.

15-inch culvert: Improvements

The 15-inch culvert would need to be replaced with an 18-inch to carry the 25-year without surcharging. In addition, the 18-inch culvert could carry the 100-year with minimal surcharging and no road overtopping assuming all flow can enter the culvert. The ditch capacity was evaluated based on road slope. The slope for the road from the west is approximately 1.9%. At that slope, a trapezoidal ditch 1-ft deep with a 1-ft bottom width and 2:1 side slopes can carry up through the 100-year assuming a Manning's of 0.035. The slope for the road from the east is at most 0.5%. A ditch with similar size as the west side can carry the 25-year. To carry the 100-year, the east ditch would need to be the same trapezoidal shape with the depth increased to 15-inches. To install the proper ditches to the east of the 15-inch culvert, it is likely that the driveway culverts would also need to be replaced and/or increased in size to 15-inch as most are 12-inch.

Recommendations

Storage Analysis

The 2-ft raised berm from Storage Alternative 3 would provide benefit to the homeowners on Tamarisk Court and those downstream on Leeway Drive. To implement the raised berm scenario, additional survey would be necessary to confirm elevations along the channel as detailed survey of the channel throughout the park was not completed as part of the restoration project for the park. The detailed channel survey will aid in confirming the channel hydraulics and the results of the current modeling. Additionally, survey along the rear of the residential properties to confirm a berm could be raised 2-ft versus existing conditions. Finally, the proposed berm would increase the depth and duration of flooding in the forested areas of the park for larger events (i.e. 10-year). This could impact the mature trees depending on the duration of the flooding and the species of the trees. If the trees only experience significant flooding once or twice a year for a day or less, they may be fine. A tree survey should be completed to understand if the trees can indeed survive the additional flooding that would occur.

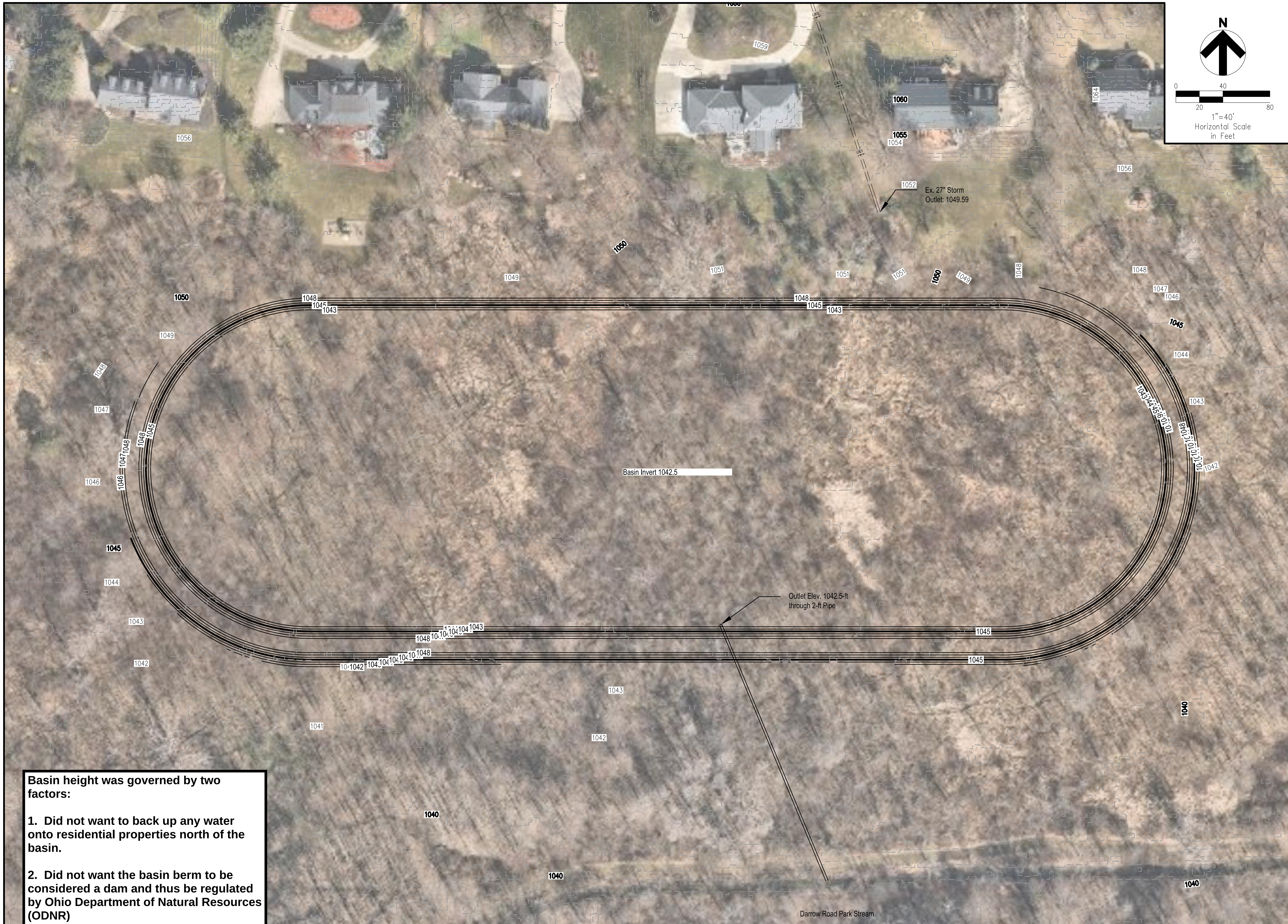
Edgeview Drive Analysis

The proposed improvements on Edgeview Drive involve increasing the size of the culverts and associated ditches. The largest challenge for these improvements would be coordination with property owners as some of the ditches are outside of the right-of-way. Additional detailed survey of the locations for the expanded private property ditches and roadside ditches would be needed to complete the design of the improvements.

Attachment A

Basin Schematic

PRELIMINARY DRAFT NOT FOR CONSTRUCTION, BID, RELIANCE, RECORDING PURPOSES OR IMPLEMENTATION



Basin height was governed by two factors:

1. Did not want to back up any water onto residential properties north of the basin.

2. Did not want the basin berm to be considered a dam and thus be regulated by Ohio Department of Natural Resources (ODNR)

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OHIO HUDSON

REV.	DATE	DESCRIPTION

Darrow Road Park Basin Study
Hudson, Ohio

Darrow Road Park Basin

ISSUED FOR:	
PERMIT	-
BID	-
CONSTRUCTION	-
RECORD	-

PROJECT MANAGER	DESIGNER

JOB NO.
2024041.50

SHEET:

SHEET NO: 1 OF1

Attachment B

Comment Reponses

The following are responses to comments in the memo that were not directly discussed in the memo.

City comment: Why PCSWMM versus other modeling approaches?

GPD response: PCSWMM or other SWMM based software are well suited for watershed studies and master planning as the hydrology and hydraulics are contained within on software. PCSWMM and other proprietary software have tools built in that aid in model building, calibration, alternative analysis, etc.

City comment: Would two smaller basins at each channel location be ”better”?

GPD response: Two basins could function as well as one basin. Some things to consider would be environmental permitting and long-term maintenance. It may be easier to permit and maintain a single basin versus two.

City comment: Why isn’t more pond volume being utilized in the scenario presented.

GPD response: The basin size and footprint were somewhat arbitrary. We had a set height we were targeting to not back up water onto the properties to the north and to keep it out of being regulated by ODNR. We made a large basin to be sure that we had enough storage, knowing that if the project was pursued, it could be right sized based on the volume needed.