CDM

City of North Royalton, Ohio

Ohio Turnpike 3rd Lane Expansion Investigation Study

July 19, 2006

Final Report

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Section 1
Introduction

Chronic flooding problems have been identified by residents throughout the City of North Royalton (City) especially those living downstream from the Ohio Turnpike who attribute flooding in this area to the Ohio Turnpike Commission's 3rd lane expansion. Major flooding events occurred in this area on June 18, 2000, May 10, 2003, May 20 through 22, 2004 followed by another flooding event on June 9, 2004.

The purpose of the Ohio Turnpike 3rd Lane Expansion Investigation Project is to determine the validity of the assertion that the expansion of the Turnpike has caused or contributed to increased property flooding and to make recommendations to the City on alternatives available to address resident flooding concerns in this area. This report presents the findings, results, and recommendations of the Ohio Turnpike 3rd Lane Expansion Flood Investigation Study prepared for a series of tributary watersheds within the City of North Royalton receiving drainage from the Ohio Turnpike. The report is organized into this introduction and three additional sections:

- **Section 2** describes the data and information that were obtained, organized, and analyzed to determine the hydrologic characteristics of the watersheds, the hydraulic characteristics of the study area system, and the nature of observed drainage problems within the study area.

- **Section 3** presents our evaluation of the existing drainage system under pre-3rd lane expansion and existing land use conditions, quantifying the frequency and severity of drainage problems within the study area and defining those specific areas and problems that are significantly influenced by drainage from the Ohio Turnpike 3rd Lane Expansion.

- **Section 4** describes the evaluation of alternatives to resolve each drainage problem that is impacted by the Ohio Turnpike 3rd Lane Expansion and does not meet the City's Level of Service in the watershed, the costs and benefits associated with implementing the alternatives evaluated, and presents the final recommendation of solutions to the City.

Section 2
Watershed Data and Model Development

This section summarizes hydrologic and hydraulic characteristics of the portion of the East Branch Rocky River watershed within the Ohio Turnpike 3rd Lane Expansion study area. This section is divided into the following subsections to describe the data and information that were obtained, organized, and analyzed for this study:

- Watershed Description
- Data Collection Approach
- Hydrologic Characteristics
  - Topography
  - Hydrologic Land Use
  - Soil Properties
- Hydraulic Characteristics
  - Streams
  - Closed Conduits
  - Detention
- Rainfall
- Model Development

2.1 Watershed Description

Figure 2-1 depicts the portion of the East Branch Rocky River watershed within the City of North Royalton that was evaluated during the Ohio Turnpike 3rd Lane Expansion Study:

- The ***flooding problem area***, approximately 3 to 4 square miles in size, is defined as the portion of the watershed that affects and/or is affected by drainage from the Ohio Turnpike. A detailed evaluation of flooding problems and alternative solutions was conducted within the study area.

- The ***tributary drainage area*** is defined as the area upstream and tributary to the study area (approximately 5 to 6 square miles) that must be evaluated in sufficient detail to define flows entering the study area.

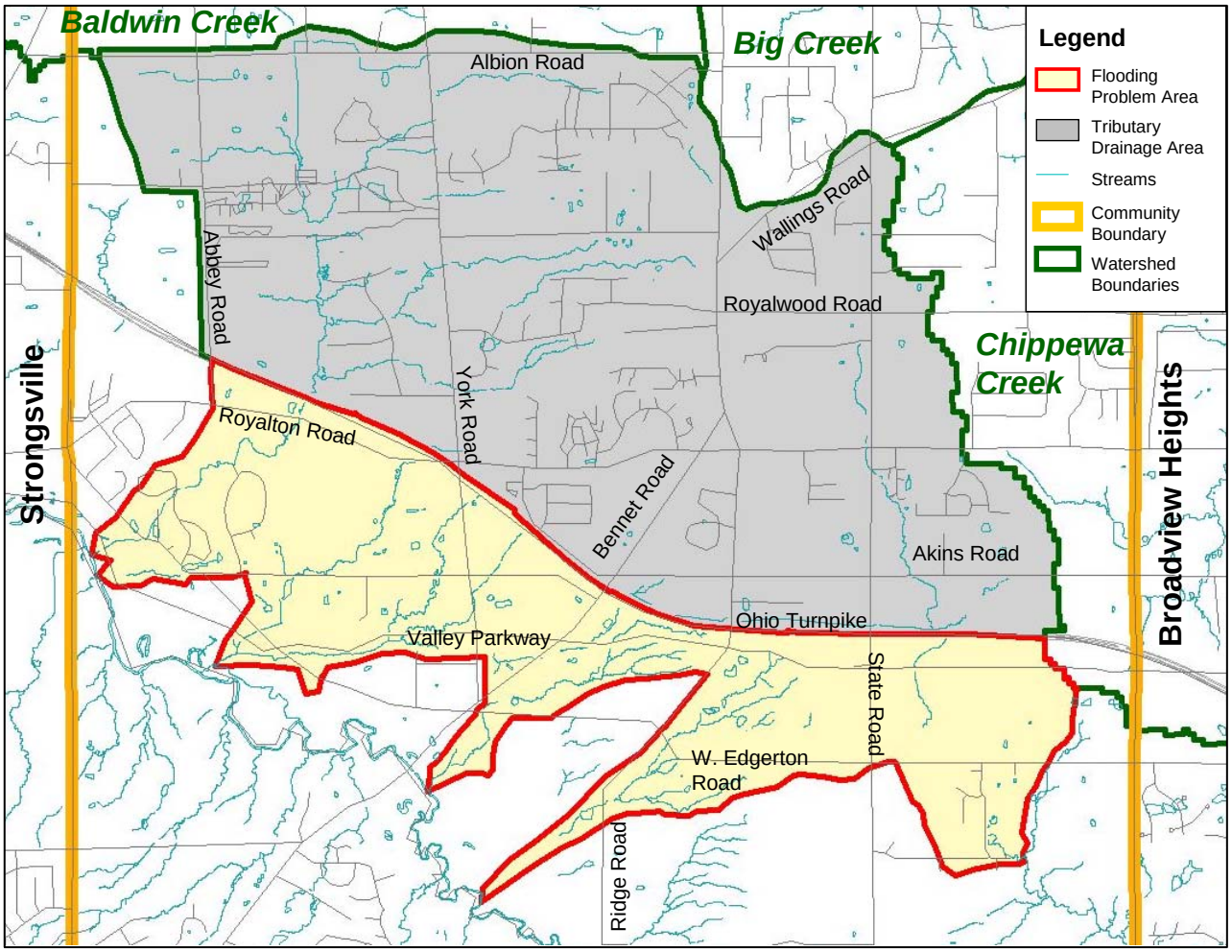


Figure 2-1. Ohio Turnpike 3rd Lane Expansion Study Area and Contributing Drainage Area

2.2 Data Collection Approach

This section summarizes CDM's approach for obtaining, organizing, and analyzing the data and information used to establish the hydrologic characteristics of the flooding problem area and tributary drainage area, the hydraulic characteristics of the primary stormwater conveyance system, and the stormwater planning model of the existing drainage.

2.2.1 Review Available Data

CDM compiled and evaluated available, pertinent data from the City, the Ohio Turnpike Commission (OTC), the Ohio Department of Transportation (ODOT), the Cuyahoga County Engineer, the Northeast Ohio Regional Sewer District, and the U.S. Army Corps of Engineers, including:

- Construction plans, design drawings, and record drawings (**Table 2-1)**.
- Previous engineering studies, reports, and memoranda (including geotechnical and hydrogeology data).

Table 2-1.
Available Construction Plans, Design Drawings, and Record Drawings for Drainage Systems within the Ohio Turnpike 3rd Lane Expansion Study Area

1. Cuyahoga County Culvert No. 22, Edgerton Road (C. R. – 63), City of North Royalton, last updated 1/16/01.
2. November 1998, Pinestream Subdivision III Drawings, City of North Royalton.
   - Sheet 9 – Plan, Profile & Cross Sections for Retention Basin "A".
   - Sheet 10 – Plan, Profile & Cross Sections for Retention Basin "B".
   - Sheet 14 – Grading & Erosion Control Plan.
3. April 1996, Plan for Stream Enclosure for Tri County Concrete Co., Inc.
4. 5/15/96; North Royalton Pump Station.
   - Proposed Site Layout #2, Preliminary 30% D. D.
   - 11/18/1998; Planimetric Map, Topographic Map.
5. March 1989; Dover Farms Apartments, City of North Royalton:
   - Site Plan.
   - Detention/Retention Basin Plans.
   - Retention Basin No. 3.
6. 11/6/98; Department of Public Utilities, 3rd High Service District:
   - North Royalton – Bennett, 30" Supply Water Main Phase II; Survey STA. 111+00 to STA. 117+00 (No. SM-3238).
   - North Royalton – Broadview, 24" Water Supply Main Phase I; Survey STA. 42+00 to STA. 46+35.70 (No. SM-3250).
   - North Royalton – Broadview, 24" Water Supply Main Phase I; Survey STA. 46+35.70 to STA. 1576+00 (No. SM-3251).
7. Plan and Profile Sheets for 72-inch culvert under Independence Drive.
8. North Royalton; Northern Off-Site Drainage Areas for North Royalton Middle School.

Table 2-1 (continued).
Available Construction Plans, Design Drawings, and Record Drawings for Drainage Systems within the Ohio Turnpike 3rd Lane Expansion Study Area

9. North Royalton; Existing Drainage Map for North Royalton Middle School, 12/15/94.

10. North Royalton; Proposed Drainage Map for North Royalton Middle School, 1/03/95.

11. North Royalton; Department of Engineering; North Royalton Middle School, Site Development Stormwater Management; December 1994.

12. North Royalton; Storm Water Drainage Plan, Figure 8.

13. North Royalton; Figure A-10, Culvert No. 292; Valley Parkway Culvert.

14. North Royalton; Culvert No. 284; Royalton Road Culvert; 4/2/73.

15. North Royalton; Figure A-9, Culvert No. 252; Edgerton Road Culvert; 1973.

16. North Royalton; Figure A-4, Culvert No. 285; Royalton Road Culvert; 1973.

17. City of North Royalton Existing Land Use Map

18 City mark-up of estimated year for City of North Royalton street construction

19. January 1998, Dodson-Stilson, Inc. Report: "Hydraulic Analysis for Turnpike Detail Drainage Design; OTC 3rd Lane Project No. 71-95-33; Milepost 165.00 to 168.68".

20. March 1998, Dodson-Stilson, Inc. Report: "Culvert Inspection Report for Ohio Turnpike Mainline Culverts at Mileposts: 165.35, 165.63, 165.87, 166.43, 167.60, 168.36 and 168.52".

21. December 1994, GPD Associates Report: "North Royalton Middle School; Site Development Stormwater Management".

- Digital map layers including traffic route types (arterial, residential, etc.), extent of curb/gutter and swales, location of non-standard inlet types, water and wetland features, vacant City-owned parcels, and floodplain zones.
- Flooding complaint records, surveyed high water marks, road centerline elevations, and building first floor elevations.
- Easement and right-of-way data, special agreements, and ownership and maintenance responsibilities for ODOT, County, or City systems.
- Available topographic, planimetric, and orthophotographs available from Cuyahoga County.
- Available land use and/or zoning information available from the City.
- Data used by, and drainage evaluations and alternative solutions generated during the NEORSD Regional Intercommunity Drainage Evaluation (RIDE) Study, the Army Corps of Engineers study of Baldwin Creek, and other pertinent drainage studies available from the City.

Based upon the information collected, CDM prepared a base map of the study area including basin boundaries and critical features of the storm water management system.

2.2.2 Field Reconnaissance Survey

CDM conducted a field reconnaissance survey to supplement available drainage system data. The purpose of the field reconnaissance survey was to verify physical dimensions and elevations as well as define the extent of debris and sediment that may affect drainage in the designated problem area. The field reconnaissance survey focused on the following items:

- Describing and photographing existing stream conditions and stream crossings.
- Assessing known problem areas (flooding, streambank erosion, and obstructions).
- Assisting with determination of idealized channel characteristics.
- Identifying major storm water detention facilities.

Figure 2-2 shows the location of each field reconnaissance site visited during the Ohio Turnpike 3rd Lane Expansion Study. A field reconnaissance notebook, bound separately and available for viewing at the North Royalton Engineering Department, provides a complete listing of the various field reconnaissance sites, cross-referenced by the letter shown on Figure 2-2. The notebook contains data collected in the field reconnaissance survey, with information cross-referenced to the appropriate drainage element in the storm water model. This was not a detailed survey, and no

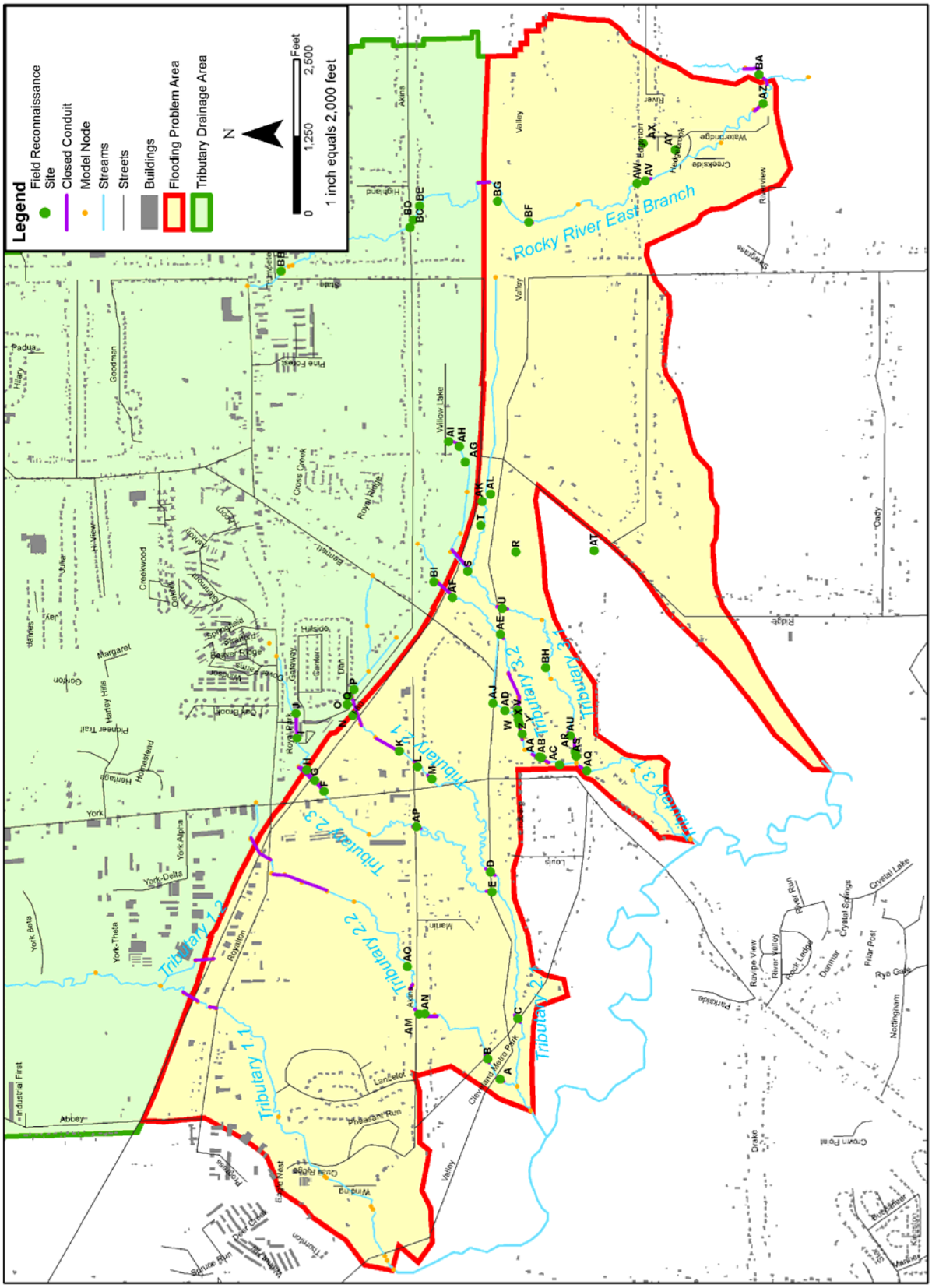


Figure 2-2. Location of Field Reconnaissance Sites Visited during the Ohio Turnpike 3rd Lane Expansion Study

vertical or horizontal control was used. Rather, dimensions and relative invert offsets (e.g., culvert invert depth below top of road crown) were estimated.

CDM's field reconnaissance survey included visiting over 60 sites within the flooding problem area. The number of field reconnaissance sites is significantly greater than 20 sites originally scoped and is primarily due to two factors:

- CDM coordinated on-site resident interviews under Task 2 in coordination with Task 3 field reconnaissance, which resulted in visiting additional sites compared to what was outlined in the scope.
- Some reported drainage problems required additional field investigation to better understand the potential causes.

During field reconnaissance, photos were taken of problem areas, streams, stream crossings, and detention facilities within the existing storm water management system. Dimensions for the major elements of the storm water management system were measured by CDM and recorded on field forms.

2.3 Drainage System Characteristics

The study area is served by an extensive system of streams, open channels, storm sewers, stream crossings, and detention facilities, illustrated in **Figure 2-3**. This system was represented at the following level of detail:

- ***Primary Drainage System*** consists of drainage system elements that drain areas greater than 300 acres and were represented in both the flooding problem area and the tributary drainage area.
- ***Secondary Drainage System*** consists of drainage system elements that drain areas less than 300 acres and were only represented within the study area.

Features of the drainage system that control its ability to convey runoff through the watershed include:

- ***Streams*** – length, cross-sectional area, slope, and roughness properties affecting routing of flow through natural and constructed open drainage systems.
- ***Closed Conduits*** – length, cross-sectional area, slope, and roughness properties affecting routing of flow through stream crossings, storm sewers, and culverted streams.
- ***Detention*** – stage / storage / discharge relationships for facilities designed to retard the runoff for flow through the drainage system.

Typical cross-sections of open channels were generally developed from digital topographic data available from the Cuyahoga County Engineer. The geometric

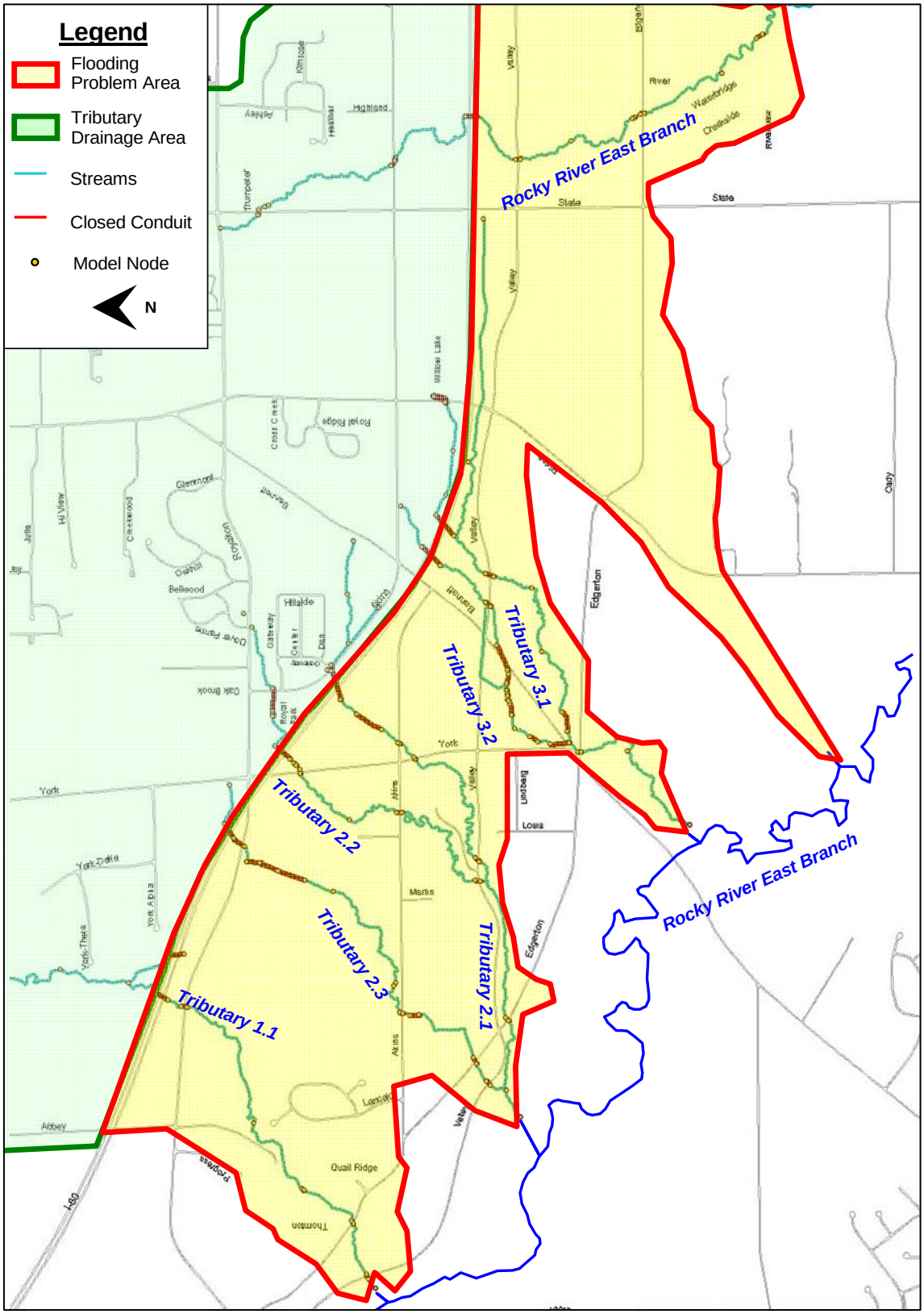


Figure 2-3. Model Representation of Streams and Closed Conduits in the Ohio Turnpike 3rd Lane Expansion Study Area

properties of stream crossings were measured as part of field reconnaissance conducted during this project. Photos taken during the field reconnaissance were used to establish channel roughness and head loss properties. Locations of debris and sediment buildup were noted in the field and represented in the hydraulic model where significant. Locations and dimensions of modeled detention basins were determined through field reconnaissance.

Table 2-2 lists the conduits within the drainage system that were represented within the Ohio Turnpike 3rd Lane Expansion Study area, grouped by tributary. For each conduit, the table shows the unique model ID and its location. The conduit ID is the same as the upstream node model ID. Conduit geometric properties are listed next, including the depth, width (for non-circular pipes), length, and upstream and downstream invert elevations. The roughness factor (Manning's n) was estimated using the field photographs and adjusted based on model calibration.

A junction establishes the invert elevation at the intersection between two or more conduits, which are typically located at the ends of culverts, confluence of tributaries, and other critical points along the drainage system. **Table 2-3** lists the junctions between each conveyance conduit within the represented drainage system. Storage may be added to a junction to represent a specific facility (e.g., a detention basin), floodplain storage that is not adequately represented by the channel cross-section, and other atypical locations that provide storage for flood flows within the conveyance system.

No comprehensive City drainage system maps exist for either the pre- or post-3rd lane Ohio Turnpike expansion. Few storm sewer improvements have occurred along the major drainage ways within the study area for several years. Information collected by the City from OTC was provided to CDM for review, which included as-built drawings showing drainage infrastructure along the Ohio Turnpike within the study area and drainage reports discussing the hydrologic and hydraulic analysis conducted for sizing the drainage infrastructure as part of the Ohio Turnpike 3rd lane expansion project. The City was not aware of additional hydrologic or hydraulic studies relevant to the study area. The City worked with CDM to help identify locations and dimensions of detention basins, culverts, storm sewers, and any major improvements between 1993 and 2002 within the study area.

TABLE 2-2. REPRESENTATION OF CONDUITS IN THE OHIO TURNPIKE EXPANSION 3RD LAND EXPANSION STUDY

INPUT NUMBER	CONDUIT NUMBER	LENGTH (FT)	CONDUIT CLASS	AREA (SQ FT)	MANNING COEF.	WIDTH (FT)	DEPTH (FT)	JUNCTIONS AT THE ENDS		INVERT HEIGHT ABOVE JUNCTION		SIDE SLOPES	
TRIBUTARY NO. 1													
1	L11001010	198	TRAPEZOID	1100	0.035	15	20	J11001010	J11001000			2	2
2	L11001020	74	RECTANGLE	120	0.014	20	6	J11001020	J11001010				
3	L11001040	843	TRAPEZOID	1100	0.035	15	20	J11001040	J11001020			2	2
4	L11001050	36	RECTANGLE	180	0.014	18	10	J11001050	J11001040				
5	L11001052	950	TRAPEZOID	1100	0.035	15	20	J11001052	J11001050			2	2
6	L11001053	30	CIRCULAR	28.27	0.035	6	6	J11001053	J11001052				
7	L11001055	1467	TRAPEZOID	1100	0.035	15	20	J11001055	J11001053			2	2
8	L11001060	2554	TRAPEZOID	1100	0.035	15	20	J11001060	J11001055			2	2
9	L11001070	72	RECTANGLE	432	0.014	24	18	J11001070	J11001060				
10	L11001080	296	TRAPEZOID	1100	0.035	15	20	J11001080	J11001070			2	2
11	L11001090	240	RECTANGLE	176	0.014	16	11	J11001090	J11001080				
12	L11001100	573	TRAPEZOID	1100	0.03	15	20	J11001100	J11001090			2	2
13	L11001110	1168	NATURAL	3681	0.035	290	20	J11001110	J11001100				
14	L11001120	2353	TRAPEZOID	1100	0.03	15	20	J11001120	J11001110			2	2
15	L11001130	200	CIRCULAR	28.27	0.024	6	6	J11001130	J11001120				
16	L11001130A	200	CIRCULAR	28.27	0.024	6	6	J11001130	J11001120				
17	L12001010	767	TRAPEZOID	900	0.03	5	20	J12001010	J11001100			2	2
18	L12001020	277	CIRCULAR	4.91	0.014	2.5	2.5	J12001020	J12001010				
19	L11001130X	200	TRAPEZOID	300	0.025	30	5	J11001130	J11001120	12	12	6	6
20	L11001070X	72	TRAPEZOID	350	0.025	20	5	J11001070	J11001060	26.76	26.76	10	10
21	L11001050X	36	TRAPEZOID	350	0.025	20	5	J11001050	J11001040	11	11	10	10
22	L11001053X	30	TRAPEZOID	400	0.025	30	5	J11001053	J11001052	7.65	7.65	10	10
23	L11001020X	74	TRAPEZOID	350	0.025	20	5	J11001020	J11001010	8.56	8.56	10	10
TRIBUTARY NO. 2													
1	L21001010	473	TRAPEZOID	570	0.035	8	15	J21001010	J21001000			2	2
2	L21001020	1168	TRAPEZOID	566.25	0.035	7.75	15	J21001020	J21001010			2	2
3	L21001030	60	RECTANGLE	96.53	0.014	14.3	6.75	J21001030	J21001020				
4	L21001040	2350	TRAPEZOID	566.25	0.035	7.75	15	J21001040	J21001030			2	2
5	L21001050	83	RECTANGLE	24	0.014	6	4	J21001050	J21001040				
6	L21001060	2898	TRAPEZOID	295	0.035	12	10	J21001060	J21001050			1	2.5
7	L21001070	67	RECTANGLE	21	0.014	5	4.2	J21001070	J21001060				
8	L21001075	1051	TRAPEZOID	612	0.035	8	20	J21001075	J21001070			0.42	1.84
9	L21001080	1163	TRAPEZOID	193	0.025	8	10	J21001080	J21001075			0.42	1.84
10	L21001090	62	RECTANGLE	8.94	0.014	3.35	2.67	J21001090	J21001080				
11	L21001100	81	TRAPEZOID	502.5	0.03	3.5	15	J21001100	J21001090			2	2
12	L21001105	50	RECTANGLE	12.97	0.014	4.09	3.17	J21001105	J21001100				
13	L21001110	88	TRAPEZOID	300	0.03	5	15	J21001110	J21001105			1	1
14	L21001120	291	CIRCULAR	38.48	0.024	7	7	J21001120	J21001110				
15	L21001130	601	TRAPEZOID	860	0.03	3	20	J21001130	J21001120	0	5.5	2	2
16	L21001140	31	RECTANGLE	22.54	0.014	8.67	2.6	J21001140	J21001130				
17	L21001150	37	TRAPEZOID	90	0.014	6	15	J21001150	J21001140			0	0
18	L21001160	341	CIRCULAR	19.63	0.024	5	5	J21001160	J21001150				
19	L21001170	1072	TRAPEZOID	525	0.04	5	15	J21001170	J21001160	0	4.67	2	2
20	L22001010	275	TRAPEZOID	682.5	0.035	8	15	J22001010	J21001010			2	3
21	L22001020	84	RECTANGLE	33.44	0.014	8.8	3.8	J22001020	J22001010				
22	L22001030	315	TRAPEZOID	570	0.035	8	15	J22001030	J22001020			2	2
23	L22001040	105	RECTANGLE	36	0.014	9	4	J22001040	J22001030				
24	L22001050	1315	TRAPEZOID	570	0.035	8	15	J22001050	J22001040			2	2
25	L22001060	130	CIRCULAR	20.43	0.024	5.1	5.1	J22001060	J22001050				
26	L22001070	125	TRAPEZOID	960	0.035	8	20	J22001070	J22001060			2	2
27	L22001080	40	RECTANGLE	36	0.014	9	4	J22001080	J22001070				
28	L22001090	569	TRAPEZOID	250	0.03	5	10	J22001090	J22001080			2	2
29	L22001100	60	CIRCULAR	14.52	0.014	4.3	4.3	J22001100	J22001090				
30	L22001100A	60	CIRCULAR	14.52	0.014	4.3	4.3	J22001100	J22001090				
31	L22001110	2164	TRAPEZOID	600	0.03	10	15	J22001110	J22001100			2	2
32	L22001115	469	TRAPEZOID	300	0.03	10	10	J22001115	J22001110			2	2
33	L22001120	431	CIRCULAR	19.63	0.024	5	5	J22001120	J22001115				
34	L22001122	318	CIRCULAR	19.63	0.024	5	5	J22001122	J22001120				
35	L22001124	219	CIRCULAR	19.63	0.024	5	5	J22001124	J22001122				
36	L22001126	253	TRAPEZOID	1000	0.03	10	20	J22001126	J22001124			2	2
37	L22001130	79	RECTANGLE	10	0.014	4	2.5	J22001130	J22001126				
38	L22001140	135	TRAPEZOID	525	0.03	5	15	J22001140	J22001130			2	2
39	L22001150	245	CIRCULAR	23.76	0.014	5.5	5.5	J22001150	J22001140				
40	L22001160	607	TRAPEZOID	663	0.03	5	17	J22001160	J22001150			2	2
41	L23001010	364	TRAPEZOID	267.5	0.035	15.5	10	J23001010	J21001040			1	1.25
42	L23001020	83	RECTANGLE	30	0.014	6	5	J23001020	J23001010	0	1.2		
43	L23001030	2797	NATURAL	2017.85	0.045	262	14	J23001030	J23001020				
44	L23001040	46	RECTANGLE	52	0.03	13	4	J23001040	J23001030				
45	L23001050	302	TRAPEZOID	166.7	0.045	6.17	10	J23001050	J23001040			1.3	0.8

TABLE 2-2. REPRESENTATION OF CONDUITS IN THE OHIO TURNPIKE EXPANSION 3RD LAND EXPANSION STUDY

INPUT NUMBER	CONDUIT NUMBER	LENGTH (FT)	CONDUIT CLASS	AREA (SQ FT)	MANNING COEF.	WIDTH (FT)	DEPTH (FT)	JUNCTIONS AT THE ENDS		INVERT HEIGHT ABOVE JUNCTION		SIDE SLOPES	
46	L23001060	42	RECTANGLE	62.55	0.014	13.9	4.5	J23001060	J23001050				
47	L23001070	324	TRAPEZOID	230	0.035	10	10	J23001070	J23001060			1.8	0.8
48	L23001100	465	RECTANGLE	30.87	0.024	6.3	4.9	J23001100	J23001070				
49	L23001110	349	TRAPEZOID	787.5	0.035	15	15	J23001110	J23001100			2.5	2.5
50	L23001120	458	CIRCULAR	38.48	0.024	7	7	J23001120	J23001110			0	3.25
51	L23001130	88	CIRCULAR	23.76	0.014	5.5	5.5	J23001130	J23001120	0	1.5		
52	L23001140	415	TRAPEZOID	775	0.025	6	25	J23001140	J23001130	1	1		
53	L23001150	771	TRAPEZOID	500	0.025	5	20	J23001150	J23001140			1	1
54	L23001160	844	TRAPEZOID	500	0.025	5	20	J23001160	J23001150			1	1
55	L23101010	58	CIRCULAR	1.77	0.014	1.5	1.5	J23101010	J23001120	0	4.5		
56	L23201010	703	TRAPEZOID	285	0.022	4	15	J23201010	J23001140			1	1
57	L21001160X	341	TRAPEZOID	1200	0.025	20	10	J21001160	J21001150	6.6	6.6	10	10
58	L21001140X	31	TRAPEZOID	1200	0.025	20	10	J21001140	J21001130	4.83	4.83	10	10
59	L21001105X	50	TRAPEZOID	1200	0.025	20	10	J21001105	J21001100	6.75	6.75	10	10
60	L21001090X	62	TRAPEZOID	1200	0.025	20	10	J21001090	J21001080	4.75	4.75	10	10
61	L21001070X	67	TRAPEZOID	1200	0.025	20	10	J21001070	J21001060	12.9	12.9	10	10
62	L21001050X	83	TRAPEZOID	1200	0.025	20	10	J21001050	J21001040	7	7	10	10
63	L21001030X	60	TRAPEZOID	1200	0.025	20	10	J21001030	J21001020	9	9	10	10
64	L22001130X	79	TRAPEZOID	4400	0.025	40	10	J22001130	J22001126	3.9	3.9	40	40
65	L22001124X	219	TRAPEZOID	1200	0.025	20	10	J22001124	J22001122	8	8	10	10
66	L22001122X	318	TRAPEZOID	1200	0.025	20	10	J22001122	J22001120	8	8	10	10
67	L22001120X	431	TRAPEZOID	1200	0.025	20	10	J22001120	J22001115	8	8	10	10
68	L22001100X	60	TRAPEZOID	1200	0.025	20	10	J22001100	J22001090	16	16	10	10
69	L22001080X	40	TRAPEZOID	1200	0.025	20	10	J22001080	J22001070	7.38	7.38	10	10
70	L22001060X	130	TRAPEZOID	1200	0.025	20	10	J22001060	J22001050	6.5	6.5	10	10
71	L22001040X	105	TRAPEZOID	1200	0.025	20	10	J22001040	J22001030	6	6	10	10
72	L22001020X	84	TRAPEZOID	1200	0.025	20	10	J22001020	J22001010	7	7	10	10
73	L23001100X	465	TRAPEZOID	350	0.025	20	5	J23001100	J23001070	10	10	10	10
74	L23001060X	42	TRAPEZOID	350	0.025	20	5	J23001060	J23001050	6.5	6.5	10	10
75	L23001040X	46	TRAPEZOID	350	0.025	20	5	J23001040	J23001030	6.9	6.9	10	10
76	L23001020X	83	TRAPEZOID	350	0.025	20	5	J23001020	J23001010	8.67	9.87	10	10
TRIBUTARY NO. 3													
1	L31001005	887	NATURAL	1984.59	0.035	200	15.9	J31001005	J31001000				
2	L31001010	887	NATURAL	1984.59	0.035	200	15.9	J31001010	J31001005				
3	L31001020	1117	NATURAL	1984.59	0.035	200	15.9	J31001020	J31001010				
4	L31001030	49	RECTANGLE	27	0.045	9	3	J31001030	J31001020				
5	L31001040	259	NATURAL	1186.55	0.05	145	14.5	J31001040	J31001030				
6	L31001045	107	NATURAL	793	0.05	81	16.9	J31001045	J31001040				
7	L31001047	324	CIRCULAR	12.57	0.024	4	4	J31001047	J31001045				
8	L31001049	1204	NATURAL	1792.01	0.05	214	15.3	J31001049	J31001047	0	1.75		
9	L31001050	1050	NATURAL	2203.5	0.05	245	16	J31001050	J31001049				
10	L31001060	693	TRAPEZOID	150	0.03	5	10	J31001060	J31001050			1	1
11	L31001070	139	CIRCULAR	7.07	0.024	3	3	J31001070	J31001060				
12	L31001080	861	TRAPEZOID	150	0.03	5	10	J31001080	J31001070			1	1
13	L31001090	408	CIRCULAR	19.63	0.024	5	5	J31001090	J31001080				
14	L31001100	362	TRAPEZOID	240	0.014	4	10	J31001100	J31001090			2	2
15	L31001110	680	TRAPEZOID	240	0.014	4	10	J31001110	J31001100			2	2
16	L31001120	762	TRAPEZOID	240	0.03	4	10	J31001120	J31001110			2	2
17	L31101005	1371	TRAPEZOID	250	0.035	5	10	J31101005	J31001080			2	2
18	L31101010	3724	TRAPEZOID	250	0.035	5	10	J31101010	J31101005			2	2
19	L32001010	290	RECTANGLE	50	0.014	5	10	J32001010	J31001040				
20	L32001020	201	TRAPEZOID	412.5	0.035	5	15	J32001020	J32001010			1.5	1.5
21	L32001030	143	CIRCULAR	7.07	0.014	3	3	J32001030	J32001020				
22	L32001040	13	RECTANGLE	9.6	0.014	4.8	2	J32001040	J32001030	0	3.5		
23	L32001045	299	NATURAL	935	0.05	276	7	J32001045	J32001040				
24	L32001050	220	NATURAL	1295.08	0.05	312	11.2	J32001050	J32001045				
25	L32001060	177	CIRCULAR	5.94	0.014	2.75	2.75	J32001060	J32001050	0	1.3		
26	L32001070	57	NATURAL	2426.2	0.05	335	12.5	J32001070	J32001060				
27	L32001080	17	CIRCULAR	9.62	0.024	3.5	3.5	J32001080	J32001070				
28	L32001090	52	NATURAL	1454.12	0.05	250	10.9	J32001090	J32001080				
29	L32001100	32	CIRCULAR	4.91	0.024	2.5	2.5	J32001100	J32001090				
30	L32001110	49	NATURAL	833.98	0.05	162	9.9	J32001110	J32001100				
31	L32001115	16	RECTANGLE	15.5	0.03	5	3.1	J32001115	J32001110				
32	L32001120	96	NATURAL	829.38	0.05	257.4	9.5	J32001120	J32001115				
33	L32001123	144	RECTANGLE	8.94	0.014	3.35	2.67	J32001123	J32001120	0	1		
34	L32001126	51	RECTANGLE	8.94	0.03	3.35	2.67	J32001126	J32001123				
35	L32001130	410	RECTANGLE	8.94	0.014	3.35	2.67	J32001130	J32001126				
36	L32001140	621	TRAPEZOID	525	0.03	5	15	J32001140	J32001130			2	2
37	L32001150	93	CIRCULAR	7.07	0.024	3	3	J32001150	J32001140				
38	L32001160	1051	TRAPEZOID	300	0.035	5	15	J32001160	J32001150			1	1
39	L32001170	385	CIRCULAR	12.57	0.014	4	4	J32001170	J32001160				

TABLE 2-2. REPRESENTATION OF CONDUITS IN THE OHIO TURNPIKE EXPANSION 3RD LAND EXPANSION STUDY

INPUT NUMBER	CONDUIT NUMBER	LENGTH (FT)	CONDUIT CLASS	AREA (SQ FT)	MANNING COEF.	WIDTH (FT)	DEPTH (FT)	JUNCTIONS AT THE ENDS		INVERT HEIGHT ABOVE JUNCTION		SIDE SLOPES	
40	L32001180	742	TRAPEZOID	750	0.15	5	15	J32001180	J32001170			3	3
41	L31001130X	213	TRAPEZOID	2550	0.025	20	15	J31001130	J31001120	8	8	10	10
42	L31001070Y	139	TRAPEZOID	400	0.025	20	10	J31001070	J31001060	8	8	2	2
43	L31001047X	324	NATURAL	782	0.05	104	10	J31001047	J31001045	6.5	6.5		
44	L31001030X	49	TRAPEZOID	350	0.025	20	5	J31001030	J31001020	6	6	10	10
45	L32001150X	1612	TRAPEZOID	259	0.025	4.5	14	J32001150	J32001120	5.84	5.84	1	1
46	L32001150Y	93	TRAPEZOID	2550	0.025	20	15	J32001150	J32001140	6.3	6.3	10	10
47	L32001130X	410	TRAPEZOID	2400	0.025	10	15	J32001130	J32001126	3	3	10	10
48	L32001126X	51	TRAPEZOID	2400	0.025	10	15	J32001126	J32001123	3	3	10	10
49	L32001123X	144	TRAPEZOID	2400	0.025	10	15	J32001123	J32001120	3	4	10	10
50	L32001115X	16	NATURAL	852	0.05	218	6	J32001115	J32001110	3.84	3.84		
51	L32001100X	32	NATURAL	1280	0.05	234	8	J32001100	J32001090	3.5	3.5		
52	L32001080X	17	NATURAL	2114	0.05	313	10	J32001080	J32001070	3.84	3.84		
53	L32001060X	177	NATURAL	2480.5	0.05	285	10	J32001060	J32001050	2.84	4.14		
54	L32001040X	13	TRAPEZOID	375	0.025	10	15	J32001040	J32001030	2.58	6.08	1	1
55	L32001030X	143	TRAPEZOID	375	0.025	10	15	J32001030	J32001020	5.58	5.58	1	1
56	L32001010X	290	TRAPEZOID	2400	0.025	10	15	J32001010	J31001040	7.33	7.33	10	10
TRIBUTARY NO. 4													
1	L41001010	417	NATURAL	3943.97	0.035	210	24.5	J41001010	J41001000				
2	L41001020	417	NATURAL	3943.97	0.035	210	24.5	J41001020	J41001010				
3	L41001030	628	NATURAL	3943.97	0.035	210	24.5	J41001030	J41001020				
4	L41001040	106	RECTANGLE	114.95	0.03	13.8	8.33	J41001040	J41001030				
5	L41001045	1123	NATURAL	6463.88	0.035	615	19.5	J41001045	J41001040				
6	L41001050	1556	NATURAL	3625.88	0.035	282	19.5	J41001050	J41001045				
7	L41001060	57	RECTANGLE	108	0.03	18	6	J41001060	J41001050				
8	L41001070	111	TRAPEZOID	600	0.03	10	15	J41001070	J41001060			2	2
9	L41001080	37	CIRCULAR	74.66	0.024	9.75	9.75	J41001080	J41001070				
10	L41001085	1414	NATURAL	3138	0.035	354	18	J41001085	J41001080				
11	L41001090	879	NATURAL	3138	0.035	354	18	J41001090	J41001085				
12	L41001100	81	RECTANGLE	64	0.014	16	4	J41001100	J41001090				
13	L41001110	973	TRAPEZOID	600	0.03	10	15	J41001110	J41001100			2	2
14	L41001120	209	RECTANGLE	72	0.014	12	6	J41001120	J41001110				
15	L41001120A	209	RECTANGLE	72	0.014	12	6	J41001120	J41001110				
16	L41001130	1859	NATURAL	1993.7	0.035	327	12	J41001130	J41001120				
17	L41001136	54	TRAPEZOID	600	0.03	10	15	J41001136	J41001130			2	2
18	L41001140	65	RECTANGLE	39	0.014	9.75	4	J41001140	J41001136				
19	L41001140A	65	RECTANGLE	34	0.014	8.5	4	J41001140	J41001136				
20	L41001150	2310	NATURAL	2409	0.035	278	14	J41001150	J41001140				
21	L41001153	62	RECTANGLE	97.5	0.014	19.5	5	J41001153	J41001150				
22	L41001156	655	TRAPEZOID	565.88	0.03	5.1	15	J41001156	J41001153			1.06	3.29
23	L41001160	68	RECTANGLE	97.5	0.03	19.5	5	J41001160	J41001156				
24	L41001170	655	NATURAL	2250.5	0.035	155	20.5	J41001170	J41001160				
25	L41001160X	68	TRAPEZOID	1200	0.025	20	10	J41001160	J41001156	8	8	10	10
26	L41001153X	62	TRAPEZOID	1200	0.025	20	10	J41001153	J41001150	10	10	10	10
27	L41001140X	65	NATURAL	1080.61	0.035	735	2.4	J41001140	J41001136	6.3	6.3		
28	L41001100X	81	TRAPEZOID	1200	0.025	20	10	J41001100	J41001090	7	7	10	10
29	L41001080X	37	TRAPEZOID	1200	0.025	20	10	J41001080	J41001070	11.5	11.5	10	10
30	L41001080Y	37	TRAPEZOID	1200	0.025	20	10	J41001080	J41001070	9.36	9.36	10	10
31	L41001060X	57	TRAPEZOID	1200	0.025	20	10	J41001060	J41001050	9	9	10	10
32	L41001040X	106	TRAPEZOID	1200	0.025	20	10	J41001040	J41001030	12	12	10	10

TABLE 2-3.
JUNCTIONS BETWEEN CONDUITS WITHIN THE OHIO TURNPIKE 3RD LANE EXPANSION STUDY AREA

INPUT NUMBER	JUNCTION NUMBER	CROWN ELEV.	INVERT ELEV.	STORAGE MAX. AREA (SQ. FT.)	STORAGE MAX. VOLUME (CU. FT.)	CONNECTING CONDUITS			
TRIBUTARY NO. 1									
1	J11001000	832	812			L11001010			
2	J11001010	836.73	816.73			L11001010	L11001020	L11001020X	
3	J11001020	836.93	816.93			L11001020	L11001040	L11001020X	
4	J11001040	836.43	816.43			L11001040	L11001050	L11001050X	
5	J11001050	837.08	817.08			L11001050	L11001052	L11001050X	
6	J11001052	839.8	819.8			L11001052	L11001053	L11001053X	
7	J11001053	840	820			L11001053	L11001055	L11001053X	
8	J11001055	850	830			L11001055	L11001060		
9	J11001060	872.61	840.85			L11001060	L11001070	L11001070X	
10	J11001070	873.38	841.62			L11001070	L11001080	L11001070X	
11	J11001080	865	845			L11001080	L11001090		
12	J11001090	866	846			L11001090	L11001100		
13	J11001100	868	848			L11001100	L11001110	L12001010	
14	J11001110	874	854			L11001110	L11001120		
15	J11001120	889	869			L11001120	L11001130	L11001130A	L11001130X
16	J11001130	887	870	93,654	1,009,764	L11001130	L11001130A	L11001130X	
17	J12001010	890	870			L12001010	L12001020		
18	J12001020	874.7	872.2			L12001020			
TRIBUTARY NO. 2									
1	J21001000	839	824			L21001010			
2	J21001010	840.5	825.5			L21001010	L21001020	L22001010	
3	J21001020	848.8	829.8			L21001020	L21001030	L21001030X	
4	J21001030	849	830	21,780	348,981	L21001030	L21001040	L21001030X	
5	J21001040	864	847			L21001040	L21001050	L23001010	L21001050X
6	J21001050	864.1	847.1	21,780	429,622	L21001050	L21001060	L21001050X	
7	J21001060	893.9	871			L21001060	L21001070	L21001070X	
8	J21001070	894.9	872	21,780	264,209	L21001070	L21001075	L21001070X	
9	J21001075	902	882			L21001075	L21001080		
10	J21001080	908.58	893.83			L21001080	L21001090	L21001090X	
11	J21001090	909.12	894.12	21,780	441,361	L21001090	L21001100	L21001090X	
12	J21001100	911.78	895.03			L21001100	L21001105	L21001105X	
13	J21001105	912.35	895.6	21,780	416,798	L21001105	L21001110	L21001105X	
14	J21001110	911.8	896.8			L21001110	L21001120		
15	J21001120	924.5	899	47,045	1,872,492	L21001120	L21001130		
16	J21001130	933	913			L21001130	L21001140	L21001140X	
17	J21001140	928.2	913.2	21,780	439,622	L21001140	L21001150	L21001140X	
18	J21001150	930.6	914			L21001150	L21001160	L21001160X	
19	J21001160	940.67	921	21,780	414,190	L21001160	L21001170	L21001160X	
20	J21001170	977	962			L21001170			
21	J21001180	973.49	973.49	46,174	2,214,155				
22	J22001010	844	827			L22001010	L22001020	L22001020X	
23	J22001020	844.1	827.1			L22001020	L22001030	L22001020X	
24	J22001030	848	832			L22001030	L22001040	L22001040X	
25	J22001040	848.1	832.1			L22001040	L22001050	L22001040X	
26	J22001050	858.5	842			L22001050	L22001060	L22001060X	
27	J22001060	863	843			L22001060	L22001070	L22001060X	
28	J22001070	864	844			L22001070	L22001080	L22001080X	
29	J22001080	861.48	844.1			L22001080	L22001090	L22001080X	
30	J22001090	874	848			L22001090	L22001100	L22001100A	L22001100X
31	J22001100	874.1	848.1			L22001100	L22001100A	L22001110	L22001100X
32	J22001110	883	868			L22001110	L22001115		
33	J22001115	890	872			L22001115	L22001120	L22001120X	
34	J22001120	899	881			L22001120	L22001122	L22001122X	L22001120X
35	J22001122	900	882			L22001122	L22001124	L22001124X	L22001122X

TABLE 2-3.
JUNCTIONS BETWEEN CONDUITS WITHIN THE OHIO TURNPIKE 3RD LANE EXPANSION STUDY AREA

INPUT NUMBER	JUNCTION NUMBER	CROWN ELEV.	INVERT ELEV.	STORAGE MAX. AREA (SQ. FT.)	STORAGE MAX. VOLUME (CU. FT.)	CONNECTING CONDUITS			
36	J22001124	903	883			L22001124	L22001126	L22001124X	
37	J22001126	904.69	884.69			L22001126	L22001130	L22001130X	
38	J22001130	900.25	885.25			L22001130	L22001140	L22001130X	
39	J22001140	903.1	888.1			L22001140	L22001150		
40	J22001150	905.7	888.7			L22001150	L22001160		
41	J22001160	915	898			L22001160			
42	J23001010	862.87	848			L23001010	L23001020	L23001020X	
43	J23001020	863.5	849.5			L23001020	L23001030	L23001020X	
44	J23001030	891.9	877.9			L23001030	L23001040	L23001040X	
45	J23001040	890	878.1			L23001040	L23001050	L23001040X	
46	J23001050	894.59	883.09			L23001050	L23001060	L23001060X	
47	J23001060	894.79	883.29			L23001060	L23001070	L23001060X	
48	J23001070	901	886			L23001070	L23001100	L23001100X	
49	J23001100	905.1	890.1			L23001100	L23001110	L23001100X	
50	J23001110	916.65	901.65			L23001110	L23001120		
51	J23001120	917	910	8,712	131,456	L23001120	L23001130	L23101010	
52	J23001130	937.85	912.85	43,560	901,510	L23001130	L23001140		
53	J23001140	949	924			L23001140	L23001150	L23201010	
54	J23001150	966	946			L23001150	L23001160		
55	J23001160	998	978			L23001160			
56	J23101010	920	918.5	8,712	131,456	L23101010			
57	J23201010	959	944			L23201010			
TRIBUTARY NO. 3									
1	J31001000	845.9	830			L31001005			
2	J31001005	855.9	840			L31001005	L31001010		
3	J31001010	865.9	850			L31001010	L31001020		
4	J31001020	871.7	855.8			L31001020	L31001030	L31001030X	
5	J31001030	870.5	856			L31001030	L31001040	L31001030X	
6	J31001040	883.33	861			L31001040	L31001045	L32001010	L32001010X
7	J31001045	878.9	862			L31001045	L31001047	L31001047X	
8	J31001047	880.55	863.5			L31001047	L31001049	L31001047X	
9	J31001049	900	884			L31001049	L31001050		
10	J31001050	922	906			L31001050	L31001060		
11	J31001060	942	924			L31001060	L31001070	L31001070Y	
12	J31001070	946	928	29,185	477,026	L31001070	L31001080	L31001070Y	
13	J31001080	962.7	952.7			L31001080	L31001090	L31101005	
14	J31001090	990.8	980.8			L31001090	L31001100		
15	J31001100	1032	1022			L31001100	L31001110		
16	J31001110	1100	1090			L31001110	L31001120		
17	J31001120	1145	1122			L31001120	L31001130X		
18	J31001130	1166	1143	13,775	785,175	L31001130X			
19	J31101005	1048	1038			L31101005	L31101010		
20	J31101010	1134	1124			L31101010			
21	J32001010	885.33	863			L32001010	L32001020	L32001010X	
22	J32001020	885.58	865	27,007	360,219	L32001020	L32001030	L32001030X	
23	J32001030	887.48	866.4	16,117	210,042	L32001030	L32001040	L32001040X	L32001030X
24	J32001040	887.58	870			L32001040	L32001045	L32001040X	
25	J32001045	886.2	875			L32001045	L32001050		
26	J32001050	893.14	879			L32001050	L32001060	L32001060X	
27	J32001060	895.84	883			L32001060	L32001070	L32001060X	
28	J32001070	897.59	883.75			L32001070	L32001080	L32001080X	
29	J32001080	898.09	884.25			L32001080	L32001090	L32001080X	
30	J32001090	896.5	885			L32001090	L32001100	L32001100X	
31	J32001100	897	885.5			L32001100	L32001110	L32001100X	
32	J32001110	895.8	885.9			L32001110	L32001115	L32001115X	

TABLE 2-3.
JUNCTIONS BETWEEN CONDUITS WITHIN THE OHIO TURNPIKE 3RD LANE EXPANSION STUDY AREA

INPUT NUMBER	JUNCTION NUMBER	CROWN ELEV.	INVERT ELEV.	STORAGE MAX. AREA (SQ. FT.)	STORAGE MAX. VOLUME (CU. FT.)	CONNECTING CONDUITS			
33	J32001115	895.84	886			L32001115	L32001120	L32001115X	
34	J32001120	906.34	886.5			L32001120	L32001123	L32001150X	L32001123X
35	J32001123	910.5	892.5			L32001123	L32001126	L32001126X	L32001123X
36	J32001126	912.1	894.1			L32001126	L32001130	L32001130X	L32001126X
37	J32001130	919	901			L32001130	L32001140	L32001130X	
38	J32001140	940.3	919			L32001140	L32001150	L32001150Y	
39	J32001150	940.97	919.67	56,192	675,451	L32001150	L32001160	L32001150X	L32001150Y
40	J32001160	963.2	948.2			L32001160	L32001170		
41	J32001170	976.7	961.7			L32001170	L32001180		
42	J32001180	1019	1004			L32001180			
TRIBUTARY NO. 4									
1	J41001000	1144.5	1120			L41001010			
2	J41001010	1146.5	1122			L41001010	L41001020		
3	J41001020	1148.5	1124			L41001020	L41001030		
4	J41001030	1150.4	1125.9			L41001030	L41001040	L41001040X	
5	J41001040	1148.1	1126.1			L41001040	L41001045	L41001040X	
6	J41001045	1148.5	1129			L41001045	L41001050		
7	J41001050	1150.33	1130.83			L41001050	L41001060	L41001060X	
8	J41001060	1150	1131			L41001060	L41001070	L41001060X	
9	J41001070	1152.72	1131.22			L41001070	L41001080	L41001080X	L41001080Y
10	J41001080	1152.92	1131.42			L41001080	L41001085	L41001080X	L41001080Y
11	J41001085	1156	1138			L41001085	L41001090		
12	J41001090	1159.55	1141.55			L41001090	L41001100	L41001100X	
13	J41001100	1158.75	1141.75	188,615	3,597,746	L41001100	L41001110	L41001100X	
14	J41001110	1161.9	1146.9			L41001110	L41001120	L41001120A	
15	J41001120	1159.5	1147.5			L41001120	L41001120A	L41001130	
16	J41001130	1168	1153			L41001130	L41001136		
17	J41001136	1168.47	1153.47			L41001136	L41001140	L41001140A	L41001140X
18	J41001140	1167.67	1153.67			L41001140	L41001140A	L41001150	L41001140X
19	J41001150	1195.3	1175.3			L41001150	L41001153	L41001153X	
20	J41001153	1195.5	1175.5			L41001153	L41001156	L41001153X	
21	J41001156	1193.8	1175.8			L41001156	L41001160	L41001160X	
22	J41001160	1196.5	1176			L41001160	L41001170	L41001160X	
23	J41001170	1204.5	1184			L41001170			

2.4 Watershed Characteristics

This section describes the watershed features and the major hydrologic characteristics that are defined from these features. The following table summarizes these watershed features and hydrologic characteristics.

2.4.1 Topography and Catchment Delineation

The terrain is moderately to steeply sloped throughout the watershed. The ground elevation exceeds 1200 ft. msl at the northeastern portion of the study area, sloping to approximately 810 ft. msl at the confluence of Tributary No. 1 and the East Branch Rocky River. The average land surface slope in the watershed is approximately 4 percent, which is relatively steeply sloped.

Watershed Feature	Hydrologic Characteristic
Topography	Catchment area; Length, slope of flow paths
Hydrologic Land Use Land Cover Site Drainage	Directly-connected impervious area
Soil Properties Soil Type Groundwater/bedrock depth	Soil infiltration rates and volumes

CDM used 2-foot contours from the Cuyahoga County Engineer's planimetric maps and 10-foot contours from USGS 1:24,000 topographic maps to delineate the watershed into a series of catchments. CDM divided the watershed into catchments of approximately 300 acres along the primary drainage system and approximately 100 acres along the secondary drainage system. Smaller catchments were delineated in the vicinity of reported drainage problems, to accurately represent drainage from the Ohio Turnpike, or to properly represent how flows enter the drainage system. In particular, the Ohio Turnpike right-of-way was divided into two types of catchments - catchments representing areas draining toward the highway median, and catchments representing areas draining away from the median. Overall, the average drainage area of delineated catchments was 70 acres. **Figure 2-4** shows the catchments used to represent stormwater runoff. Sixty-nine catchments represent the flooding problem area and tributary drainage area.

Topographic information was also used to define the length and slope of representative overland flow paths within each catchment. Overland flow path length in turn, is used to define the catchment width. The catchment width is initially calculated as the catchment area divided by the overland flow path length, and further adjusted through calibration to control the rate of runoff from the catchment. Catchment width was adjusted specifically in this study to represent accelerated overland flows attributable to the Ohio Turnpike third land expansion.

2.4.2 Soil Properties

Soil properties determine the amount of runoff from pervious areas of the watershed. Two parameters define this runoff potential:

- The minimum and maximum rate of infiltration into the soil, governed by the soil porosity (a measure of the void space in the soil) and antecedent rainfall (the amount of rainfall preceding the design event).

- The maximum volume of infiltration, defined by voids in the soil, depth to groundwater or bedrock, and antecedent rainfall.

Soil properties for the study area and tributary drainage area were taken from the Cuyahoga County Soil Survey (U.S. Department of Agriculture, Soil Conservation Service, 1980), which categorizes the soils into four major hydrologic soil groups (A-D) based on the infiltrative properties of the soil (**Figure 2-5)**. Typical infiltration rates for the soils in the study area are summarized in **Table 2-4.**

Approximately 62 percent of soils in the study area are silty clay loam classified as hydrologic soil group D. Areas of silt loam classified as hydrologic soil group C comprise 36 percent of the watershed.

Infiltration volume is the amount of soil pore space available for the storage of infiltrated water. It represents the total volume of runoff that can infiltrate into a given soil during a rainfall event, and is expressed as a depth in inches over a unit area. Calculations were based on tabular data from the Cuyahoga County Soil Survey. The average infiltration volume of soil in the study area and tributary drainage area is 1.8 in.

2.4.3 Land Cover

The most important hydrologic characteristic affecting stormwater runoff is directly-connected impervious area (DCIA), which is the land surface that does not allow infiltration of runoff into the soil and is directly connected to the local drainage system. Imperviousness correlates well with land cover and drainage system type.

Highly urbanized areas, where much of the land surface has been either paved or covered with buildings are highly impervious. Rural areas tend to have low imperviousness, in which case runoff response due to rainfall is almost entirely a function of soil type. This section describes the two land cover scenarios that were evaluated under this study:

- ***Land Cover Before Construction of OTC 3rd Lane (1993 Conditions)***. This scenario represents land cover prior to construction of the 3rd lane of the Ohio Turnpike, and was used to support projections of storm water runoff and flooding that existed before the Turnpike was expanded. Land cover under this scenario was defined using orthophotographs available from the Cuyahoga County Engineer that were flown in 1993, as shown in **Figure 2-6.**

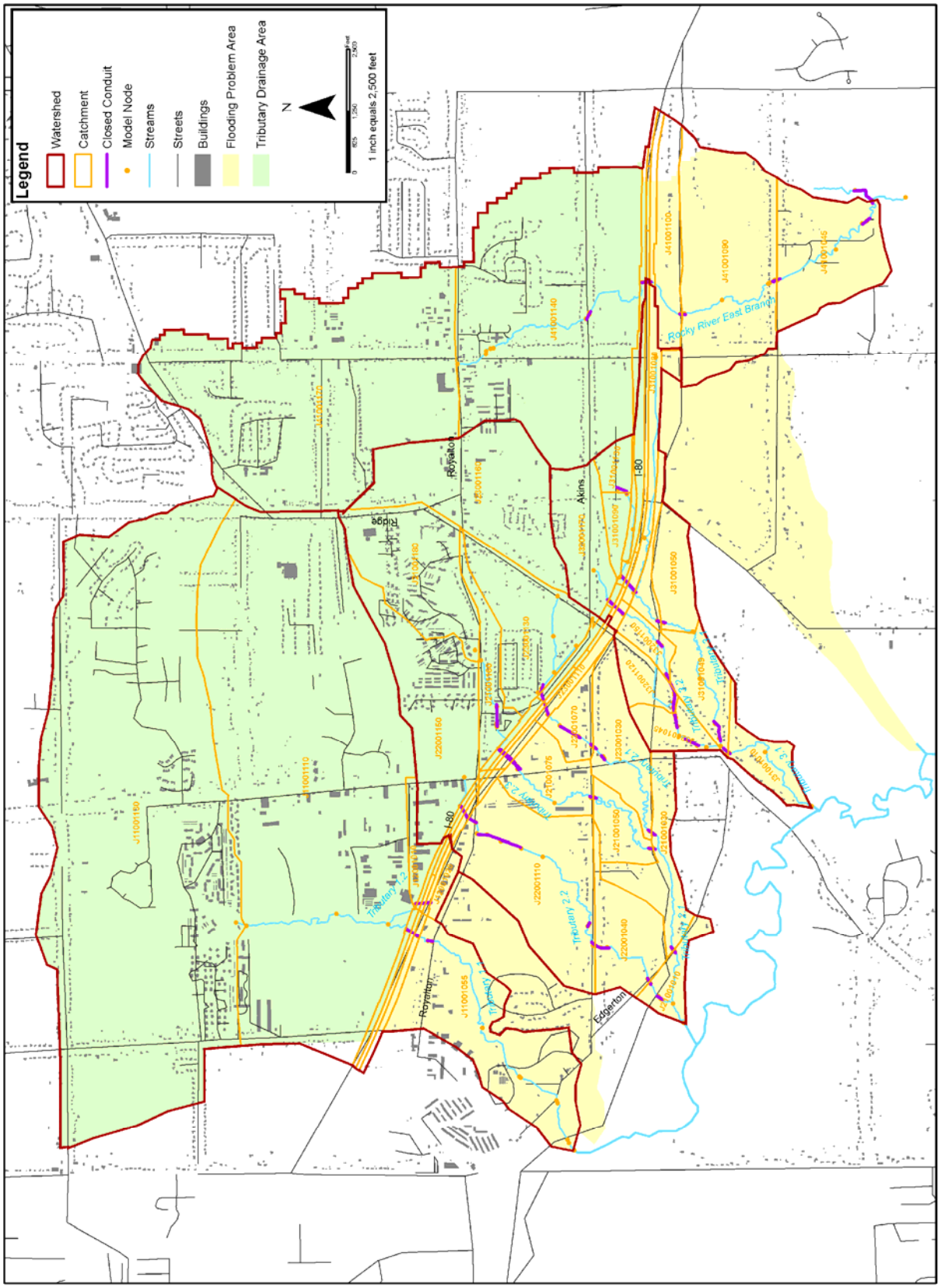


Figure 2-4. Drainage Catchments within the Ohio Turnpike 3rd Lane Expansion Study Area and Tributary Drainage Area

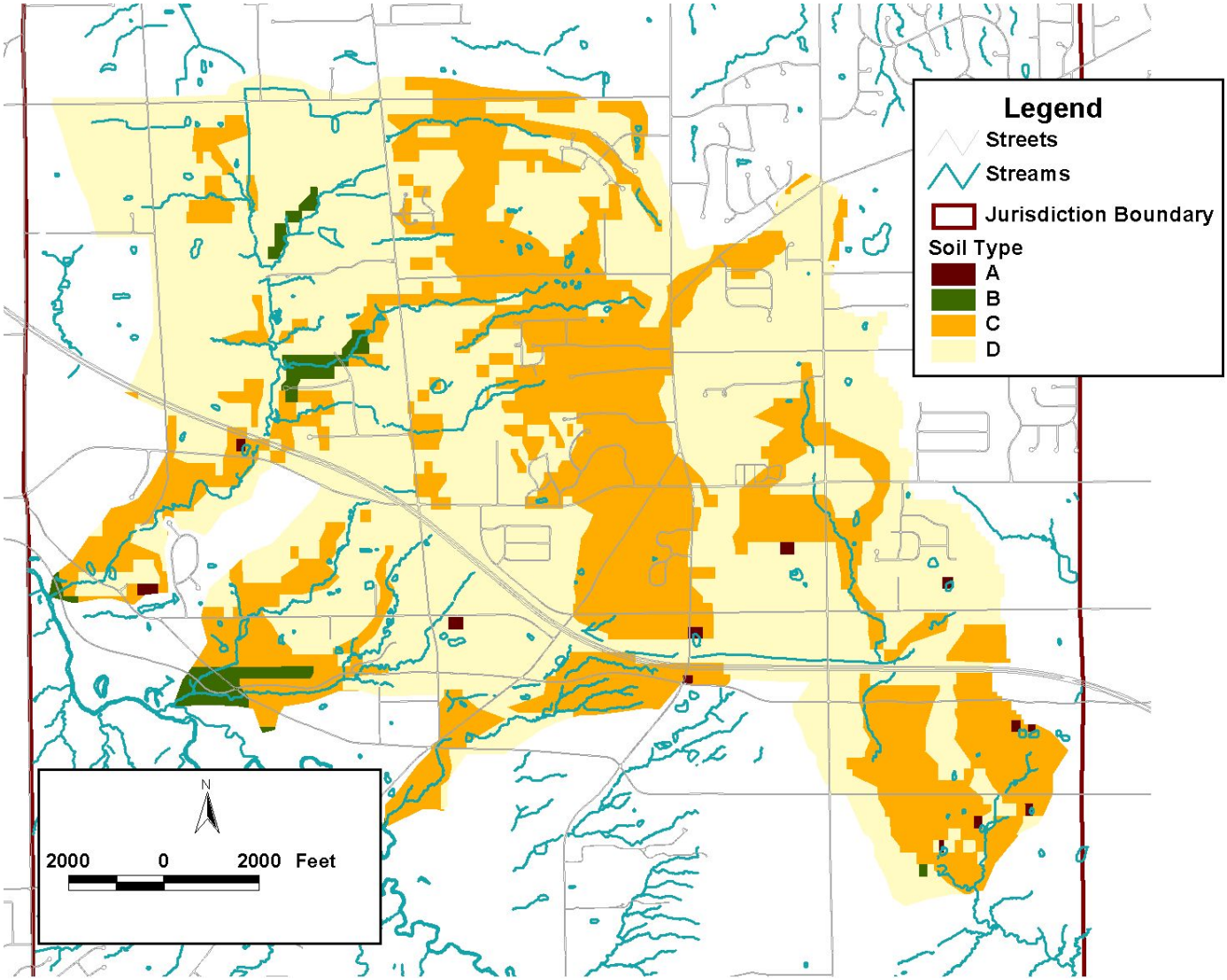


Figure 2-5. Hydrologic Soil Groups (HSGs) within the Ohio Turnpike 3rd Lane Expansion Study Area and Tributary Drainage Area

Table 2-4. Soil Infiltration Rates by Hydrologic Soil Group Classification

Hydrologic Soil Group	Description	Percentage of the Watershed	Maximum Infiltration (Dry or Initial) (in./hr.)	Minimum Infiltration (Wet or Final) (in./hr.)
A	Deep sand/loess, well-drained	0	7 in./hr.	0.4 in./hr.
B	Shallow loess, deep sandy loam, moderately drained	2	3 in./hr.	0.2 in./hr.
C	Clayey loam, shallow sandy loam, slowly drained	36	2 in./hr.	0.1 in./hr.
D	Clay, poorly-drained	62	1 in./hr.	0.05 in./hr.

- ***Existing Land Cover with OTC 3rd Land (2002 Conditions)*** This scenario represents land cover following construction of the 3rd lane of the Ohio Turnpike, and was used to support projections of storm water runoff and flooding that existed after the Turnpike was expanded. Land cover under this scenario was defined using orthophotographs available from the Cuyahoga County Engineer that were flown in 2002, as shown in **Figure 2-7,** and the existing zoning map shown in **Figure 2-8**. The third lane expansion was represented by increasing the imperviousness of the portion of the right-of-way draining toward the median from 45 to 100 percent. In some cases the catchment was directed towards new outlets constructed as part of the expansion.

The directly connected impervious area characteristic of each zoning category, listed in **Table 2-5,** was developed through review of the available area photographs. CDM then used GIS to determine the land cover distribution within each modeled catchment and develop a weighted DCIA value for each. Further review of the available orthophotographs was conducted to adjust the DCIA value when the actual land cover within a catchment was atypical of the DCIA of the underlying zoning.

2.4.4 Hydrologic Parameters for Catchments

Hydrologic parameters for each catchment were developed using the available data discussed previously in this section, appropriately distributed to each catchment, and adjusted through a model calibration process to confirm that runoff generated using these parameters resulted in flooding conditions similar to those observed by area residents and City staff. **Tables 2-6** and **2-7** list the parameters developed to represent hydrologic conditions within each catchment.

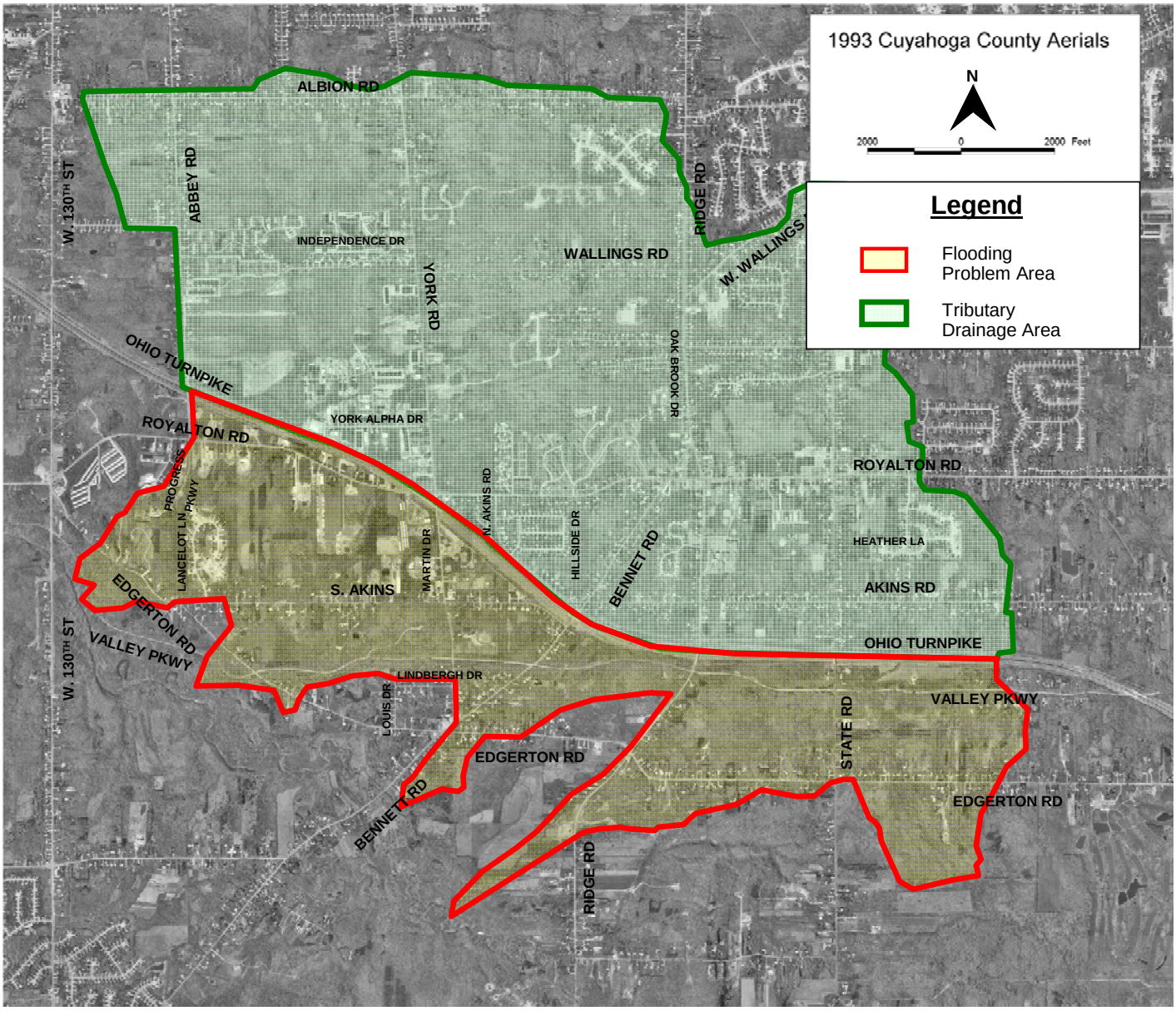


Figure 2-6. Land Cover Before (1993) Ohio Turnpike 3rd Lane Expansion

Table 2-5. Directly Connected Impervious Area Associated with Land Use Categories within North Royalton

Land Use/Zoning Category	LU Category	DCIA
RRZ	Rural Residential	15
R1-A	Single Family A	25
R1-B	Single Family B	25
R2-C	Two Family	25
RM-D	Multi Family	35
PUD	Planned Unit Development	50
BUSINESS DISTRICTS		
ABBREVIATION	NAME	DCIA (%)
OB	Office Building	50
LB	Local Business	70
GB	General Business	70
MS	Motorist Service	70
SCD	Senior Citizen	20
MU/PUD	Mixed Use/Planned Unit Development	50
INDUSTRIAL DISTRICTS		
ABBREVIATION	NAME	DCIA (%)
CS	Commercial Service	70
RO	Research Office	70
GI	General Industrial	70
PUBLIC FACILITIES		
ABBREVIATION	NAME	DCIA (%)
PF	Public Facilities	60
OTHER LAND USES		
ABBREVIATION	NAME	DCIA (%)
	Right of Way	70
	Architectural/Recreational & Utilities	5
	Vacant/Undeveloped	0

2.5 Rainfall Characteristics

Recent flooding within the Ohio Turnpike 3rd Lane Expansion study area has raised concern that existing rainfall statistics are not representative of the actual recurrence interval of precipitation and flooding. As a result, the City asked CDM to perform a statistical analysis of long-term historical rainfall data and to identify any statistically significant rainfall trends that could alternately explain or contribute to the City's flooding problems during 2004.

2.5.1 Statistical Evaluation of Rainfall Data

First, CDM reviewed available statistical evaluations of rainfall data by others, namely the Rainfall Atlas of the Midwest, published in 1992, and National Oceanic and Atmospheric Administration (NOAA) Atlas 14, published in 2004. **Table 2-8** compares these two frequency distributions. In general, rainfall volumes for equivalent design frequency events are somewhat ***lower*** in the more recently published Atlas 14. Based on this evaluation, no trend is apparent to indicate that precipitation frequencies are increasing in North Royalton.

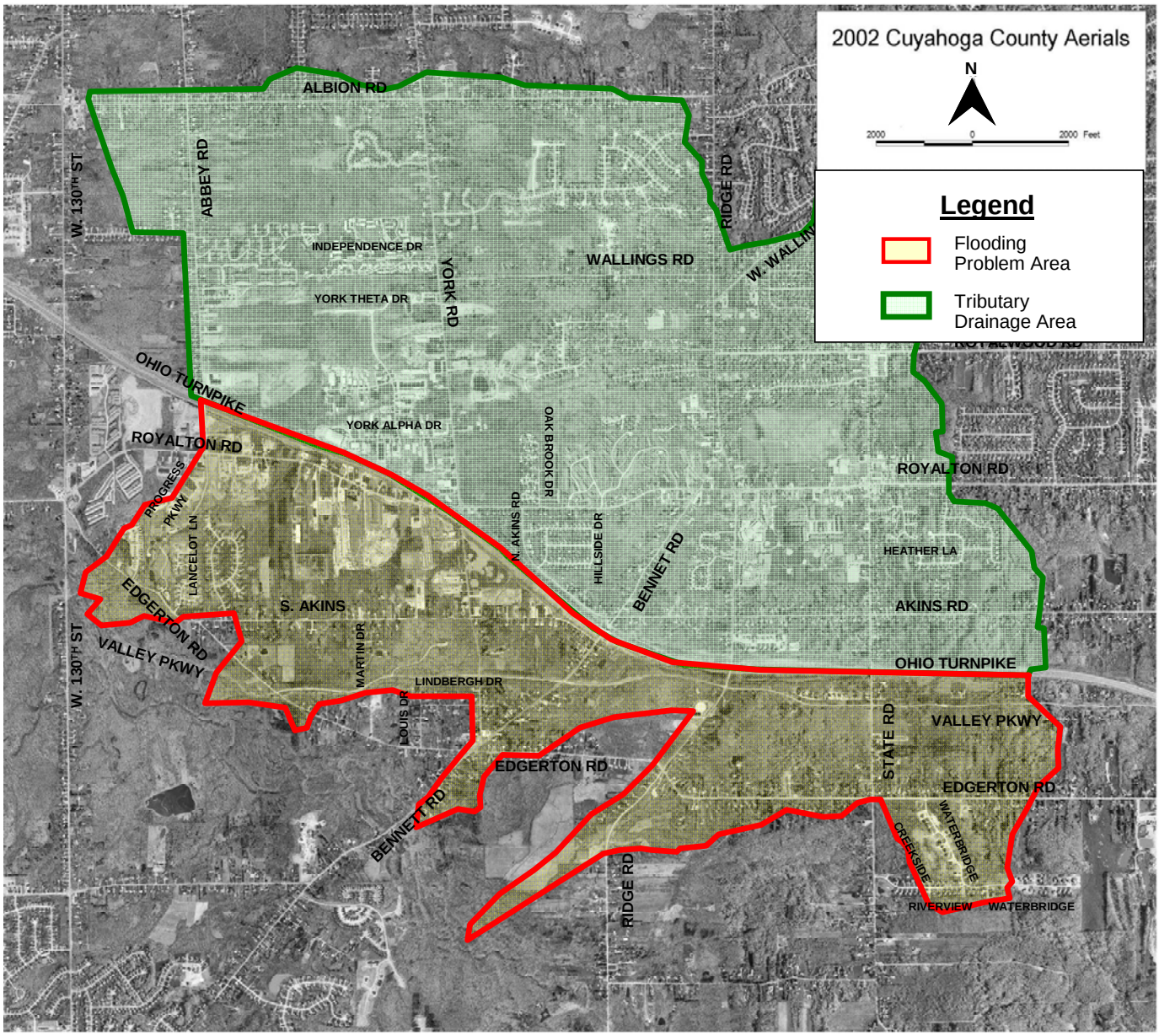


Figure 2-7. Land Cover After (2002) Ohio Turnpike 3rd Lane Expansion

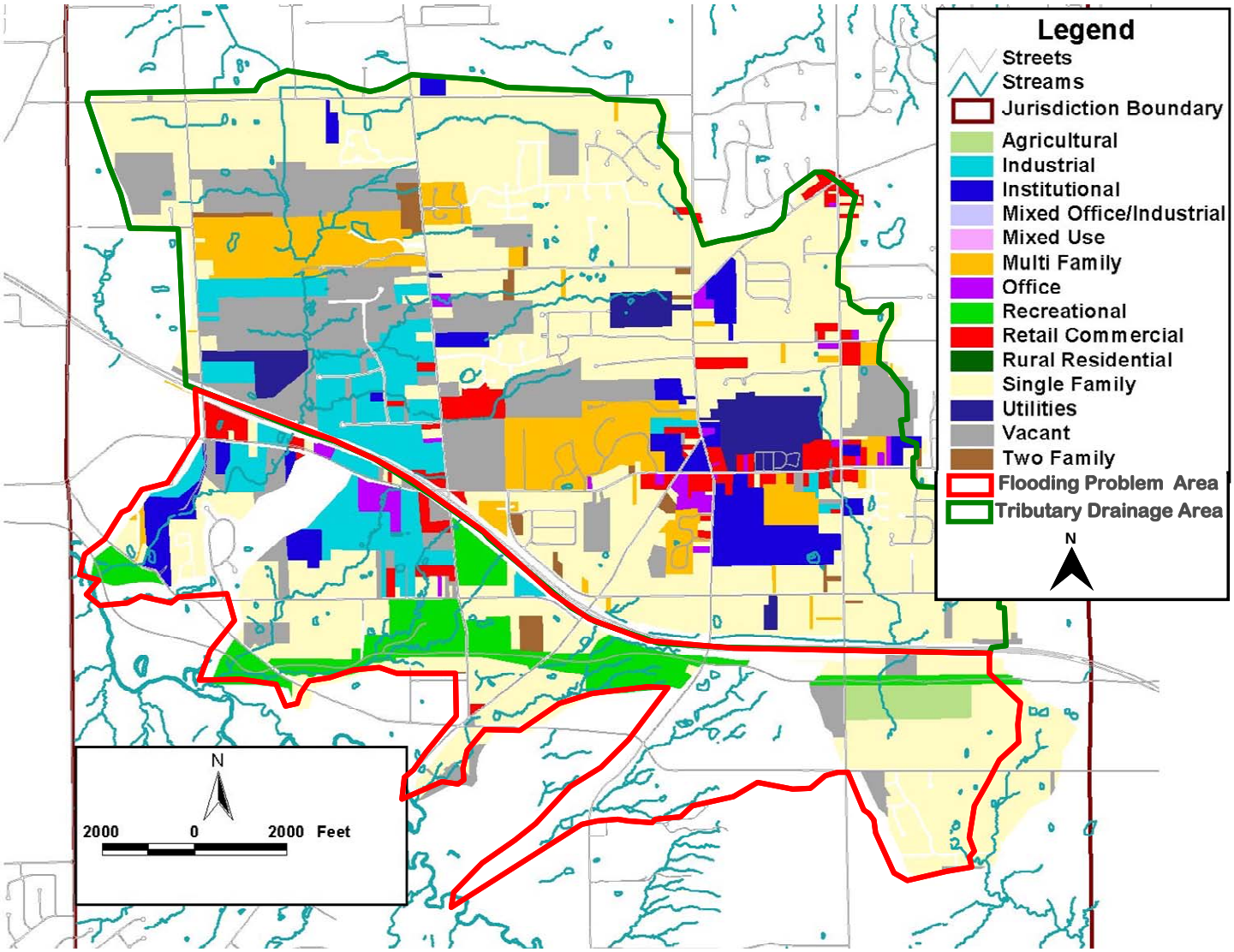


Figure 2-8. Existing Zoning within the Ohio Turnpike 3rd Lane Expansion Study Area

TABLE 2-6. SUBCATCHMENT CHARACTERISTICS -- 1993 LAND USE CONDITIONS

SUBCATCHMENT NUMBER		DISCHARGES TO CHANNEL NUMBER	WIDTH (FT)	AREA (AC)	PERCENT IMPERVIOUS	SLOPE (FT/FT)	RESISTANCE FACTOR		DEPRESSION STORAGE (IN)		INFILTRATION RATE (IN/HR)		DECAY (1/SEC)	MAXIMUM INFILTRATION (IN)
							IMPERV.	PERV.	IMPERV.	PERV.	MAX.	MIN.		
1	C11001055	J11001055	4748	174.4	32	0.033	0.015	0.25	0.05	0.2	1.98	0.05	0.00056	2.09
2	C11001080	J11001080R	1024	9.4	22	0.25	0.015	0.25	0.05	0.2	1.64	0.09	0.00056	1.98
3	C11001090	J11001090R	937	8.6	20	0.25	0.015	0.25	0.05	0.2	1.4	0.07	0.00056	1.72
4	C11001090A	J11001090	323	6.3	45	0.02	0.015	0.25	0.05	0.1	1.22	0.06	0.00056	1.4
5	C11001110	J11001110	7001	853.7	17	0.041	0.015	0.25	0.05	0.2	1.43	0.07	0.00056	2.12
6	C11001130	J11001130	7500	963	13	0.028	0.015	0.25	0.05	0.2	1.26	0.06	0.00056	1.89
7	C12001010	J12001010	1507	17.3	68	0.02	0.015	0.25	0.05	0.2	1.12	0.06	0.00056	1.57
8	C12001010A	J12001010	70	1.4	45	0.02	0.015	0.25	0.05	0.1	1.21	0.06	0.00056	0.98
9	C12001010B	J12001010R	145	2.9	20	0.25	0.015	0.25	0.05	0.2	1.15	0.06	0.00056	1.17
10	C12001020	J12001020	485	8.9	63	0.021	0.015	0.25	0.05	0.2	1.09	0.05	0.00056	1.16
11	C12001020A	J12001020R	160	3.2	21	0.25	0.015	0.25	0.05	0.2	1.12	0.06	0.00056	0.86
12	C12001020B	J12001020	75	1.5	45	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.71
13	C21001010	J21001010	2195	25.9	5	0.022	0.015	0.25	0.05	0.2	2.8	0.18	0.00056	4.95
14	C21001030	J21001030	1789	58.1	10	0.03	0.015	0.25	0.05	0.2	1.6	0.08	0.00056	2.19
15	C21001050	J21001050	2977	31.3	6	0.058	0.015	0.25	0.05	0.2	1.37	0.07	0.00056	1.79
16	C21001075	J21001075	3869	52.4	38	0.024	0.015	0.25	0.05	0.2	1.14	0.06	0.00056	1.4
17	C21001080	J21001080	47	0.5	25	0.25	0.015	0.25	0.05	0.2	1.02	0.05	0.00056	1.06
18	C21001110	J21001110R	588	5.4	14	0.25	0.015	0.25	0.05	0.2	1	0.05	0.00056	0.63
19	C21001120	J21001120R	621	5.7	18	0.25	0.015	0.25	0.05	0.2	1	0.05	0.00056	0.65
20	C21001120A	J21001120	160	3.2	45	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
21	C21001180	J21001180	7555	121.4	40	0.067	0.015	0.25	0.05	0.2	1.7	0.08	0.00056	2.19
22	C21001160	J21001160	4530	41.6	35	0.067	0.015	0.25	0.05	0.2	1.7	0.08	0.00056	2.19
23	C22001040	J22001040	2673	65.1	7	0.047	0.015	0.25	0.05	0.2	1.94	0.1	0.00056	2.49
24	C22001110	J22001110	5248	167.1	13	0.027	0.015	0.25	0.05	0.2	1.26	0.06	0.00056	1.73
25	C22001126	J22001126R	294	2.7	15	0.25	0.015	0.25	0.05	0.2	1	0.05	0.00056	0.64
26	C22001126A	J22001126R	40	0.8	45	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
27	C22001140	J22001140	305	2.8	18	0.25	0.015	0.25	0.05	0.2	1	0.05	0.00056	0.63
28	C22001160	J22001160	4112	141.6	26	0.052	0.015	0.25	0.05	0.2	1.25	0.06	0.00056	2.04
29	C22001150A	J22001150	250	2.3	18	0.25	0.015	0.25	0.05	0.2	1	0.05	0.00056	0.68
30	C22001150B	J22001150	105	2.1	45	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
31	C23001030	J23001030	900	63.6	9	0.03	0.015	0.25	0.05	0.2	1.13	0.06	0.00056	1.38
32	C23001070	J23001070	2585	27	45	0.034	0.015	0.25	0.05	0.2	1	0.05	0.00056	1.48
33	C23001110	J23001110R	1241	11.4	18	0.25	0.015	0.25	0.05	0.2	1	0.05	0.00056	1.14
34	C23001120	J23201010R	860	7.9	18	0.25	0.015	0.25	0.05	0.2	1	0.05	0.00056	0.66
35	C23001120A	J23001120	85	1.7	45	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.7
36	C23001120B	J23201010	40	0.8	45	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
37	C23001120C	J23201010	75	1.5	45	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
38	C23001160	J23001160R	5327	171.2	30	0.027	0.015	0.25	0.22	0.37	1.46	0.07	0.00056	1.77
39	C23001130	J23001130	3421	102.1	25	0.057	0.015	0.25	0.05	0.2	1.46	0.07	0.00056	1.77
40	C31001010	J31001010	2759	34.2	10	0.036	0.015	0.25	0.05	0.2	1.81	0.09	0.00056	2.05
41	C31001049	J31001049	3586	46.1	13	0.038	0.015	0.25	0.05	0.2	1.41	0.07	0.00056	1.87
42	C31001050	J31001050	1182	41.7	3	0.075	0.015	0.25	0.05	0.2	1.97	0.1	0.00056	2.27
43	C31001070	J31001070	1464	16.8	4	0.09	0.015	0.25	0.05	0.2	2.08	0.11	0.00056	2.19
44	C31001080	J31101005	3245	29.8	15	0.25	0.015	0.25	0.05	0.2	1.42	0.07	0.00056	1.79
45	C31001080A	J31101005	505	10.1	45	0.02	0.015	0.25	0.05	0.1	1.27	0.06	0.00056	1.58
46	C31001130	J31001130	810	15.8	5	0.02	0.015	0.25	0.05	0.2	1.51	0.09	0.00056	1.29
47	C31001090	J31001090	516	15.4	10	0.06	0.015	0.25	0.05	0.2	1.01	0.05	0.00056	0.66
48	C31001110	J31001110	1198	5.5	3	0.02	0.015	0.25	0.05	0.2	1.08	0.05	0.00056	1.04
49	C31001100	J31001100R	1928	17.7	20	0.25	0.015	0.25	0.05	0.2	1	0.05	0.00056	0.63
50	C31101010	J31101010	474	4.9	6	0.007	0.015	0.25	0.05	0.2	1	0.05	0.00056	1.59
51	C32001120	J32001120	1851	25.5	9	0.022	0.015	0.25	0.05	0.2	1.22	0.06	0.00056	1.74
52	C32001045	J32001045	2062	28.4	14	0.029	0.015	0.25	0.05	0.2	1.22	0.06	0.00056	1.74
53	C32001150	J32001150	1840	16.9	9	0.035	0.015	0.25	0.05	0.2	1.12	0.06	0.00056	1.68
54	C32001160	J32001160	305	2.8	15	0.25	0.015	0.25	0.05	0.2	1	0.05	0.00056	1.28
55	C32001180	J32001180	2875	66	15	0.083	0.015	0.25	0.05	0.2	1.89	0.09	0.00056	2.18
56	C32001170A	J32001170	196	1.8	18	0.25	0.015	0.25	0.05	0.2	1	0.05	0.00056	0.63
57	C32001170B	J32001170	523	2.4	18	0.25	0.015	0.25	0.05	0.2	1	0.05	0.00056	0.63
58	C32001170C	J32001170	60	1.2	45	0.02	0.015	0.25	0.05	0.1	0.99	0.05	0.00056	0.69
59	C32001170D	J32001170	70	1.4	45	0.02	0.015	0.25	0.05	0.1	1.56	0.08	0.00056	1.56
60	C41001045	J41001045	4084	112.5	5	0.033	0.015	0.25	0.05	0.2	1.61	0.08	0.00056	1.69
61	C41001085	J41001085	4413	192.1	10	0.028	0.015	0.25	0.05	0.2	1.61	0.08	0.00056	1.77
62	C41001100	J41001100	1448	39.9	17	0.037	0.015	0.25	0.05	0.2	1.57	0.08	0.00056	1.53
63	C41001110	J41001110R	1111	10.2	20	0.25	0.015	0.25	0.05	0.2	1.34	0.07	0.00056	1.01
64	C41001110A	J41001110	90	1.8	45	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
65	C41001110B	J41001110	60	1.2	45	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
66	C41001110C	J41001110	100	2	45	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
67	C41001120	J41001120R	1296	11.9	20	0.25	0.015	0.25	0.05	0.2	1	0.05	0.00056	0.67
68	C41001140	J41001140	14696	438.6	15	0.024	0.015	0.25	0.05	0.2	1.26	0.06	0.00056	1.71
69	C41001170	J41001170	11953	475.4	18	0.012	0.015	0.25	0.05	0.2	1.21	0.06	0.00056	1.73

NUMBER OF SUBCATCHMENTS	69
TRIBUTARY AREA (ACRES)	4837.8
IMPERVIOUS AREA (ACRES)	849.5
PERVIOUS AREA (ACRES)	3988.3
TOTAL WIDTH (FEET)	142567.0
TOTAL IMPERVIOUSNESS	17.6

TABLE 2-7. SUBCATCHMENT CHARACTERISTICS -- 2002 LAND USE CONDITIONS

SUBCATCHMENT NUMBER		DISCHARGES TO CHANNEL NUMBER	WIDTH (FT)	AREA (AC)	PERCENT IMPERVIOUS	SLOPE (FT/FT)	RESISTANCE FACTOR		DEPRESSION STORAGE (IN)		INFILTRATION RATE (IN/HR)		DECAY (1/SEC)	MAXIMUM INFILTRATION (IN)
							IMPERV.	PERV.	IMPERV.	PERV.	MAX.	MIN.		
1	C11001055	J11001055	5586	174.4	39.5	0.033	0.015	0.25	0.05	0.1	1.98	0.05	0.00056	0.09
2	C11001080	J11001080R	1024	9.4	21.7	0.25	0.015	0.25	0.05	0.2	1.64	0.09	0.00056	1.98
3	C11001090	J11001090R	937	8.6	20	0.25	0.015	0.25	0.05	0.2	1.4	0.07	0.00056	1.72
4	C11001090A	J11001090	646	6.3	100	0.02	0.015	0.25	0.05	0.1	1.22	0.06	0.00056	1.4
5	C11001110	J11001110	8751	853.7	28.5	0.041	0.015	0.25	0.05	0.1	1.43	0.07	0.00056	2.12
6	C11001130	J11001130	9375	963	26	0.028	0.015	0.25	0.05	0.1	1.26	0.06	0.00056	1.89
7	C12001010	J12001010	1507	17.3	68	0.02	0.015	0.25	0.05	0.2	1.12	0.06	0.00056	1.57
8	C12001010A	J12001010	140	1.4	100	0.02	0.015	0.25	0.05	0.1	1.21	0.06	0.00056	0.98
9	C12001010B	J12001010R	290	2.9	19.9	0.25	0.015	0.25	0.05	0.2	1.15	0.06	0.00056	1.17
10	C12001020	J12001020	485	8.9	62.5	0.021	0.015	0.25	0.05	0.2	1.09	0.05	0.00056	1.16
11	C12001020A	J12001020R	320	3.2	21.1	0.25	0.015	0.25	0.05	0.2	1.12	0.06	0.00056	0.86
12	C12001020B	J12001020	150	1.5	100	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.71
13	C21001010	J21001010	2195	25.9	8.7	0.022	0.015	0.25	0.05	0.1	2.8	0.18	0.00056	4.95
14	C21001030	J21001030	1789	58.1	10.3	0.03	0.015	0.25	0.05	0.1	1.6	0.08	0.00056	2.19
15	C21001050	J21001050	2977	31.3	6.5	0.058	0.015	0.25	0.05	0.1	1.37	0.07	0.00056	1.79
16	C21001075	J21001075	3869	52.4	37.7	0.024	0.015	0.25	0.05	0.2	1.14	0.06	0.00056	1.4
17	C21001080	J21001080	47	0.5	25	0.25	0.015	0.25	0.05	0.2	1.02	0.05	0.00056	1.06
18	C21001110	J21001110R	588	5.4	15	0.25	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
19	C21001120	J21001120R	621	5.7	20	0.25	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.65
20	C21001120A	J21001120	320	3.2	100	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
21	C21001180	J21001180	7555	121.4	40	0.067	0.015	0.25	0.05	0.2	1.7	0.08	0.00056	2.19
22	C21001160	J21001160	4530	41.6	35	0.067	0.015	0.25	0.05	0.2	1.7	0.08	0.00056	2.19
23	C22001040	J22001040	2673	65.1	7	0.047	0.015	0.25	0.05	0.2	1.94	0.1	0.00056	2.49
24	C22001110	J22001110	6617	167.1	22	0.027	0.015	0.25	0.05	0.1	1.26	0.06	0.00056	1.73
25	C22001126	J22001126R	294	2.7	15	0.25	0.015	0.25	0.05	0.2	1	0.05	0.00056	0.64
26	C22001126A	J22001126R	80	0.8	100	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
27	C22001140	J22001140	305	2.8	20	0.25	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
28	C22001160	J22001160	4112	141.6	28.5	0.052	0.015	0.25	0.05	0.1	1.25	0.06	0.00056	2.04
29	C22001150A	J22001150	250	2.3	20	0.25	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.68
30	C22001150B	J22001150	210	2.1	100	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
31	C23001030	J23001030	900	63.6	10	0.03	0.015	0.25	0.05	0.1	1.13	0.06	0.00056	1.38
32	C23001070	J23001070	2585	27	45.1	0.034	0.015	0.25	0.05	0.2	1	0.05	0.00056	1.48
33	C23001110	J23001110R	1241	11.4	20.2	0.25	0.015	0.25	0.05	0.1	1	0.05	0.00056	1.14
34	C23001120	J23201010R	860	7.9	20	0.25	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.66
35	C23001120A	J23001120	170	1.7	100	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.7
36	C23001120B	J23201010	80	0.8	100	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
37	C23001120C	J23201010	150	1.5	100	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
38	C23001160	J23001160R	6780	171.2	50	0.027	0.015	0.25	0.22	0.27	1.46	0.07	0.00056	1.77
39	C23001130	J23001130	3421	102.1	25	0.057	0.015	0.25	0.05	0.1	1.46	0.07	0.00056	1.77
40	C31001010	J31001010	2759	34.2	10.3	0.036	0.015	0.25	0.05	0.2	1.81	0.09	0.00056	2.05
41	C31001049	J31001049	3586	46.1	12.5	0.038	0.015	0.25	0.05	0.2	1.41	0.07	0.00056	1.87
42	C31001050	J31001050	1300	41.7	4	0.075	0.015	0.25	0.05	0.1	1.97	0.1	0.00056	2.27
43	C31001070	J31001070	1464	16.8	7.5	0.09	0.015	0.25	0.05	0.1	2.08	0.11	0.00056	2.19
44	C31001080	J31101005	3245	29.8	15	0.25	0.015	0.25	0.05	0.2	1.42	0.07	0.00056	1.79
45	C31001080A	J31101005	1010	10.1	100	0.02	0.015	0.25	0.05	0.1	1.27	0.06	0.00056	1.58
46	C31001130	J31001130	2699	15.8	30	0.02	0.015	0.25	0.05	0.1	1.51	0.09	0.00056	1.29
47	C31001090	J31001090	516	15.4	10	0.06	0.015	0.25	0.05	0.1	1.01	0.05	0.00056	0.66
48	C31001110	J31001110	1198	5.5	3	0.02	0.015	0.25	0.05	0.2	1.08	0.05	0.00056	1.04
49	C31001100	J31001100R	1928	17.7	20	0.25	0.015	0.25	0.05	0.2	1	0.05	0.00056	0.63
50	C31101010	J31101010	474	4.9	12	0.007	0.015	0.25	0.05	0.1	1	0.05	0.00056	1.59
51	C32001120	J32001120	1851	25.5	10	0.022	0.015	0.25	0.05	0.1	1.22	0.06	0.00056	1.74
52	C32001045	J32001045	2062	28.4	15	0.029	0.015	0.25	0.05	0.1	1.22	0.06	0.00056	1.74
53	C32001150	J32001150	1840	16.9	10	0.035	0.015	0.25	0.05	0.1	1.12	0.06	0.00056	1.68
54	C32001160	J32001160	305	2.8	15	0.25	0.015	0.25	0.05	0.2	1	0.05	0.00056	1.28
55	C32001180	J32001180	2875	66	15	0.083	0.015	0.25	0.05	0.2	1.89	0.09	0.00056	2.18
56	C32001170A	J32001170	196	1.8	20	0.25	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
57	C32001170B	J32001170	523	2.4	20	0.25	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
58	C32001170C	J32001170	120	1.2	100	0.02	0.015	0.25	0.05	0.1	0.99	0.05	0.00056	0.69
59	C32001170D	J32001170	140	1.4	100	0.02	0.015	0.25	0.05	0.1	1.56	0.08	0.00056	1.56
60	C41001045	J41001045	6126	112.5	15	0.033	0.015	0.25	0.05	0.1	1.61	0.08	0.00056	1.69
61	C41001085	J41001085	4413	192.1	5	0.028	0.015	0.25	0.05	0.2	1.61	0.08	0.00056	1.77
62	C41001100	J41001100	1448	39.9	10	0.037	0.015	0.25	0.05	0.1	1.57	0.08	0.00056	1.53
63	C41001110	J41001110R	1111	10.2	19.9	0.25	0.015	0.25	0.05	0.2	1.34	0.07	0.00056	1.01
64	C41001110A	J41001110	180	1.8	100	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
65	C41001110B	J41001110	120	1.2	100	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
66	C41001110C	J41001110	200	2	100	0.02	0.015	0.25	0.05	0.1	1	0.05	0.00056	0.63
67	C41001120	J41001120R	1296	11.9	20.1	0.25	0.015	0.25	0.05	0.2	1	0.05	0.00056	0.67
68	C41001140	J41001140	15921	438.6	20	0.024	0.015	0.25	0.05	0.1	1.26	0.06	0.00056	1.71
69	C41001170	J41001170	12551	475.4	20	0.012	0.015	0.25	0.05	0.1	1.21	0.06	0.00056	1.73

NUMBER OF SUBCATCHMENTS	69
TRIBUTARY AREA (ACRES)	4837.8
IMPERVIOUS AREA (ACRES)	1198.4
PERVIOUS AREA (ACRES)	3639.4
TOTAL WIDTH (FEET)	157,887
TOTAL IMPERVIOUSNESS	24.8

2.5.2 Rainfall during Recent Flood Events

CDM also collected rainfall data corresponding to the recent flooding events in North Royalton:

- The gage at the North Royalton WWTP-A (WWTP-A). Storm events include reported flooding during 5/10/03, 5/20-22/04, 6/9/04.
- NEORSD's rain gage located at the North Royalton City Hall.

Measured rainfall during the May 21-22, 2004 and June 9, 2004 events is shown on Table 2-8 along side the two published rainfall frequency distributions. The following conclusions can be drawn from this comparison:

- Review of the 24-hour storm totals for each event indicate that the May 21-22 event had a rainfall recurrence interval between a 5-year and 10-year event, while the June 9 event had less than a 2-year recurrence interval.
- In small watersheds like the Ohio Turnpike 3rd Lane Expansion study area, storm durations shorter than 24-hours are the critical event for flood evaluation. The 24-hour rainfall totals do indicate that relatively wet conditions occurred during the period of peak rainfall intensity.
- Review of the 30-minute to 6 hour rainfall volumes indicate that both storm events had a 2-year to 5-year rainfall recurrence interval. The time of concentration for the study area falls within this 30-minute to 6 hour range, indicating that the flood frequency was in the range of a 2-year to 5-year recurrence interval.

Table 2-8. Comparison of Published Rainfall Frequency Distributions and Measured Rainfall During Observed Flooding

Sectional Mean Frequency Distributions for Storm Periods of 5 Minutes to 10 Days and Recurrence Intervals of 2 Years to 100 Years in Northeast Ohio

Rainfall (inches) for given recurrence interval						
Duration	2-year	5-year	10-year	25-year	50-year	100-year
10-day	4.29	5.34	6.17	7.30	8.19	9.14
5-day	3.34	4.23	4.95	5.96	6.82	7.74
72-hr	2.99	3.72	4.34	5.31	6.15	7.09
48-hr	2.75	3.42	3.99	4.87	5.66	6.55
24-hr	2.50	3.10	3.60	4.39	5.11	5.89
18-hr	2.35	2.91	3.38	4.13	4.80	5.54
12-hr	2.17	2.70	3.13	3.82	4.45	5.12
6-hr	1.88	2.32	2.70	3.29	3.83	4.42
3-hr	1.60	1.98	2.30	2.81	3.27	3.77
2-hr	1.45	1.80	2.09	2.55	2.96	3.42
1-hr	1.17	1.46	1.69	2.06	2.40	2.77
30-min	0.93	1.15	1.33	1.62	1.89	2.18
15-min	0.68	0.84	0.97	1.19	1.38	1.59
10-min	0.52	0.65	0.76	0.92	1.07	1.24
5-min	0.30	0.37	0.43	0.53	0.61	0.71

Source: Huff, F.A. and J. R. Angel, "Rainfall Frequency Atlas of the Midwest", Illinois State Water Survey, Champaign, Bulletin 71, 1992, Page 135

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Ohio 41.296 N 81.735 W 1049 feet

Rainfall (inches) for given recurrence interval							
Duration		2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
10	day	4.31	5.16	5.84	6.76	7.50	8.24
7	day	3.76	4.56	5.19	6.07	6.77	7.49
4	day	3.14	3.85	4.42	5.23	5.89	6.58
48	hr	2.77	3.41	3.94	4.68	5.30	5.95
24	hr	2.41	3.00	3.48	4.19	4.78	5.40
18	hr						
12	hr	2.06	2.58	3.02	3.66	4.21	4.80
6	hr	1.77	2.24	2.62	3.19	3.67	4.19
3	hr	1.50	1.90	2.23	2.69	3.06	3.46
120	min	1.41	1.79	2.09	2.50	2.85	3.21
60	min	1.21	1.53	1.77	2.10	2.36	2.63
30	min	0.99	1.22	1.39	1.62	1.79	1.97
15	min	0.74	0.89	1.00	1.15	1.25	1.36
10	min	0.60	0.72	0.81	0.93	1.01	1.10
5	min	0.39	0.47	0.53	0.61	0.67	0.73

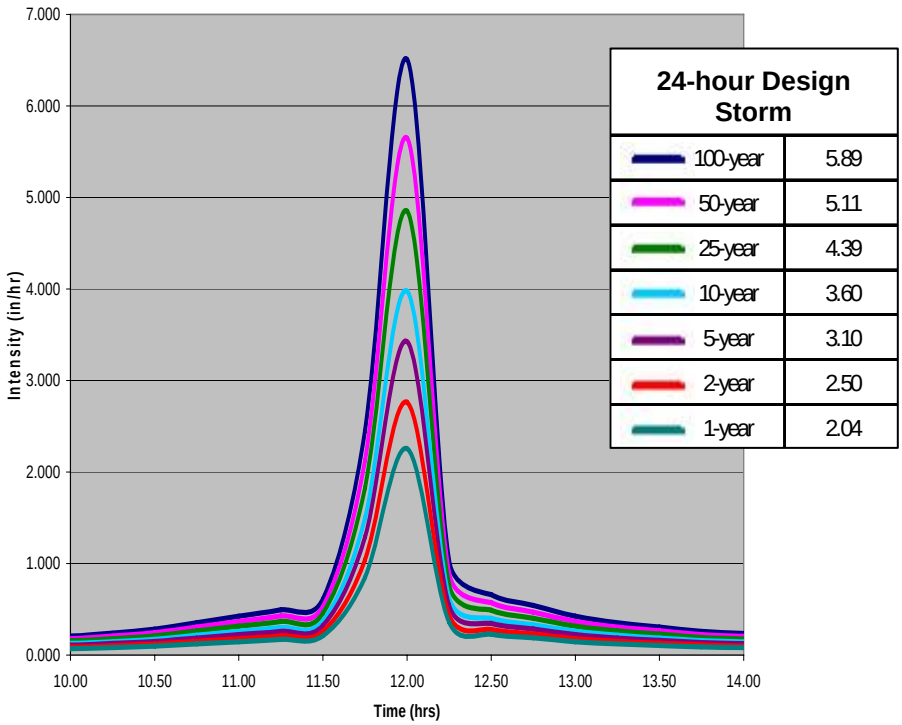
from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 2, Version 2 (draft)
G.M. Bonnin, D. Todd, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2004
Extracted: Wed Nov 2 2005

Measured Precipitation In City of North Royalton

Rainfall (inches)					
May 10, 2003		May 21-22, 2004		June 9, 2004	
WWTP-A	WWTP-B	WWTP-A	WWTP-B	WWTP-A	WWTP-B
			3.79		
2.37	1.70	3.24	3.13	2.24	1.58
0.70	0.70	2.03	1.99	1.73	1.36
0.70	0.70	1.09	1.99	1.72	1.35
0.70	0.70	1.09	1.99	1.72	1.35
0.70	0.70	1.09	1.99	1.66	1.30
0.37	0.41	1.07	1.15	1.66	1.28
0.25	0.18	0.92	0.49	1.66	1.28
0.15	0.09	0.33	0.34	0.90	0.65

2.5.3 Design Rainfall Hyetographs

The design storms for master planning evaluations are based on synthetic unit hyetographs and local rainfall volume statistics. The unit hyetographs were developed by the Soil Conservation Service (SCS) in 1986 for use in the United States for storms of 6 to 24 hours duration. There are four 24-hour duration storms, called Types I, IA, II, and III; each is applied in a different geographic location in the United States. The Type II storm applies to northeast Ohio, as well as most of the United States.



Design Storm Hyetograph

CDM referred to a publication entitled Rainfall Frequency Atlas of the Midwest, by Floyd A. Huff and James R. Angel, dated 1992, to obtain expected total rainfall in North Royalton for storms which last 24-hours and occur every 2, 10, 25, and 100-years. The data in the Rainfall Frequency Atlas was compiled from an intense study of rainfall frequency relationships throughout the Midwest. The figure to the right shows the total 24-hour rainfall depths and the maximum 15-minute rainfall intensities for the design storms used in the study.

Section 3
Drainage Problem Evaluation

This section summarizes the location and severity of drainage problems in the Ohio Turnpike 3rd Lane Expansion Evaluation study area, including an assessment of the contribution of Ohio Turnpike drainage to each problem area. The following approach was used to define the location and severity of drainage problems:

- Compile a database of drainage complaints based on the City's existing flooding complaint records.
- Conduct an initial neighborhood meeting to solicit resident information about observed drainage problems.
- Conduct interviews with residents near drainage courses to better understand the location and magnitude of flooding problems.
- Perform a hydrologic / hydraulic evaluation of the existing drainage system during historic and design storm events to quantify the frequency and severity of flooding and correlate these projections to resident reports.
- Define the relative contribution of drainage from the Ohio Turnpike to each problem area, and determine if capacity constraints in Ohio Turnpike drainage infrastructure contributes to flooding.

3.1 Drainage Complaints Database

CDM obtained the City's existing flooding complaint records and developed a complaint database in Microsoft Access. **Figure 3-1** is a map of the study area showing the location of each property where a drainage complaint was reported. This database was supplemented with information obtained from residents at an initial neighborhood meeting held on April 20, 2005, through questionnaires completed by residents at and following this meeting, and through field visits to problem locations. The complete database is provided in **Appendix A** of this report. This section describes the process used to assemble this database.

3.1.1 Information Sources

The flooding complaint database and figure were developed for the designated problem area by evaluating the following information sources:

- City table listing flooding complaints reported on May 22, 2004.
- City table listing flooding complaints reported on June 9, 2004.
- City map showing flooding complaints reported on May 22, 2004 and June 9, 2004.
- City map showing flooding complaints reported on May 10, 2003.

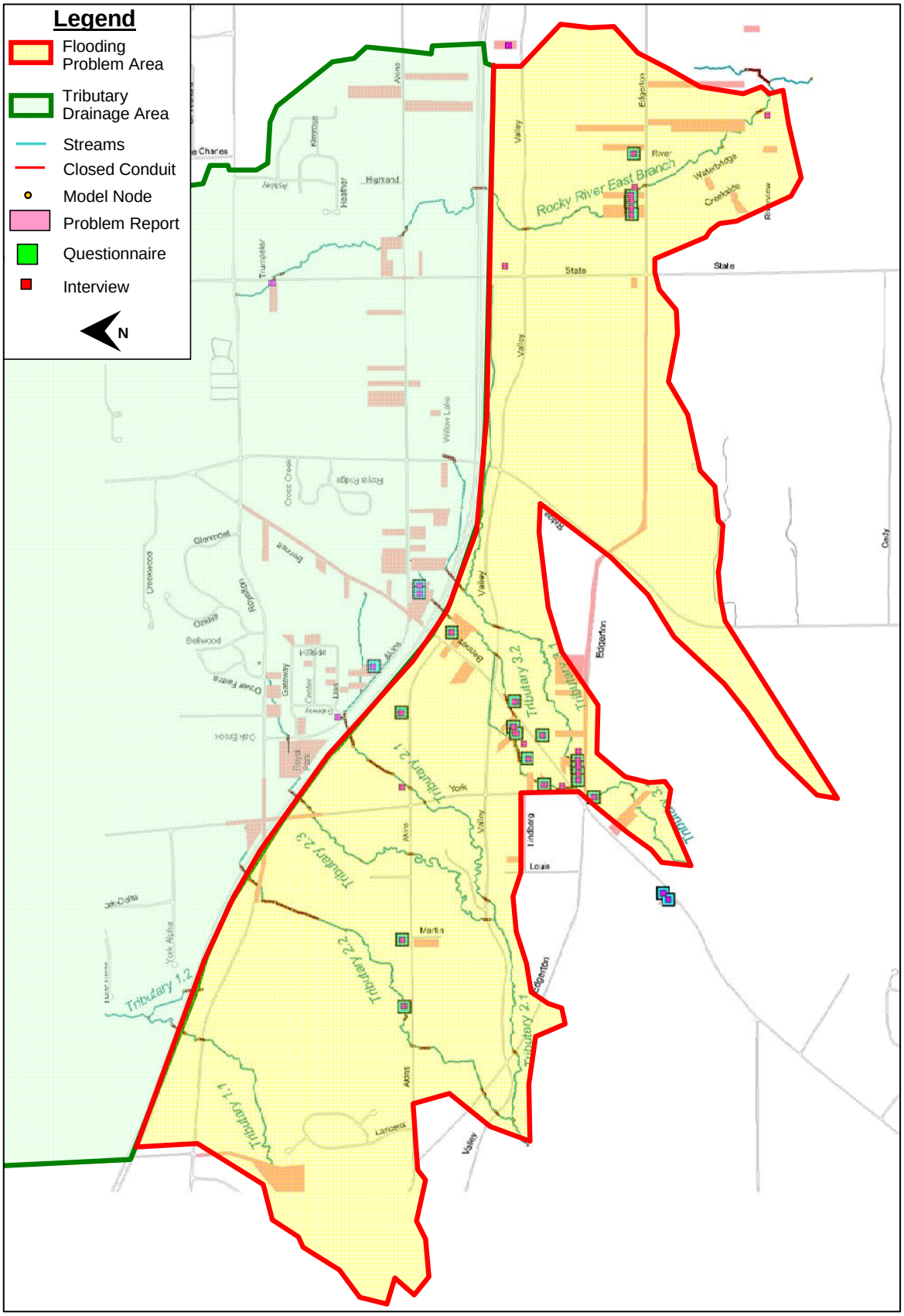


Figure 3-1. Location of Reported Problems, Resident Questionnaires, and Resident Interviews within the Ohio Turnpike 3rd Land Expansion Study

- Task 1 April 20, 2005 initial neighborhood meeting questionnaires.
- Task 2 Resident interviews conducted by CDM from April 2005 through July 2005.

81 problems within the Ohio Turnpike 3rd Lane Evaluation flooding problem area were reported to the City during the May 10, 2003, May 22, 2004, and June 9, 2004 storm events and are presented by parcel in the drainage complaint database. In addition, 52 problems were reported in the tributary drainage area and are included in both the flooding complaint database and figure to better understand potential causes of flooding. The problems in the tributary drainage area are identified in the flooding complaint database by the field "Outside of Designated Problem Area".

3.1.2 Initial Neighborhood Meeting

The initial neighborhood meeting occurred on April 20, 2005 at the North Royalton High School. The meeting had a relatively good turnout with approximately 50 people in attendance, including some City Council members. The City provided a brief introduction to start the meeting, informed the residents about the scope of the project, and indicated that the goal of the evening was to fully understand the existing flooding problems within the study area. Four identical stations were set up for the residents to visit, fill out questionnaires, and discuss their flooding problems with both CDM and City staff. 25 questionnaires were filled out during the April 20, 2005 initial neighborhood meeting. The questionnaires included the following information requests:

- Discuss any flooding problems that have occurred along their property.
- Discuss any general concerns or questions they had regarding the project.
- Indicate if a CDM employee should contact them to discuss the matter further.
- Indicate if a CDM employee could access their property to evaluate the problem in the field.

In general, residents indicated that their flooding problems have occurred both more severely and more frequently over the past five years. Residents primarily focused on discussing flooding related problems that occurred during either the May 20 through 22nd, 2004 storm or the June 9, 2004 storm. Several photos showing property and street flooding were provided by the residents. Most residents indicated they would like CDM to contact them to discuss their flooding problems further and that CDM was permitted to access their property for evaluation purposes. The problems reported by meeting attendees were primarily located along the following streets: Edgerton Road, Bennett Road, Akins Road and York Road.

3.1.3 Resident Interviews

CDM conducted 36 resident interviews, primarily during the field reconnaissance surveys described in Section 2. Some residents interviewed by CDM did not attend the initial neighborhood meeting. Therefore, additional flooding problems within the study area were identified. During the interviews residents reported several flooding problems previously reported to the city, and also reported erosion problems.

The purpose of the interviews was to obtain, organize, and supplement the City's existing flooding complaint records. Compiling and evaluating this data helped to better understand the severity and potential causes of flooding in the flooding problem area. Where appropriate, CDM photographed sites where flooding was reported and documented findings in the field notebook. Once interviews were complete, CDM updated the flooding complaint database and revised the flooding location map to identify the location, type, and severity of flooding problems.

3.1.4 Hydrologic / Hydraulic Evaluation

The Ohio Turnpike 3rd Lane Expansion Study used the USEPA Stormwater Management Model (SWMM) to conduct the hydrologic/hydraulic evaluation of the modeled drainage system and to develop alternative drainage solutions. SWMM is a dynamic computer model that simulates surface water hydrology and open and closed conduit hydraulics. The surface water hydrology evaluation was conducted using the RUNOFF Block of USEPA SWMM, and the open and closed conduit hydraulic evaluation was conducted using the EXTRAN block of USEPA SWMM. This subsection contains descriptions of the selected models and how they were applied, calibrated, and verified.

3.1.4.1 Hydrographs: RUNOFF

The RUNOFF Block of USEPA SWMM was used for this study. The program simulates the rates of runoff from subbasins using a kinematic wave approximation. Hydrologic routing techniques are then used to route the overland flows through the pipe, culvert, channel, or detention pond drainage system as required. Program results can be saved for input to the EXTRAN Block of SWMM to perform hydraulic routing through downstream pipes, channels, and ponds.

RUNOFF was originally developed in 1970 as part of the original USEPA SWMM. The program has been applied many times since its inception and has gained world-wide acceptance. Over the years, the program has undergone many changes and modifications although the main formulations and calculations remain mostly unchanged from the original codes.

3.1.4.2 Storm Routing and Water Surface Profiles: EXTRAN

EXTRAN is a hydraulic flow routing model for open channel and/or closed conduit systems. It uses a link-node (conduit-junction) representation of the drainage system in an explicit finite difference solution of the equations of gradually varied, unsteady

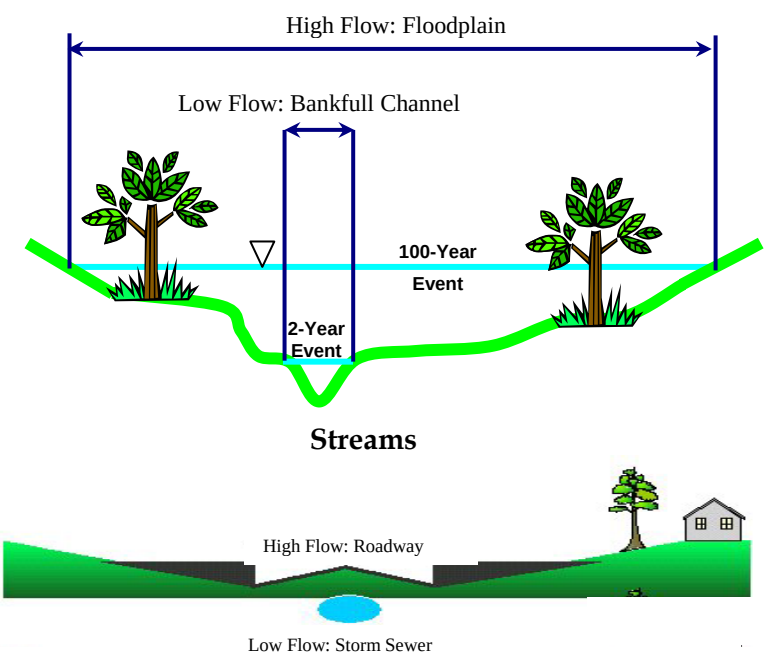
flow. EXTRAN receives hydrograph input at specific junctions by disk file transfer from a hydrologic model such as RUNOFF, and/or manual input. The model performs dynamic routing of stormwater flows through the major storm conveyance system to the points of outfall to the receiving water system.

The program simulates branched or looped networks, backwater due to non-tidal conditions, free-surface flow, pressure flow or surcharge, flow reversals, flow transfer by weirs and orifices, and storage at on-line or off-line facilities. Types of conduits that can be simulated include circular, rectangular, horseshoe, and baskethandle pipes, plus trapezoidal or irregular cross-sections. Simulation output takes the form of water-surface elevations and discharges at selected system locations.

3.2 Recommended Level of Service for Flood Control

Flooding is a natural phenomenon accommodated within natural drainage systems. In undeveloped watersheds, stormwater runoff is usually contained within the banks, or the bankfull channel, of streams during rainfall events of small to moderate size (e.g., during a 2-year design storm event). During larger, less frequent storms, runoff overflows the channel banks into the surrounding floodplain. Flooding occurs when:

- Impervious surfaces are placed within the watershed draining into the stream, increasing runoff, stream flow, out-of-bank flooding, and floodplain size.
- Buildings, roads, infrastructure, or other human activities encroach into the floodplain.



Both natural streams and urban drainage systems need a low-flow and high-flow component to accommodate flooding.

As areas develop, portions of the natural drainage system are often replaced with underground storm sewers sized to collect and convey runoff from small to moderate storms. Modern, properly designed developments use streets or swales to convey runoff from larger, less frequent storms to the open channel drainage system. Building or extended street flooding may occur if an appropriate surface drainage system is not provided.

Effective drainage system design depends upon how ***frequently*** the capacity of the "low-flow" system should be exceeded, and how ***severe*** the impact of flooding would be within

the "high-flow" system. ***Frequency*** is usually expressed as a recurrence interval. An example of a recurrence interval is the 100-year design storm event, defined as a storm with a 1% probability of occurrence in any given year. ***Severity*** is quantified through hydraulic modeling to determine specific characteristics such as flood depth, length of roadway flooding, number of roadways that become impassable (e.g., greater than 8 in. in depth), number of structures where flooding reaches the foundation, and depth of flooding at structures.

The level of service of a properly designed drainage system is defined as the frequency of the storm event that should not exceed the performance standard. The performance standard is defined as the level of flood protection provided for each defined feature. The recommended level of service performance standard is defined for two features:

- Buildings
- Streets

Table 3-1 summarizes CDM's recommended level of service performance standard for each feature, which was based upon CDM's understanding of Chapter 1481 "Storm Water Management" of the City's Code of Ordinances, coordination with City staff, and best engineering judgment. The recommended level of service is for the 25-year, 24-hour design storm. The performance standard is based upon preventing inundation of street pavement and building first floor flooding.

CDM evaluated the drainage system within the study area and tributary drainage system by applying a 25-year, 24-hour design storm SCS Type II rainfall distribution equal to 4.39 inches and published in both Chapter 1481 of the City's Ordinance and in the 1992 document authored by Huff and Angel titled: "Rainfall Frequency Atlas of the Midwest, Bulletin 71".

Table 3-1
Recommended Level of Service Performance Standard

Feature	Recommended Level of Service	Recommended Performance Standard
Buildings	25-year	0-feet below foundation of residences and/or occupied non-residential buildings
Streets	25-year	0-feet below road crown

The Ohio Turnpike Commission established the following design criteria for the third lane expansion project within North Royalton:

1. Design storm frequency/maximum allowable headwater for existing culverts.

   A. Surcharge shall not exceed one (1) foot below the near, low edge of the shoulder for a design storm frequency of 100 years.

   B. Surcharge shall not exceed two (2) feet above the inlet crown on above a tailwater elevation that submerges the inlet crown for a design storm frequency of 100 years.

2. Design storm frequency/maximum allowable headwater for proposed culverts:

   A. Culverts up to and including 72 inches in size with a drainage area less than 400 acres shall pass a design storm frequency of 10 years with no surcharge.

   B. Culverts larger than 72 inches in size with a drainage area less than 400 acres shall pass a design storm frequency of 25 years with no surcharge.

   C. All culverts draining more than 400 acres shall be designed to pass a 25-year flood with no surcharge at the entrance.

   D. In flat areas the culverts shall be designed for a design storm frequency of 100 years with adequate capacity to prevent undue damage to adjacent property owners from ponding.

   E. Surcharge shall not exceed one (1) foot below the near, low edge of the shoulder for a design storm frequency of 100 years.

   F. Surcharge shall not exceed two (2) feet above the inlet crown on above a tailwater elevation that submerges the inlet crown for a design storm frequency of 100 years.

   G. Concrete box culverts shall be designed to pass a design storm frequency of 25 years with no surcharge.

3. Design storm frequency hydraulic gradient for storm sewers.

   A. Design frequency (just full) 10 year.

   B. Hydraulic gradient shall not exceed:

      1) 12 inches below edge of pavement for 25 year frequency storm.
      2) Catch basin grate or lip of inlet for 25 year frequency storm.
      3) Catch basin grate or lip of inlet for 100 year frequency storm in a depressed pavement sag.

4. Design storm frequency for ditches.

   A. Design frequency to determine:

      1) Depth of flow and protection (where required) 10 year.
      2) Velocity determination 10 year.

5. Design storm frequency for curbed pavement: 10 year

3.3 Projected Flooding during Historic Storm Events

Storm events during May and June of 2004 were represented in the hydrologic/hydraulic model of existing land cover conditions and compared with resident reports of flooding to confirm that the model is a reasonably accurate tool for projecting flooding. For each scenario, CDM prepared summary tables and thematic maps identifying the locations and magnitudes of predicted street and building flooding occurrences throughout the study area, based on available structure elevations (e.g., road crown and building finished floor elevations).

The evaluation of historic flood events compared projected water surface elevations to reported flooding locations and severity during two rain events (May 22, 2004 and June 9, 2004) to determine whether the model appropriately represented both the surface water hydrology and open and closed conduit hydraulics for conceptual design purposes. The hydrologic/hydraulic model parameters were adjusted to develop a better overall representation of the entire modeled system under a complete range of design storms, offering a "reality check" for the storm water model.

3.3.1 Methodology

CDM defined flood elevations for features located throughout the study area (e.g., road crown, building finished floor, top of stream bank, etc) by utilizing information collected throughout the course of this project and applying best engineering judgment. Rain data collected at the WWTP-A and B rain gauges during each rain event were evaluated, and a hyetograph was developed and utilized to represent the rainfall response during each rain event. Next, the model was used to project maximum water surface elevations along the drainage system for each rain event. The flood elevations projected with the model were compared to the defined flood elevations for each feature to assess whether the feature was projected to flood. Finally, projected flooding was compared to reported flooding to assess whether the model appropriately represented both the surface water hydrology and open and closed conduit hydraulics for conceptual design purposes.

3.3.2 May 22, 2004 Rain Event

Table 3-2 and **Figure 3-2** identify the location and magnitude of projected street, building, and significant yard flooding occurrences throughout the flooding problem area during the May 22, 2004 rain event for each tributary. Table 3-2 also identifies where flooding was reported during the rain event. Reviewing the results presented

in both Table 3-2 and Figure 3-2, the model predicts similar flooding along each tributary compared to reported flooding. Significant flooding occurred during this event at the following locations:

- Tributary 2.1 flooded York Road, North Akins Road, and a building along North Akins Road.
- Tributary 2.2 flooded Royalton Road, Edgerton Road, and a building along Edgerton Road.
- Tributary 3.1 flooded Edgerton Road, Valley Parkway, and several structures along Edgerton Road and Bennett Road.
- Tributary 3.2 flooded Valley Parkway and several buildings and adjacent property along York Road and Bennett Road.
- Rocky River East Branch flooded Valley Parkway, North Akins Road, Edgerton Road, and buildings adjacent to North Akins Road and Edgerton Road.

In general, peak flood stages during the May 22, 2004 event fell between those projected during the 2-year, 24-hour design storm and the 5-year, 24-hour design storm.

3.3.3 June 9, 2004 Rain Event

Table 3-3 and **Figure 3-3** identify the location and magnitude of projected street, building, and significant yard flooding occurrences throughout the designated problem area during the June 9, 2004 rain event. Table 3-3 also identifies where flooding was reported during the rain event. Reviewing the results presented in both Table 3-3 and Figure 3-3, the model predicts similar flooding along each tributary compared to reported flooding. Significant flooding occurred during this event at the same locations that flooded during the May 22 event. Flooding also occurred at the following locations:

- Tributary 1.1 flooded Valley Parkway and Independence Drive.
- Tributary 2.1 flooded the Royal Park Condominium complex.
- Tributary 2.3 flooded North Akins Road at South Gateway Drive.

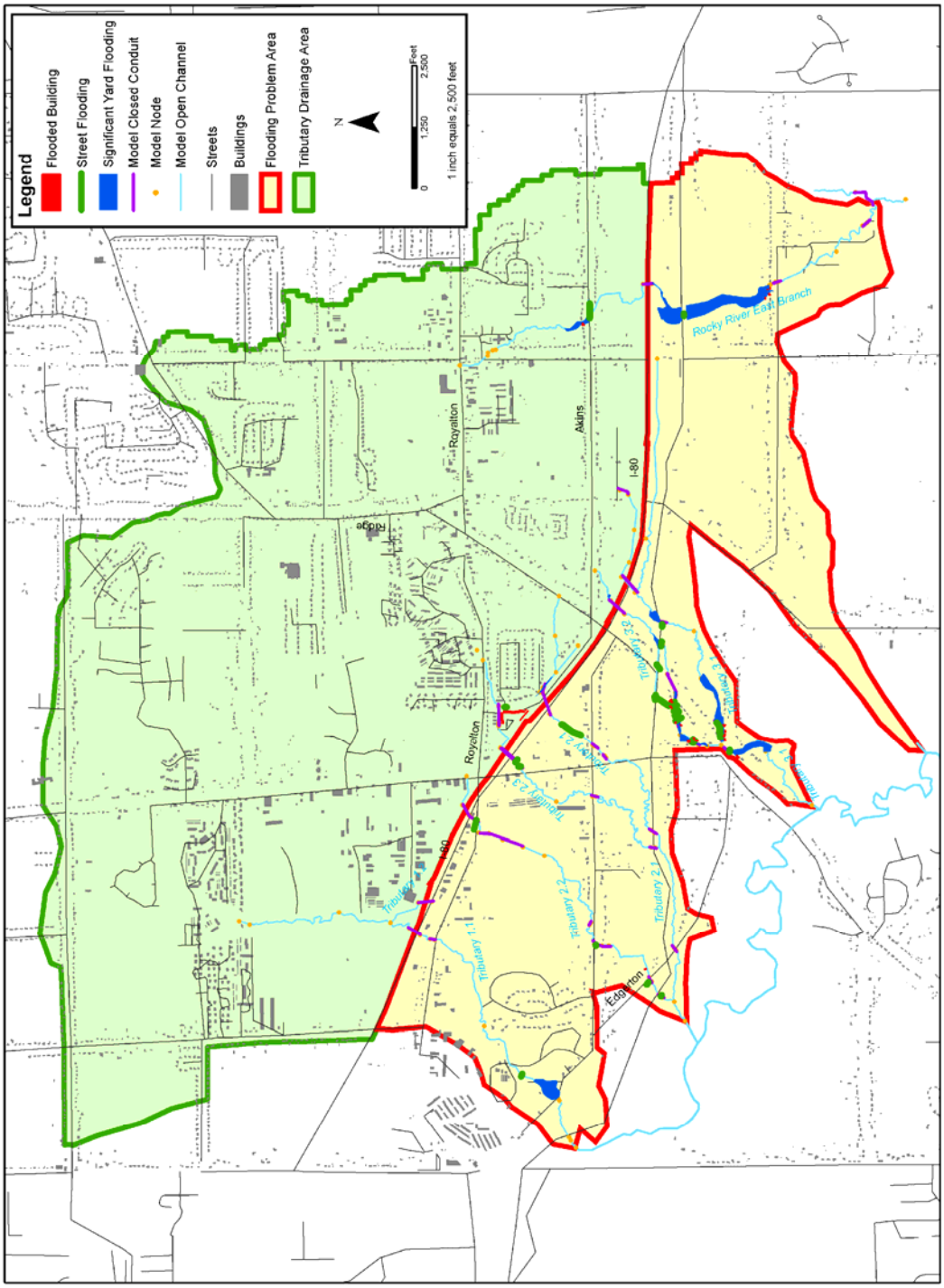


Figure 3-2. Flood Severity during the May 22, 2004 Rainfall Event

Table 3-2
Projected Flooding during the 5/22/04 Rain Event

Location	SWMM Node Invert Elevation (msl)	Minimum Flooding Elevation (msl)	Feature Flooded at Minimum Flooding Elevation	5/22/2004 Rain Event			
				Model Predicted HGL (msl)	Depth of Flooding (ft)	Feature(s) Reported Flooded	Features Model Predicted Flooded
Tributary 1.1							
Valley Pkwy	816.93	825.5	STREET	825.02			
Edgerton Rd	817.08	826.0	YARD	826.95	0.95		YARD
Business Stream Crossing	820	827.7	STREET	830.12	2.47		STREET
Royalton Rd	841.62	868.4	STREET	848.18			
Ohio Turnpike	846	882.0	STREET	854.13			
Independence Dr	870	882.0	STREET	880.46			
Tributary 1.2							
Ohio Turnpike	872.2	881.9	STREET	874.5			
Tributary 2.1							
Edgerton Road	834.1	843.1	STREET	836.2			
Valley Pkwy	847.1	854.1	STREET	853.33			
S. Akins Rd	872	884.9	STREET	880.74			
York Rd	894.12	898.9	STREET	900.03	1.16		STREET
Cuyahoga County access road	895.6	902.4	STREET	903.02	0.67		STREET
Ohio Turnpike	899	907.0	STREET	904.85			
Royal Park Condo	913.2	918.0	STREET, BUILDING	917.84			
Royal Park Condo	914	920.0	BUILDING	916.19			
N. Akins Rd	921	927.6	STREET	928.23	0.64	BUILDING	STREET, BUILDING
Dover Lake Detention Basin	973.49	980.7	EMERGENCY SPILLWAY	979.93			
Tributary 2.2							
Valley Pkwy	827.1	834.1	STREET	834.31	0.21		STREET
Edgerton Rd	832.1	835.0	BUILDING	838.03	3.03		BUILDING, STREET
Private culvert (next to pond)	843	849.5	YARD	850.48	0.98		YARD
S. Akins Rd	844.1	851.5	STREET	851.58	0.1		STREET
Private Driveway	848.1	864.1	STREET	854.06			
Tri County Concrete Co	881	889.0	STREET	885.23			
Tri County Concrete Co	882	890.0	STREET	887.62			
Tri County Concrete Co	883	891.0	STREET	889.79			
Royalton Rd	885.25	889.2	STREET	889.83	0.68		STREET
Ohio Turnpike	888.7	900.0	BUILDING	894.02			
Mom's Deli	898	904.7	STREET	898.01		STREET	

Table 3-2
Projected Flooding during the 5/22/04 Rain Event

Location	SWMM Node Invert Elevation (msl)	Minimum Flooding Elevation (msl)	Feature Flooded at Minimum Flooding Elevation	5/22/2004 Rain Event			
				Model Predicted HGL (msl)	Depth of Flooding (ft)	Feature(s) Reported Flooded	Features Model Predicted Flooded
Tributary 2.3							
Valley Pkwy	849.5	858.2	STREET	856.45			
York Rd	878.1	885.0	STREET	883.36			
House south of N. Akins Rd, East of York Rd	883.09	888.7	BUILDING	887.87			
S. Akins Rd	883.29	890.9	STREET	888.56			
Cuyahoga County access road	890.1	900.1	STREET	900.8	0.7		STREET
Junction chamber below N Akins Rd, S. Gateway Dr	910	922.0	STREET	917.66			
Inlet at Int. of N Akins Rd, S. Gateway Dr	912.85	922.6	STREET	922.27			
N. Akins Rd	924	928.0	STREET	926.59			
Int. of N Akins Rd, S. Gateway Dr	918.5	922.9	STREET	918.52			
N. Akins Rd	944	946.0	STREET	944.6			
Tributary 3.1							
16551 Bennett Rd	855.8	859.5	BUILDING	859.83	0.33	BARN	BARN
Edgerton Rd	856	862.0	STREET	862.9	0.9		STREET
8920 Edgerton Rd	861	864.0	BUILDING	864.08	0.08		BUILDING
8908, 8920 Edgerton Rd	862	866.0	BUILDING	867.3	1.3		YARD, BUILDING
8908 Edgerton Rd	863.5	870.0	BUILDING	871.96	1.96	BUILDING	YARD, BUILDING
16219 Bennett Rd	884	886.0	YARD	886.66	0.66		YARD
Valley Pkwy	928	936.0	STREET	936.37	0.37		STREET
Ohio Turnpike	980.8	990.0	OTHER	982.47			
York Rd, Willow Lake Detention Basin	1143	1146.3	STREET	1145.6			

Table 3-2
Projected Flooding during the 5/22/04 Rain Event

Location	SWMM Node Invert Elevation (msl)	Minimum Flooding Elevation (msl)	Feature Flooded at Minimum Flooding Elevation	5/22/2004 Rain Event			
				Model Predicted HGL (msl)	Depth of Flooding (ft)	Feature(s) Reported Flooded	Features Model Predicted Flooded
Tributary 3.2							
York Rd, Bennett Rd int.	863	870.3	BUILDING	866.24			
15965 York Rd	866.4	872.0	YARD	872.95	1.0		YARD, BUILDING
15953 York Rd	870	872.6	YARD	873.82	1.24		YARD, BUILDING
15941 York Rd	875	876.0	YARD	876.91	0.91		YARD
16214 Bennett Rd	879	882.0	BARN	882.67	0.67	YARD, BARN	YARD, BARN
16212 Bennett Rd	883	885.8	BARN	886.55	0.71	YARD	YARD
15942 Bennett Rd	884.25	888.1	YARD	888.63	0.54	YARD	YARD
15930 Bennett Rd	885.5	889.0	YARD	889.93	0.93	YARD	YARD
15918 Bennett Rd	886	889.8	YARD	890.49	0.65	YARD	YARD, BUILDING
15906 Bennett Rd	892.5	895.5	YARD	893.74			
15838 Bennett Rd	894.1	897.1	YARD	897.42	0.32		YARD
Bennett Rd	901	904.0	STREET	902.64			
Valley Pkwy	919.67	925.5	SIDE SWALE	926.46	0.95	STREET	STREET
Ohio Turnpike	961.7	970.0	YARD	963.45			
7631 N. Akins Rd	1004	1008.0	BUILDING	1006.52			
Rocky River East Branch							
Waterbridge Dr	1126.1	1138.1	BUILDING	1133.34			
Edgerton Rd	1131	1140.0	BUILDING	1138.55			
Edgerton Rd	1131.42	1139.0	BUILDING	1140.69	1.69	GARAGE, BUILDING	GARAGE, BUILDING
Valley Pkwy	1141.75	1148.8	STREET	1149.02	0.27		STREET
Ohio Turnpike	1147.5	1159.2	STREET	1152.04			
N Akins Rd	1153.67	1160.0	STREET	1160.53	0.58	N/A	STREET, BUILDING
Trumpeter	1175.5	1185.5	STREET	1179.26			
State Rd	1176	1183.9	BUILDING	1182.59			

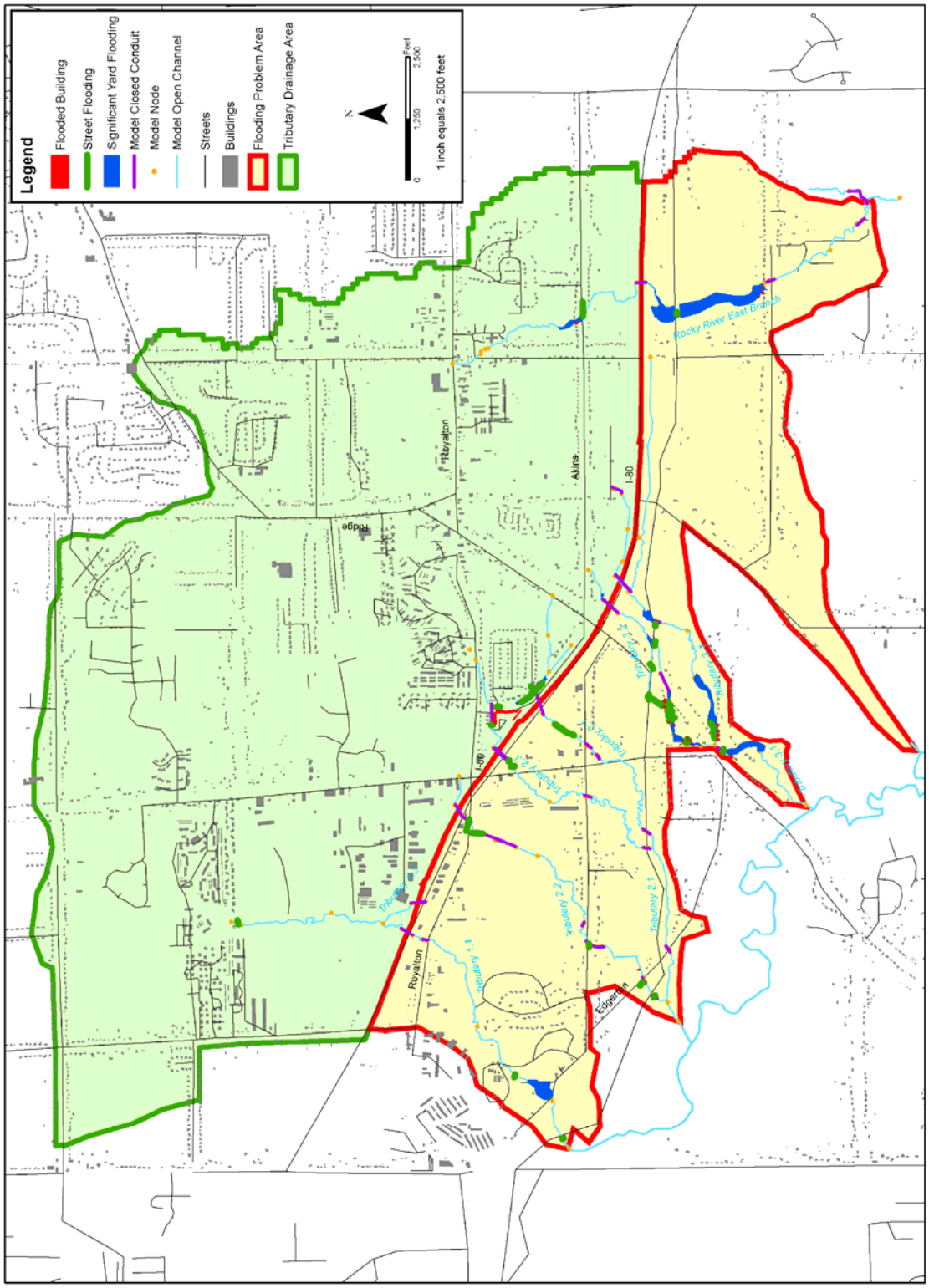


Figure 3-3. Flood Severity during the June 9, 2004 Rainfall Event

Table 3-3
Projected Flooding during the 6/9/04 Rain Event

Location	SWMM Node Invert Elevation (msl)	Minimum Flooding Elevation (msl)	Feature Flooded at Minimum Flooding Elevation	6/9/2004 Rain Event			
				Model Predicted HGL (msl)	Depth of Flooding (ft)	Feature(s) Reported Flooded	Features Model Predicted Flooded
Tributary 1.1							
Valley Pkwy	816.93	825.5	STREET	826.01	0.55		STREET
Edgerton Rd	817.08	826.0	YARD	828.15	2.15		YARD
Business Stream Crossing	820	827.7	STREET	830.54	2.89		STREET
Royalton Rd	841.62	868.4	STREET	849.07			
Ohio Turnpike	846	882.0	STREET	855.51			
Independence Dr	870	882.0	STREET	882.52	0.52		STREET
Tributary 1.2							
Ohio Turnpike	872.2	881.9	STREET	876.09			
Tributary 2.1							
Edgerton Road	834.1	843.1	STREET	836.34			
Valley Pkwy	847.1	854.1	STREET	853.54			
S. Akins Rd	872	884.9	STREET	881.81			
York Rd	894.12	898.9	STREET	900.21	1.34		STREET
Cuyahoga County access road	895.6	902.4	STREET	903.21	0.86		STREET
Ohio Turnpike	899	907.0	STREET	905.62			
Royal Park Condo	913.2	918.0	STREET, BUILDING	918.43	0.4		STREET, BUILDING
Royal Park Condo	914	920.0	BUILDING	916.62			
N. Akins Rd	921	927.6	STREET	928.39	0.8	BUILDING	STREET, BUILDING
Dover Lake Detention Basin	973.49	980.7	EMERGENCY SPILLWAY	980.25			
Tributary 2.2							
Valley Pkwy	827.1	834.1	STREET	834.78	0.68		STREET
Edgerton Rd	832.1	835.0	BUILDING	838.62	3.62		BUILDING, STREET
Private culvert (next to pond)	843	849.5	YARD	850.73	1.23		YARD
S. Akins Rd	844.1	851.5	STREET	852.14	0.66		STREET
Private Driveway	848.1	864.1	STREET	855.42			
Tri County Concrete Co	881	889.0	STREET	885.66			
Tri County Concrete Co	882	890.0	STREET	888.78			
Tri County Concrete Co	883	891.0	STREET	891.37	0.37		STREET
Royalton Rd	885.25	889.2	STREET	891.36	2.21		STREET
Ohio Turnpike	888.7	900.0	BUILDING	895.59			
Mom's Deli	898	904.7	STREET	898.01		STREET	

Table 3-3
Projected Flooding during the 6/9/04 Rain Event

Location	SWMM Node Invert Elevation (msl)	Minimum Flooding Elevation (msl)	Feature Flooded at Minimum Flooding Elevation	6/9/2004 Rain Event			
				Model Predicted HGL (msl)	Depth of Flooding (ft)	Feature(s) Reported Flooded	Features Model Predicted Flooded
Tributary 2.3							
Valley Pkwy	849.5	858.2	STREET	856.9			
York Rd	878.1	885.0	STREET	884.12			
House south of N. Akins Rd, East of York Rd	883.09	888.7	BUILDING	888.28			
S. Akins Rd	883.29	890.9	STREET	889.24			
Cuyahoga County access road	890.1	900.1	STREET	901.07	0.97		STREET
Junction chamber below N Akins Rd, S. Gateway Dr	910	922.0	STREET	919.63			
Inlet at Int. of N Akins Rd, S. Gateway Dr	912.85	922.6	STREET	924.17	1.57	STREET	STREET
N. Akins Rd	924	928.0	STREET	927.22			
Int. of N Akins Rd, S. Gateway Dr	918.5	922.9	STREET	924.16	1.23		STREET
N. Akins Rd	944	946.0	STREET	944.79			
Tributary 3.1							
16551 Bennett Rd	855.8	859.5	BUILDING	860.09	0.59	BARN	BARN, BUILDING
Edgerton Rd	856	862.0	STREET	863.08	1.08	STREET	STREET
8920 Edgerton Rd	861	864.0	BUILDING	864.27	0.27	BUILDING	BUILDING
8908, 8920 Edgerton Rd	862	866.0	BUILDING	867.29	1.29	YARD, BUILDING	YARD, BUILDING
8908 Edgerton Rd	863.5	870.0	BUILDING	871.98	1.98	YARD, BUILDING	YARD, BUILDING
16219 Bennett Rd	884	886.0	YARD	886.77	0.77	YARD	YARD
Valley Pkwy	928	936.0	STREET	936.49	0.49		STREET
Ohio Turnpike	980.8	990.0	OTHER	982.69			
York Rd, Willow Lake Detention Basin	1143	1146.3		1145.62			

Table 3-3
Projected Flooding during the 6/9/04 Rain Event

Location	SWMM Node Invert Elevation (msl)	Minimum Flooding Elevation (msl)	Feature Flooded at Minimum Flooding Elevation	6/9/2004 Rain Event			
				Model Predicted HGL (msl)	Depth of Flooding (ft)	Feature(s) Reported Flooded	Features Model Predicted Flooded
Tributary 3.2							
York Rd, Bennett Rd int.	863	870.3	BUILDING	866.84			
15965 York Rd	866.4	872.0	YARD	873.14	1.16	N/A	YARD, BUILDING
15953 York Rd	870	872.6	YARD	874.04	1.46		YARD, BUILDING
15941 York Rd	875	876.0	YARD	877.03	1.03		YARD
16214 Bennett Rd	879	882.0	BARN	883.14	1.14	YARD, BARN	YARD, BARN
16212 Bennett Rd	883	885.8	BARN	886.72	0.88	YARD	YARD
15942 Bennett Rd	884.25	888.1	YARD	888.84	0.75	YARD	YARD
15930 Bennett Rd	885.5	889.0	YARD	890.08	1.08	YARD	YARD
15918 Bennett Rd	886	889.8	YARD	890.66	0.82	YARD, BUILDING	YARD, BUILDING
15906 Bennett Rd	892.5	895.5	YARD	894.01			
15838 Bennett Rd	894.1	897.1	YARD	897.6	0.5	YARD	YARD
Bennett Rd	901	904.0	STREET	903			
Valley Pkwy	919.67	925.5	SIDE SWALE	926.6	1.09	STREET	STREET
Ohio Turnpike	961.7	970.0	YARD	963.73		YARD	YARD
7631 N. Akins Rd	1004	1008.0	BUILDING	1006.63		BUILDING	
Rocky River East Branch							
Waterbridge Dr	1126.1	1138.1	BUILDING	1132.93			
Edgerton Rd	1131	1140.0	BUILDING	1138.39			
Edgerton Rd	1131.42	1139.0	BUILDING	1140.41	1.41	GARAGE, BUILDING	GARAGE, BUILDING
Valley Pkwy	1141.75	1148.8	STREET	1149.07	0.32		STREET
Ohio Turnpike	1147.5	1159.2	STREET	1152.39			
N Akins Rd	1153.67	1160.0	STREET	1160.81	0.86	BUILDING	STREET, BUILDING
Trumpeter	1175.5	1185.5	STREET	1179.97			
State Rd	1176	1183.9	BUILDING	1183.62			

In general, peak flood stages during the June 9, 2004 event were somewhat more severe than flooding on May 22, falling between those projected during the 5-year, 24-hour design storm and the 25-year, 24-hour design storm.

3.4 Contribution of Ohio Turnpike 3rd Lane Expansion to Flooding

3.4.1 Methodology

CDM evaluated a series of design storm events to quantify the location and severity of flooding within the Ohio Turnpike 3rd Lane Expansion study area and tributary drainage area and the relative contribution of the Ohio Turnpike 3rd Lane expansion to this flooding. Three development scenarios were evaluated under these design rainfall events:

- ***Pre-3rd Lane expansion*** – We established a baseline condition representing hydrologic/hydraulic conditions during 1993 prior to the 3rd lane expansion of the Ohio Turnpike.

- ***Post-3rd Lane Expansion with 1993 Development*** – In order to isolate the impact of Ohio Turnpike expansion from the impact of other development in the City, we developed a hypothetical scenario consisting of post-3rd lane conditions along the Ohio Turnpike right of way overlain onto 1993 development conditions within the remainder of the City.

- ***Post-3rd Lane expansion*** – We depicted land cover based upon 2002 aerial photographs and design drawings from the 3rd lane expansion of the Ohio Turnpike to represent conditions during the 2004 flood events.

- Hydrologic/hydraulic evaluation of the existing drainage system under each of these scenarios was conducted to determine the degree that runoff from the Ohio Turnpike 3rd lane caused increased peak flood elevations during the various design storms.

3.4.2 Hydrologic/Hydraulic Evaluation

Table 3-4 lists projected peak flood stages and flooding during the 1-year, 2-year, 5-year, and 25-year design storms under the three land cover scenarios listed above. **Figure 3-4** identifies the location of projected street and building during the 25-year design storm, the level of service performance standard recommended in Section 3.3. Significant flooding is projected during the 25-year design storm at the same locations that flooded during the June 9 event. In addition, Tributary 2.1 is projected to flood Valley Parkway and South Akins Road during the 25-year design storm. Approximately 36 street locations and 22 buildings flood during the 25-year design storm. Most of these flooding problems are projected to occur under 1993 land cover conditions prior to the 3rd lane expansion, with flooding becoming more severe and more frequent under current land cover conditions in a few locations (e.g., Tributaries 1.1, 2.3, and 3.1).

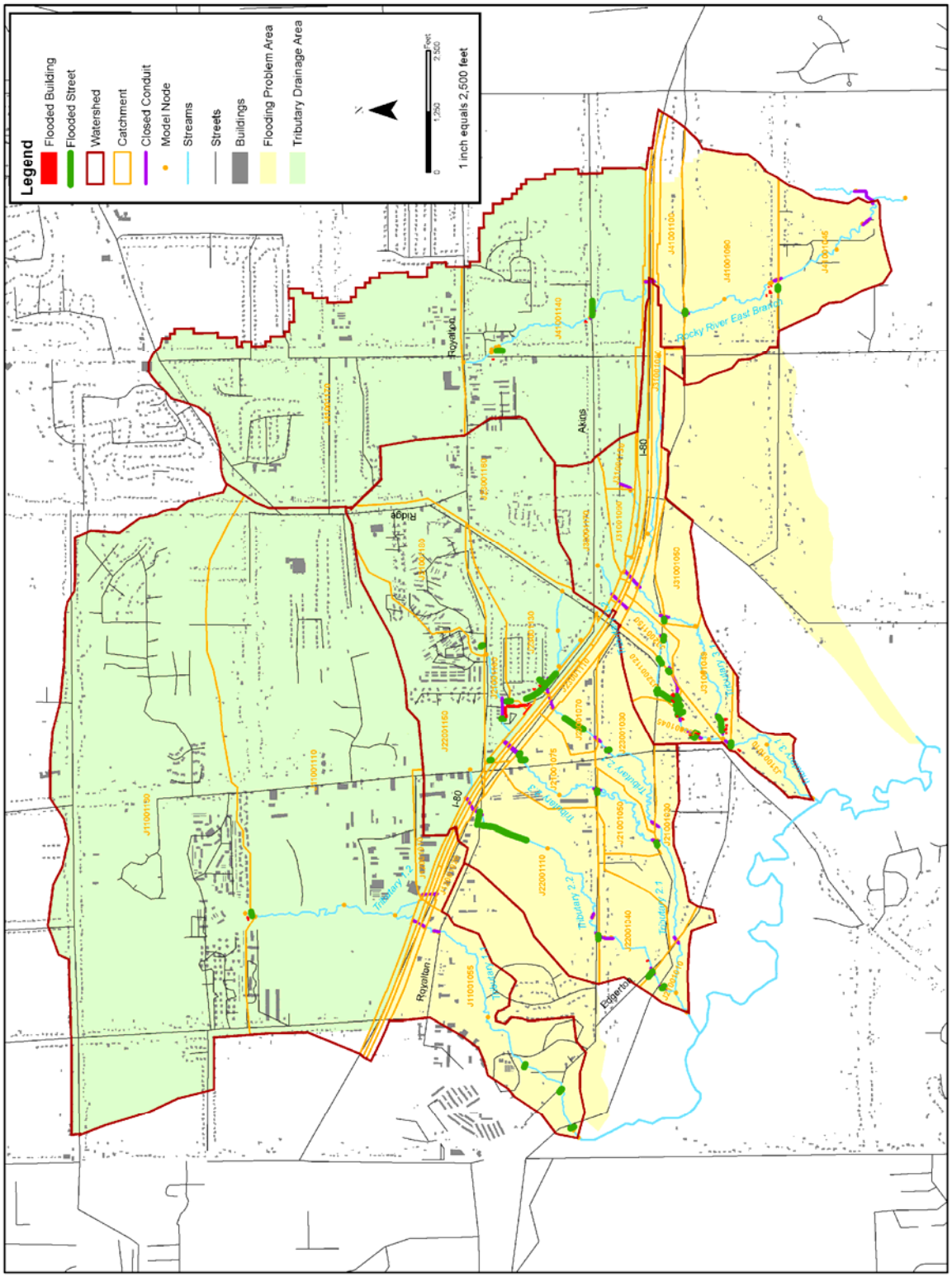


Figure 3-4. Flood Severity during the 25-year, 24-hour Design Storm Event

Table 3-4
Comparison of Flooding under Alternative Land Cover Scenarios

SWMM ID	Location	SWMM Node Invert Elevation (msl)	Minimum Flooding Elevation (msl)	Feature Flooded at Minimum Flooding Elevation	1-year, 24-hour Design Storm						2-year, 24-hour Design Storm						5-year, 24-hour Design Storm						25-year, 24-hour Design Storm					
					1993 Conditions		1993 Conditions with 3rd Lane		2002 Conditions		1993 Conditions		1993 Conditions with 3rd Lane		2002 Conditions		1993 Conditions		1993 Conditions with 3rd Lane		2002 Conditions		1993 Conditions		1993 Conditions with 3rd Lane		2002 Conditions	
					HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)
Tributary 1.1																												
J11001020	Valley Pkwy	816.93	825.5	STREET	821.4		821.4		823.4		822.5		822.5		824.5		823.7		823.8		825.7	0.2	826.0	0.5	826.0	0.5	827.3	1.8
J11001050	Edgerton Rd	817.08	826.0	YARD	823.4		823.4		825.4		824.4		824.5		826.5	0.5	825.7		825.7		827.7	1.7	828.1	2.1	828.1	2.1	829.9	3.9
J11001053	Business Stream Crossing	820	827.7	STREET	828.6	1.0	828.6	1.0	829.5	1.9	829.1	1.4	829.1	1.4	830.0	2.3	829.7	2.0	829.7	2.0	830.4	2.7	830.5	2.9	830.5	2.9	831.3	3.7
J11001070	Royalton Rd	841.62	868.4	STREET	846.0		846.0		847.3		846.8		846.8		848.0		847.6		847.6		848.8		848.9		848.9		850.9	
J11001090	Ohio Turnpike	846	882.0	STREET	851.0		851.0		852.8		852.0		852.0		853.8		853.1		853.1		855.0		855.2		855.3		858.5	
J11001130	Independence Dr	870	882.0	STREET	875.6		875.6		878.7		876.8		876.8		880.3		878.6		878.6		882.1	0.1	881.6		881.6		884.1	2.1
Tributary 1.2																												
J12001020	Ohio Turnpike	872.2	881.9	STREET	874.1		874.2		874.3		874.5		874.7		874.9		876.0		876.5		876.9		880.2		881.0		881.6	
Tributary 2.1																												
J21001030	Edgerton Road	834.1	843.1	STREET	834.0		834.0		834.4		835.0		835.0		835.3		835.9		835.9		836.2		837.8		837.8		838.0	
J21001050	Valley Pkwy	847.1	854.1	STREET	850.8		850.8		851.0		851.9		852.0		852.1		853.4		853.4		853.6		855.7	1.6	855.7	1.6	855.8	1.7
J21001070	S. Akins Rd	872	884.9	STREET	875.6		875.7		875.7		877.6		877.7		877.7		882.0		882.0		882.1		885.7	0.8	885.7	0.8	885.7	0.8
J21001090	York Rd	894.12	898.9	STREET	899.3	0.5	899.3	0.5	899.3	0.5	899.7	0.8	899.7	0.8	899.7	0.8	900.2	1.3	900.2	1.3	900.2	1.3	900.8	1.9	900.8	1.9	900.8	1.9
J21001105	Cuyahoga County access road	895.6	902.4	STREET	900.9		901.0		901.0		901.8		901.8		901.9		903.2	0.8	903.2	0.9	903.2	0.9	903.8	1.4	903.8	1.4	903.8	1.4
J21001120	Ohio Turnpike	899	907.0	STREET	901.9		901.9		901.9		902.9		902.9		902.9		905.5		905.5		905.5		910.5	3.5	910.5	3.5	910.5	3.5
J21001140	Royal Park Condo	913.2	918.0	STREET, BUILDING	915.3		915.3		915.3		916.1		916.1		916.1		918.3	0.3	918.3	0.3	918.3	0.3	919.7	1.7	919.7	1.7	919.7	1.7
J21001150	Royal Park Condo	914	920.0	BUILDING	915.0		915.0		915.0		915.5		915.5		915.5		916.5		916.5		916.5		918.3		918.3		918.3	
J21001160	N. Akins Rd	921	927.6	STREET	925.2		925.2		925.2		927.9	0.3	927.9	0.3	927.9	0.3	928.4	0.8	928.4	0.8	928.4	0.8	929.0	1.4	929.0	1.4	929.0	1.4
J21001180	Dover Lake Detention Basin	973.49	980.7	EMERGENCY SPILLWAY	979.1		979.1		979.1		979.6		979.6		979.6		980.2		980.2		980.2		981.0	0.4	981.0	0.4	981.0	0.4
Tributary 2.2																												
J22001020	Valley Pkwy	827.1	834.1	STREET	830.9		830.9		831.5		832.1		832.1		832.7		833.4		833.5		834.2	0.1	835.6	1.5	835.7	1.5	835.8	1.7
J22001040	Edgerton Rd	832.1	835.0	BUILDING	835.1	0.1	835.1	0.1	835.6	0.6	835.9	0.9	835.9	0.9	836.7	1.6	837.0	2.0	837.1	2.0	837.8	2.8	839.0	4.0	839.0	4.0	839.2	4.2
J22001060	Private culvert (next to pond)	843	849.5	YARD	848.3		848.3		849.8	0.3	849.9	0.4	849.9	0.4	850.2	0.7	850.2	0.7	850.2	0.7	850.5	1.0	850.8	1.3	850.8	1.3	851.0	1.5
J22001080	S. Akins Rd	844.1	851.5	STREET	848.5		848.5		850.1		850.3		850.3		850.8		850.9		850.9		851.5	0.0	852.3	0.9	852.4	0.9	852.6	1.1
J22001100	Private Driveway	848.1	864.1	STREET	851.6		851.6		852.2		852.3		852.3		853.0		853.1		853.1		853.9		856.2		856.3		857.4	
J22001120	Tri County Concrete Co	881	889.0	STREET	884.7		884.7		885.0		885.2		885.3		885.4		885.7		885.8		886.2		889.7	0.7	889.7	0.7	889.7	0.7

Table 3-4
Comparison of Flooding under Alternative Land Cover Scenarios

					1-year, 24-hour Design Storm						2-year, 24-hour Design Storm						5-year, 24-hour Design Storm						25-year, 24-hour Design Storm					
					1993 Conditions		1993 Conditions with 3rd Lane		2002 Conditions		1993 Conditions		1993 Conditions with 3rd Lane		2002 Conditions		1993 Conditions		1993 Conditions with 3rd Lane		2002 Conditions		1993 Conditions		1993 Conditions with 3rd Lane		2002 Conditions	
SWMM ID	**Location**	**SWMM Node Invert Elevation (msl)**	**Minimum Flooding Elevation (msl)**	**Feature Flooded at Minimum Flooding Elevation**	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)
J22001122	Tri County Concrete Co	882	890.0	STREET	886.6		886.6		887.0		887.6		887.7		888.0		889.1		889.3		890.3	0.3	891.7	1.7	891.7	1.7	891.8	1.8
J22001124	Tri County Concrete Co	883	891.0	STREET	887.9		888.0		888.7		889.8		889.8		890.5		891.5	0.5	891.6	0.6	891.9	0.9	892.6	1.6	892.6	1.6	892.6	1.6
J22001130	Royalton Rd	885.25	889.2	STREET	889.5	0.3	889.5	0.4	889.6	0.5	889.8	0.6	889.9	0.7	890.5	1.3	891.5	2.3	891.6	2.4	891.9	2.8	892.8	3.6	892.8	3.6	892.8	3.7
J22001150	Ohio Turnpike	888.7	900.0	BUILDING	893.4		893.4		893.8		894.3		894.4		895.0		896.3		896.4		897.0		898.3		898.4		898.6	
J22001160	Mom's Deli	898	904.7	STREET	899.9		899.9		900.0		900.2		900.2		900.3		900.6		900.6		900.7		901.3		901.3		901.5	
Tributary 2.3																												
J23001020	Valley Pkwy	849.5	858.2	STREET	853.9		854.0		854.7		854.8		854.9		855.6		855.8		855.8		856.4		857.3		857.3		858.0	
J23001040	York Rd	878.1	885.0	STREET	881.4		881.4		881.9		881.9		882.0		882.9		883.0		883.0		883.7		884.4		884.4		885.2	0.2
J23001050	House south of N. Akins Rd, East of York Rd	883.09	888.7	BUILDING	886.6		886.6		886.9		886.9		886.9		887.6		887.7		887.7		888.1		888.4		888.4		888.7	0.0
J23001060	S. Akins Rd	883.29	890.9	STREET	886.9		886.9		887.3		887.3		887.3		888.2		888.3		888.3		888.9		889.5		889.5		890.0	
J23001100	Cuyahoga County access road	890.1	900.1	STREET	894.9		895.0		897.9		897.5		897.6		900.7	0.5	900.6	0.5	900.7	0.6	901.0	0.9	901.2	1.1	901.2	1.1	901.4	1.3
J23001120	Junction chamber below N Akins Rd, S. Gateway Dr	910	922.0	STREET	914.0		914.1		915.3		915.1		915.1		917.2		917.2		917.2		918.7		920.2		920.2		923.4	1.4
J23001130	Inlet at Int. of N Akins Rd, S. Gateway Dr	912.85	922.6	STREET	918.1		918.2		920.0		919.7		919.8		921.5		921.5		921.5		923.3	0.7	924.6	2.0	924.7	2.0	927.0	4.4
J23001140	N. Akins Rd	924	928.0	STREET	925.6		925.6		926.1		925.9		925.9		926.5		926.3		926.3		926.9		927.1		927.1		927.8	
J23101010	Int. of N Akins Rd, S. Gateway Dr	918.5	922.9	STREET	918.5		918.5		918.5		918.5		918.5		918.5		918.5		918.5		922.5		924.6	1.7	924.6	1.7	927.0	4.1
J23201010	N. Akins Rd	944	946.0	STREET	944.5		944.5		944.6		944.6		944.6		944.7		944.7		944.8		944.8		944.9		945.0		945.0	
Tributary 3.1																												
J31001020	16551 Bennett Rd	855.8	859.5	BUILDING	858.6		858.6		858.7		859.0		859.1		859.2		859.8	0.3	859.8	0.3	860.1	0.6	861.1	1.6	861.2	1.7	861.4	1.9
J31001030	Edgerton Rd	856	862.0	STREET	859.7		859.8		860.0		861.2		861.3		861.7		862.8	0.8	862.9	0.9	863.1	1.1	864.1	2.0	864.1	2.1	864.3	2.3
J31001040	8920 Edgerton Rd	861	864.0	BUILDING	862.9		863.0		863.0		863.4		863.4		863.5		864.0	0.0	864.1	0.0	864.3	0.3	865.6	1.6	865.7	1.7	866.0	2.0
J31001045	8908, 8920 Edgerton Rd	862	866.0	BUILDING	865.2		865.2		865.3		865.7		865.8		865.9		866.5	0.5	866.7	0.7	867.4	1.4	869.7	3.7	869.8	3.8	871.2	5.2
J31001047	8908 Edgerton Rd	863.5	870.0	BUILDING	867.8		867.9		868.3		869.9		870.1	0.1	870.5	0.5	871.3	1.3	871.5	1.5	872.1	2.1	873.5	3.5	873.6	3.6	873.8	3.8
J31001049	16219 Bennett Rd	884	886.0	YARD	885.6		885.6		885.6		885.9		886.0		886.0	0.0	886.4	0.4	886.4	0.4	886.9	0.9	888.3	2.3	888.4	2.4	888.7	2.7
J31001070	Valley Pkwy	928	936.0	STREET	932.2		932.6		932.9		934.0		934.3		935.0		936.2	0.2	936.3	0.3	936.5	0.5	937.0	1.0	937.0	1.0	937.2	1.2
J31001090	Ohio Turnpike	980.8	990.0	OTHER	981.9		981.9		981.9		982.1		982.1		982.2		982.4		982.4		982.6		982.9		982.9		983.4	
J31001130	York Rd, Willow Lake Detention Basin	1143	1146.3	STREET	1144.2		1144.2		1145.0		1144.8		1144.8		1145.3		1145.0		1145.0		1145.6		1145.4		1145.4		1145.9	

Table 3-4
Comparison of Flooding under Alternative Land Cover Scenarios

SWMM ID	Location	SWMM Node Invert Elevation (msl)	Minimum Flooding Elevation (msl)	Feature Flooded at Minimum Flooding Elevation	1-year, 24-hour Design Storm						2-year, 24-hour Design Storm						5-year, 24-hour Design Storm						25-year, 24-hour Design Storm					
					1993 Conditions		1993 Conditions with 3rd Lane		2002 Conditions		1993 Conditions		1993 Conditions with 3rd Lane		2002 Conditions		1993 Conditions		1993 Conditions with 3rd Lane		2002 Conditions		1993 Conditions		1993 Conditions with 3rd Lane		2002 Conditions	
					HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)	HGL (msl)	Depth of Flooding (ft)
Tributary 3.2																												
J32001010	York Rd, Bennett Rd int.	863	870.3	BUILDING	864.3		864.3		864.4		864.9		865.0		865.2		866.5		866.6		866.7		869.3		869.4		869.3	
J32001030	15965 York Rd	866.4	872.0	YARD	870.3		870.4		871.0		872.4	0.5	872.5	0.5	872.6	0.6	873.0	1.0	873.1	1.1	873.1	1.1	874.1	2.1	874.1	2.2	874.2	2.2
J32001040	15953 York Rd	870	872.6	YARD	872.6	0.0	872.6	0.1	872.8	0.2	873.2	0.6	873.3	0.7	873.4	0.8	873.9	1.3	873.9	1.3	874.0	1.4	875.0	2.4	875.0	2.4	875.0	2.4
J32001045	15941 York Rd	875	876.0	YARD	876.4	0.4	876.4	0.4	876.5	0.5	876.6	0.6	876.6	0.6	876.7	0.7	877.0	1.0	877.0	1.0	877.0	1.0	877.5	1.5	877.5	1.5	877.5	1.5
J32001050	16214 Bennett Rd	879	882.0	BARN	881.2		881.2		881.3		881.8		881.9		882.0		882.9	0.9	882.9	0.9	883.0	1.0	884.8	2.8	884.9	2.9	884.9	2.9
J32001060	16212 Bennett Rd	883	885.8	BARN	885.6		885.6		885.8		886.3	0.4	886.3	0.5	886.4	0.5	886.6	0.8	886.6	0.8	886.7	0.8	887.0	1.2	887.1	1.2	887.1	1.2
J32001080	15942 Bennett Rd	884.25	888.1	YARD	887.8		887.8		887.8		888.0		888.0		888.2	0.1	888.7	0.6	888.7	0.6	888.8	0.7	889.3	1.2	889.3	1.3	889.4	1.3
J32001100	15930 Bennett Rd	885.5	889.0	YARD	889.4	0.4	889.4	0.4	889.5	0.5	889.7	0.7	889.7	0.7	889.7	0.7	890.0	1.0	890.0	1.0	890.0	1.0	890.5	1.5	890.5	1.5	890.5	1.5
J32001115	15918 Bennett Rd	886	889.8	YARD	889.6		889.7		889.7		890.1	0.3	890.1	0.3	890.2	0.4	890.6	0.7	890.6	0.7	890.6	0.8	891.2	1.3	891.2	1.3	891.2	1.3
J32001123	15906 Bennett Rd	892.5	895.5	YARD	893.3		893.3		893.3		893.4		893.4		893.4		893.8		893.8		893.9		896.0	0.5	896.0	0.5	896.1	0.5
J32001126	15838 Bennett Rd	894.1	897.1	YARD	896.3		896.3		896.3		896.5		896.6		896.6		897.5	0.4	897.5	0.4	897.5	0.4	897.9	0.8	897.9	0.8	897.9	0.8
J32001130	Bennett Rd	901	904.0	STREET	902.0		902.1		902.1		902.2		902.2		902.2		902.7		902.8		902.8		904.8	0.8	904.8	0.8	904.8	0.8
J32001150	Valley Pkwy	919.67	925.5	SIDE SWALE	925.0		925.2		925.4		926.1	0.6	926.1	0.6	926.2	0.6	926.5	1.0	926.5	1.0	926.5	1.0	926.9	1.4	926.9	1.4	926.9	1.4
J32001170	Ohio Turnpike	961.7	970.0	YARD	963.0		963.0		963.0		963.2		963.3		963.3		963.7		963.7		963.7		965.2		965.3		965.3	
J32001180	7631 N. Akins Rd	1004	1008.0	BUILDING	1005.6		1005.6		1005.6		1006.0		1006.0		1006.0		1006.5		1006.5		1006.5		1007.2		1007.2		1007.2	
Rocky River East Branch																												
J41001040	Waterbridge Dr	1126.1	1138.1	BUILDING	1130.2		1130.2		1130.6		1131.1		1131.1		1131.6		1132.3		1132.3		1132.7		1134.7		1134.7		1135.2	
J41001060	Edgerton Rd	1131	1140.0	BUILDING	1135.6		1135.6		1136.0		1136.4		1136.4		1136.8		1137.5		1137.5		1138.0		1140.1	0.1	1140.1	0.1	1140.7	0.7
J41001080	Edgerton Rd	1131.42	1139.0	BUILDING	1136.6		1136.6		1137.1		1137.7		1137.7		1138.3		1139.2	0.2	1139.2	0.2	1139.8	0.8	1142.1	3.0	1142.0	3.0	1142.5	3.5
J41001100	Valley Pkwy	1141.75	1148.8	STREET	1145.4		1145.4		1145.8		1146.1		1146.1		1146.7		1147.4		1147.3		1148.0		1150.2	1.4	1150.2	1.4	1150.6	1.9
J41001120	Ohio Turnpike	1147.5	1159.2	STREET	1149.8		1149.8		1150.1		1150.3		1150.3		1150.7		1151.2		1151.2		1151.6		1153.4		1153.4		1154.0	
J41001140	N Akins Rd	1153.67	1160.0	STREET	1158.1		1158.1		1158.6		1158.9		1158.9		1159.4		1159.8		1159.8		1160.3	0.3	1161.1	1.1	1161.1	1.1	1161.2	1.3
J41001153	Trumpeter	1175.5	1185.5	STREET	1178.0		1178.0		1178.2		1178.4		1178.4		1178.6		1179.0		1179.0		1179.2		1180.2		1180.2		1180.6	
J41001160	State Rd	1176	1183.9	BUILDING	1180.9		1180.9		1181.2		1181.5		1181.5		1181.9		1182.3		1182.3		1182.7		1184.0	0.1	1184.0	0.1	1184.5	0.6

The design storm evaluations summarized in Table 3-4 illustrate how changes in land cover since 1993 have affected peak water surface elevations, especially changes that are attributable to the Ohio Turnpike 3rd Lane expansion. Comparisons of "1993 Conditions" and "1993 Conditions with 3rd Lane" isolate the effect of the Ohio Turnpike 3rd Lane Expansion. This comparison indicates that the Ohio Turnpike 3rd Lane Expansion generally causes increases in peak flood elevations of approximately 0.1 foot or less. The entire peak water surface elevation along Tributary 3.1 increases by about 0.1 foot. Elsewhere, only a few isolated peak flood stage increases are attributable to the Ohio Turnpike 3rd Lane Expansion.

Stream erosion was identified visually during field reconnaissance surveys and/or reported on resident questionnaires. Hydraulic modeling to date indicates that flows may have increased between 1993 and 2002, particularly during the 1-year and 2-year design storms which are most closely associated with producing channel-forming velocities.

3.4.3 Conclusions

The hydrologic/ hydraulic evaluation of the drainage system within the Ohio Turnpike 3rd Lane Expansion study area has determined the frequency and severity of flooding problems, indicating that most of these problems existed under 1993 land cover conditions. With a few isolated exceptions, flood severity has not increased significantly, either as a result of the Ohio Turnpike 3rd Lane expansion or as a result of development within the City of North Royalton. The area most significantly affected by the Ohio Turnpike 3rd Lane Expansion is Tributary 3.1, where flood stages are projected to increase by about 0.1 feet throughout its reach. Flooding along Tributary 3 appears related to several factors:

- Miscellaneous drainage improvements on private property that do not have adequate capacity to convey peak flows during the 25-year design storm.
- Encroachment into the floodplain of Tributaries 3.1 and 3.2.
- Increased flows from the Ohio Turnpike 3rd Lane Expansion, resulting in slight increases in peak water surface elevations, but at sustained flow rates that appear to be causing significant stream erosion near Turnpike drainage outfalls.
- Siltation of culverts under Valley Parkway, causing excess flows to be conveyed west along Valley Parkway, adding to flooding caused by private property drainage improvements.
- Increased runoff volume from development north of the Ohio Turnpike.

Section 4 presents flood control alternatives for Tributary 3, the only portion of the drainage system where flooding is significantly affected by runoff from the Ohio Turnpike 3rd Lane Expansion. Alternative solutions to other flooding and erosion

problems revealed during this study will require further evaluation under a future work assignment.

Section 4
Alternative Development and Evaluation

The previous section identified problems within the scope of the Ohio Turnpike 3rd Lane Expansion study, and concluded that only problems along Tributary 3 are significantly affected by the additional runoff from the 3rd lane. This section presents the development and evaluation of alternative drainage improvements to relieve these problems, including the following information:

- Baseline measures common to all alternatives that maintain the capacity of the existing drainage system, including operation and maintenance measures that reduce drainage obstructions, preserve existing floodplains, provide detention for future development, and frame recommendations for solving local drainage problems.

- A description and evaluation of drainage improvement alternatives, including an evaluation of the cost-effectiveness of each alternative.

4.1 Baseline Measures to Maintain Existing Drainage System Capacity

Before structural alternatives were evaluated, CDM investigated three types of measures to maintain and preserve the existing drainage system capacity:

- Remove drainage system obstructions (Section 4.1.1)

- Preserve existing floodplains (Section 4.1.2)

- Control increased runoff from future development (Section 4.1.3)

This section presents the rationale for these measures and summarizes their effectiveness.

4.1.1 Remove Drainage System Obstructions

The first step toward relieving drainage problems is to remove drainage system obstructions. During field reconnaissance, CDM identified localized obstructions that significantly restrict conveyance capacity, such as:

- Large deposits of sediment

- Large buildup of debris

- Vegetative growth

Hydrologic/hydraulic evaluation quantified the effectiveness of a routine maintenance program that would remove debris/sediment and control vegetation. First, sediment and debris buildup within closed conduits were "removed" from the hydraulic model representing the drainage system. Next, vegetation control was

represented by reducing channel roughness to a value reflective of a well-maintained natural stream with a healthy stream habitat. This level of maintenance is considered routine and should not require a U.S. Army Corps of Engineers (USACE) Section 404 permit or trigger a Section 401 Water Quality Certification review by OEPA.

4.1.2 Preserve Existing Floodplains

The Ohio Turnpike 3rd Lane Expansion Evaluation only considers flooding to be a problem where buildings or roadways are inundated during specific design storm events. In many locations within the watershed, however, flooding occurs on property adjacent to streams and other open channels. In general, development has encroached upon floodplains, particularly small headwater streams. Therefore, the Ohio Turnpike 3rd Lane Expansion Evaluation recommends preserving remaining floodplains to retain natural flood storage properties, significantly reducing the capital costs of drainage improvements elsewhere in the watershed. This approach is consistent with current City policies and ordinances.

4.1.3 Control Increased Runoff from Future Development

The next step in the evaluation was to control potential increases in flooding attributable to future development. The City of North Royalton has a policy that requires detention storage for the critical storm event, with a release rate equal to the peak flow of the 1-year predevelopment design storm. Construction of detention basins for new development according to the City's detention storage policy will control runoff from future development by not allowing runoff to increase. Future determination is not projected to solve any of the existing problems discussed within this report.

4.2 Development of Alternatives to Resolve Drainage Problems

The Ohio Turnpike 3rd Lane Expansion Evaluation examined four distinct approaches for resolving flooding problems:

- ***Conveyance improvements (Alternative A)*** are structural measures that control flooding by moving runoff away from buildings and roadways, such as widening channels and constructing new drainage infrastructure (e.g., culverts, bridges, or storm sewers).

- ***Storage/detention improvements (Alternative B)*** are structural measures that control flooding by holding runoff back in facilities such as excavated detention basins, impoundment dams across watercourses, and hydrobrakes in storm drain inlets that promote ponding along local streets.

- ***Floodplain management (Alternative C)*** consists of structural and non-structural measures that separate buildings and roadways from flooding, such as floodplain preservation, flood prevention with berms and walls, and the purchase of flood-prone properties.

- ***Combination improvements (Alternative D)*** are a logical, cost-effective set of the previous three types of options for the watershed.

Each alternative consists of a set of improvement options that were located and sized to resolve the flooding problems described in Section 3.4 unless the alternative is not feasible or cannot physically solve the problem. Each alternative described in the following sections (e.g. Alternative A, B, C, or D) describe a comprehensive approach to resolving the drainage problems in the watershed. A preferred alternative is selected based upon the evaluation presented in Section 4.3.

Design and construction cost estimates for drainage improvement options were developed from numerous sources, including:

- Ohio Department of Transportation (ODOT) Year 2000 Cost Summary
- ODOT Office of Estimating Report (1996)
- Historical NEORSD studies, reports, designs, and construction projects
- 2002 RS Means Cost Estimating Manual
- National Menu of Best Management Practices (USEPA)
- "Cost Estimating Guidelines: Best Management Practices and Engineering Controls," Rouge River National Wet Weather Demonstration Project, 1999, Wayne County, Michigan
- Previous CDM studies, designs, and bid tabulations
- Community bid tabulations
- Cuyahoga County Auditor

The unit costs for capital improvements were increased by 40 percent to account for design, bidding, surveying, geotechnical, legal fees, construction inspection, and contingencies and to account for unknown factors or conditions. Unit costs were further increased by 7 percent to account for City project management costs. These unit costs were further adjusted for inflation because they are relative to 2002 dollars. **Appendix B** contains a detailed set of unit costs used for this study.

4.2.1 Alternative A: Conveyance Improvements

The first approach to resolving drainage problems in the Ohio Turnpike 3rd Lane Expansion flooding problem area is one based primarily on conveyance improvements. Conveyance improvements are often considered the best option when flooding is caused by a localized constriction within the drainage system. These improvements are typically designed to increase the existing conveyance capacity, allowing the water to move more quickly or efficiently downstream away from the

flooded area. While generally improving flooding conditions upstream, an evaluation of conveyance improvements must consider the potential increase of flooding conditions downstream.

4.2.1.1 Description of Improvement Options

Conveyance improvement options evaluated for the Ohio Turnpike 3rd Lane Expansion Evaluation include a variety of conduit types:

- ***Closed Conduits*** can be organized under two categories:
  - ***Storm Sewers –*** typically include manholes and inlets that collect surface runoff and convey it to a stream or open channel.
  - ***Stream Crossings –*** road culverts and bridges that allow a stream to flow under a roadway or other embankment. Culverts include standard-sized circular, elliptical, and rectangular concrete reinforced pipe materials. Bridges maintain an open cross-section across the width of the channel and often preserve the natural channel bottom.
- ***Open channels*** are rivers, streams, canals, ditches, streets, and swales. The Ohio Turnpike 3rd Lane Expansion Evaluation studied two types of open channel improvements:
  - Channel widening, regrading, and/or lining to a hydraulically efficient cross-section (e.g., trapezoidal) in locations where space is limited
  - Channel widening or regrading to a two-stage naturalized stream (i.e., compound cross-section shape) in locations where space is available
- ***Flow reduction control removal*** involves the elimination of restrictive devices and structures (e.g., orifice plates, gates, and weirs).

The acquisition of easements for construction and maintenance associated with conveyance improvements was also included when parallel conduits were added or where new alignments were proposed.

4.2.1.2 Alternative Development

Figure 4-1 and **Table 4-1** show conveyance alternatives proposed to resolve flooding problems along Tributary 3 within the flooding problem area. The following conveyance improvements were developed for the Ohio Turnpike 3rd Lane Expansion flooding problem area:

- Replacement of the two Valley Parkway culverts (Alternatives A-1 and A-4), which do not have adequate hydraulic capacity to convey peak flows during the 25-year design storm, even if sediment clogging these culverts is removed.

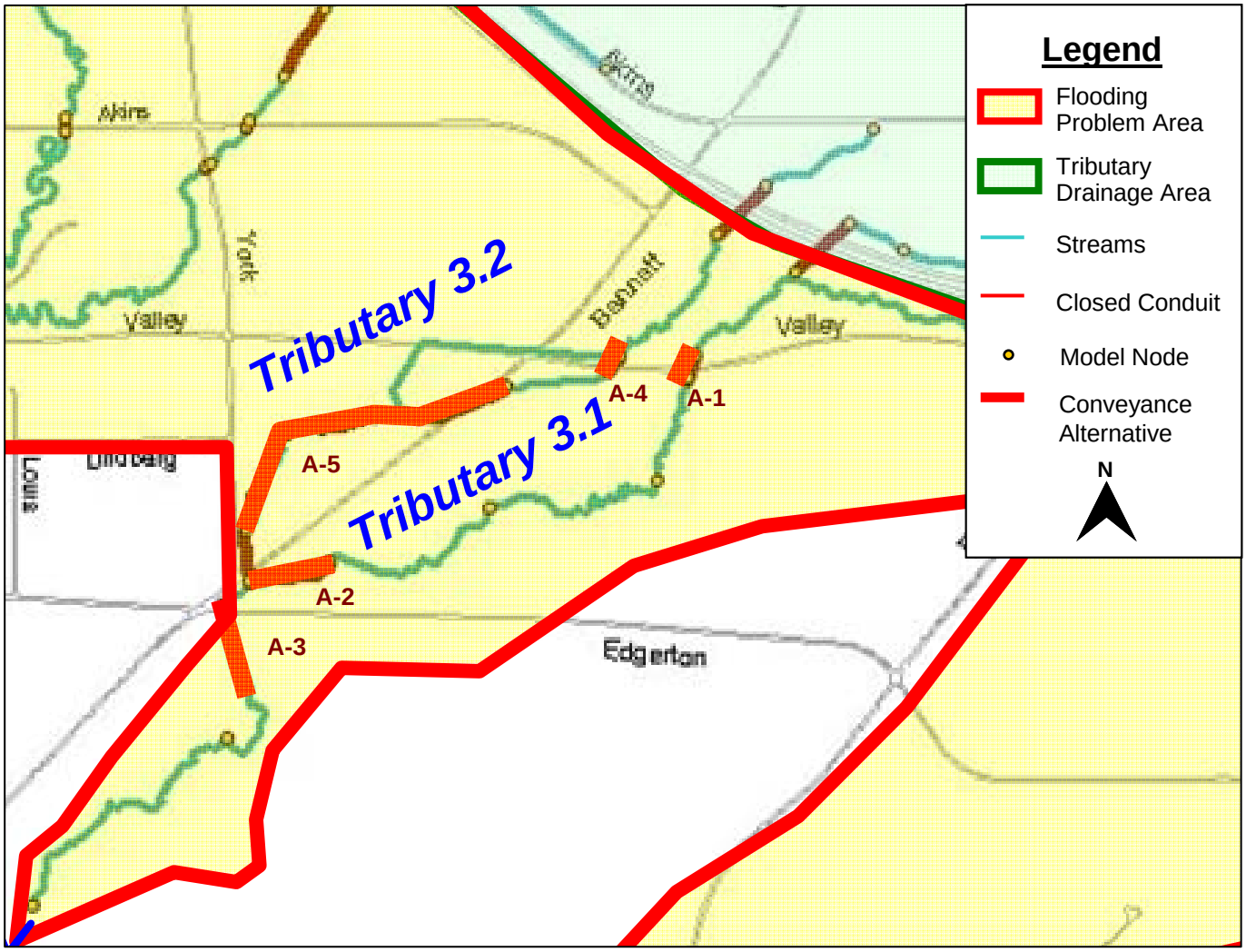


Figure 4-1. Location of Improvement Options on Tributary 3 for Conveyance Alternative.

Table 4-1. Estimated Capital Cost of Improvement Options under Alternative A: Conveyance

Improvement ID	SWMMID	Location	Improvement Option	Unit	Unit Cost	Quantity	Total Cost
A-1	T31001070	Valley Parkway	7-ft RCP Culvert Replacement	LIN FT	$1,174	139	$163,246
A-2	T31001047	8908 Edgerton Road	8-ft Deep Channel Widening	LIN FT	$629	324	$203,848
	T31001045	8920 Edgerton Road	Reinforced Concrete Demolition and Disposal	CU FT	$50	2,675	$134,640
	T31001045	8920 Edgerton Road	8-ft Deep Channel Widening	LIN FT	$629	107	$67,320
	T31001030	Intersection of Edgerton Road; Bennett Road	(2) 5x12-ft Culverts	LIN FT	$3,230	100	$322,969
A-3	T31001020	Channel just downstream of Edgerton Road Culvert	4-ft Deep Channel Widening	LIN FT	$314	1,117	$350,449
A-4	T32001150	Valley Parkway	5.5-ft RCP Parallel Culvert Installation	LIN FT	$1,846	93	$171,635
A-5	T32001130 - T32001120	Culvert along Bennett Road	3-ft x 8-ft	LIN FT	$1,846	609	$1,123,931
	T32001120	Channel from Bennett Rd Culvert outlet to 15918 Bennett Rd Driveway Culvert	4-ft Deep Channel Widening	LIN FT	$314	96	$30,119
	T32001115	DRIVEWAY CULVERT AT 15918 BENNETT RD	3x10-ft Culvert Replacement	LIN FT	$1,846	16	$29,529
	T32001110	Channel from 15918 Bennett Rd Driveway Culvert to 15930 Bennett Rd Driveway Culvert	4-ft Deep Channel Widening	LIN FT	$314	49	$15,373
	T32001100	DRIVEWAY CULVERT BEHIND 15930 BENNET RD	3x10-ft Culvert Replacement	LIN FT	$1,846	32	$59,057
	T32001090	Channel from 15930 Bennett Rd Driveway Culvert to 15942 Bennett Rd Driveway Culvert	4-ft Deep Channel Widening	LIN FT	$314	52	$16,315
	T32001080	DRIVEWAY CULVERT BEHIND 15942 BENNET RD	3x10-ft Culvert Replacement	LIN FT	$1,846	17	$31,374
	T32001070	Channel from 15942 Bennett Rd Driveway Culvert to 16212 Bennett Rd Backyard Culvert	4-ft Deep Channel Widening	LIN FT	$314	57	$17,883
	T32001060	BACKYARD CULVERT BEHIND 16212 BENNET RD	3x10-ft Culvert Replacement	LIN FT	$1,846	177	$326,660
	T32001050 - T32001040	Channel from 16212 Bennett Rd Driveway Culvert to 15953 York Rd Driveway Culvert	4-ft Deep Channel Widening	LIN FT	$314	519	$162,832
	T32001030	DRIVEWAY CULVERT BEHIND 15953 York RD (1 of 2)	5x12-ft Culvert Replacement	LIN FT	$2,538	13	$32,989
	T32001020	DRIVEWAY CULVERT BEHIND 15953 York RD (2 of 2)	5x12-ft Culvert Replacement	LIN FT	$2,538	143	$362,879
						Total Estimated Construction Cost:	**$3,623,047**

- Channel widening and culvert replacement upstream and downstream of the Edgerton Road / Bennett Road intersection (Alternatives A-2 and A-3), where resident-installed conveyance improvements do not have adequate capacity to convey the peak flow during the 25-year design storm and structures have encroached into the floodplain of Tributary 3.1.

- Channel widening and culvert replacement along Tributary 3.2 between Bennett Road and York Road (Alternative A-5), where resident-installed conveyance improvements do not have adequate capacity to convey the peak flow during the 25-year design storm and structures have encroached into the floodplain of Tributary 3.2.

The total estimated capital cost of Alternative A is approximately $3,600,000, requiring improvements to infrastructure owned by the City, Cleveland MetroParks, and numerous private property owners.

4.2.2 Alternative B: Detention Improvements

A second approach to resolving drainage problems in the Ohio Turnpike 3rd Lane Expansion flooding problem area is one based primarily on detention improvements. Storage/detention improvement options are often the best choices for solving flooding in cases where extensive, cost-prohibitive improvements are needed to the drainage infrastructure (pipes, culverts, etc.) to adequately convey the projected flows, or structures have encroached into the floodplain. While detention generally improves flooding conditions downstream, an evaluation of storage improvements must consider increases in flooding conditions upstream, particularly in areas of flat terrain. Detention facilities can also be designed to include extended detention features that promote the settling of pollutants captured by the facility and reduce erosive flow velocities downstream of the facility.

4.2.2.1 Description of Improvement Options

Detention improvement options evaluated for the Ohio Turnpike 3rd Lane Expansion flooding problem area include a variety of facility types.

- ***Detention basins*** include the excavation and construction of new detention facilities or the modification of existing facilities (e.g., through additional storage and/or reconfiguration of existing control structures).

- ***Impoundment dams*** are built across existing watercourses as a means of increasing storage in upstream floodplains. Earthen or concrete materials may be used for the dam structure. These detention facilities are distinguished from the first category in that earthmoving activities occur in the vicinity of the dam structure and not upstream in the impoundment area.

- ***Flow reduction controls*** are added to restrict the conveyance capacity of existing stream crossings and storm sewers (e.g., orifice plate to throttle flows) or open channels (e.g., weirs).

- ***Hydrobrakes*** are used to regulate the flow capacity of inlets, promoting surface ponding within the street right-of-way. Hydrobrakes were only investigated in cases where insufficient space exists for other detention options.

Other alternatives considered included the acquisition of easements for construction and maintenance associated with storage improvements when a new facility was proposed.

4.2.2.2 Alternative Development

Figure 4-2 and **Table 4-2** show detention alternatives proposed to resolve flooding problems in the Ohio Turnpike 3rd Lane Expansion flooding problem area. The following detention improvements were developed for Ohio Turnpike 3rd Lane Expansion flooding problem area:

- Installation of two detention basins immediately upstream of Valley Parkway (Alternatives B-1 and B-3) sized to prevent flooding of Valley Parkway and contribute to downstream flood control during the 25-year design storm. Detailed of these detention basins should investigate the potential for merging the two basins into a single facility, as well as incorporation of storm water quality control capabilities and potentially interpretive wetlands that may be more compatible with the Cleveland Metro Parks.

- Installation of two smaller detention basins on Tributaries 3.1 and 3.2 between Valley Parkway and Edgerton Road, providing sufficient additional storage to prevent downstream flooding (Alternatives B-2 and B-4). Locations depicted on Figure 4-2 were placed where available open space exists. If this alternative is selected, alternative sites in this general vicinity should be examined based upon property owner considerations.

The total estimated capital cost of Alternative B is approximately $2,300,000, requiring new infrastructure on property owned by Cleveland MetroParks, and private property owners. The estimated capital cost is for flood control only, and may increase if storm water quality control and/or natural habitat features are included.

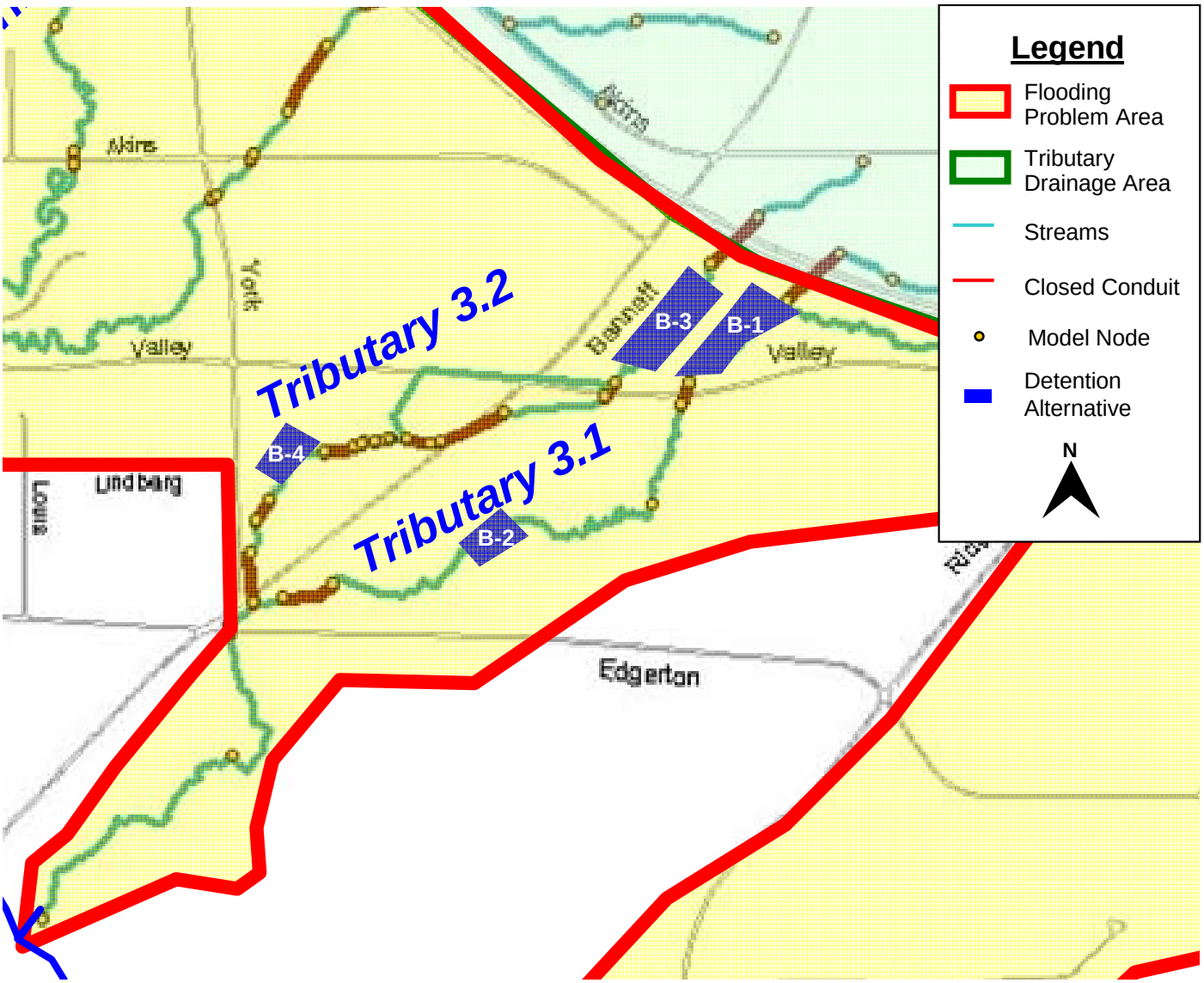


Figure 4-2. Location of Improvement Options on Tributary 3 for Detention Alternative.

Table 4-2. Estimated Capital Cost of Improvement Options under Alternative B: Detention

Improvement ID	SWMMID	Location	Improvement Option	Unit	Unit Cost	Quantity	Total Cost
B-1	T31001070	Valley Parkway	14.0 ac ft Detention Basin	Cu. Ft.	10.33 * V ^0.78	609,607	$503,444
	T31001070	Valley Parkway	Land Acquistion	Acre	$167,776	2.2	$369,107
B-2	T31001049	1,204 feet upstream of the 4-ft CMP located along 8908 Edgerton Road	1.5 ac ft Detention Basin	Cu. Ft.	10.33 * V ^0.78	65,506	$88,371
	T31001049	1,204 feet upstream of the 4-ft CMP located along 8908 Edgerton Road	Land Acquistion	Acre	$167,776	1.65	$276,830
B-3	T32001150	Valley Parkway	10.7 ac ft Detention Basin	Cu. Ft.	10.33 * V ^0.78	467,900	$409,573
	T32001150	Valley Parkway	Land Acquistion	Acre	$167,776	2.2	$369,107
B-4	T32001045	Channel from 16212 Bennett Rd Driveway Culvert to 15953 York Rd Driveway Culvert	2.0 ac ft Detention Basin	Cu. Ft.	10.33 * V ^0.78	85,559	$108,838
	T32001045	Channel from 16212 Bennett Rd Driveway Culvert to 15953 York Rd Driveway Culvert	Land Acquistion	Acre	$167,776	1.21	$203,009
						Total Estimated Construction Cost:	**$2,328,279**

4.2.3 Alternative C: Floodplain Management

The third approach to resolving drainage problems in the Ohio Turnpike 3rd Lane Expansion flooding problem area is one based primarily on floodplain management measures. Floodplain management options focus on solving problems by either preventing conditions that cause flooding, or by keeping stormwater runoff from reaching buildings or roadways. In cases where the costs of conveyance and detention options are high compared to their effectiveness, floodplain management is often the best choice available.

4.2.3.1 Description of Improvement Options

Floodplain management options evaluated for the Ohio Turnpike 3rd Lane Expansion flooding problem area include a variety of structural and nonstructural solutions:

- Flood berms are earthen embankments, stabilized to withstand stream erosion, tall enough to prevent buildings or roadways from being inundated by flooding along an open channel, and include small pumping facilities for local drainage behind the berm.

- Floodwalls are reinforced concrete walls or sheet piling tall enough to prevent buildings or roadways from being inundated by flooding along an open channel, and include small pumping facilities for local drainage behind the wall.

- Buyouts are the purchase, demolition, and restoration to natural vegetation of a residence, business, and/or private property that floods under existing conditions.

- Road raising places additional pavement/base material layers on roads to raise the road elevation above the flood stage. These measures may include regrading of sidewalks, driveways, and yards.

Options considered also include the acquisition of easements for construction and maintenance associated with berms or floodwalls.

4.2.3.2 Alternative Development

Figure 4-3 and **Table 4-3** show floodplain management alternatives proposed to resolve flooding problems in the Ohio Turnpike 3rd Lane Expansion flooding problem area. The following floodplain management options were developed for portions of the Ohio Turnpike 3rd Lane Expansion flooding problem area:

- Purchase eight floodprone residences on Edgerton Road (Alternative C-1), York Road (Alternative C-3), and Bennett Road (Alternative C-5), where extensive and severe flooding during the 25-year design storm preclude other available floodplain management options

- Floodproof three floodprone structures along Bennett Road (Alternatives C-2 and C-4), where flood extent and severity during the 25-year design storm are less than 4 feet, allowing the structure to be sealed from flooding, the structure to be raised,

and/or electric and plumbing within the structure to be raised above flood level (the exact method would be determined through a detailed assessment of the structure.

- Raise the elevation of Valley Parkway at the two culverts to an elevation where backwater flooding caused by the existing culverts would not overtop Valley Parkway during the 25-year design storm (Alternatives C-6 and C-8).

- Build an earthen berm to prevent Tributary 3.1 from flooding a structure along Bennett Road during the 25-year design storm (Alternative C-7).

The total estimated capital cost of Alternative C is approximately $3,700,000, requiring improvements on property owned by Cleveland MetroParks and private property owners. Property values are based on the assessed value of the actual properties slated for acquisition or improvements (where known), times a factor of 1.5 to account for an actual purchase price, structure demolition, and site restoration, times a factor of 1.47 for engineering, legal, unknowns, and administration.

4.2.4 Alternative D: Combination Improvements

The previous improvement alternatives focused on developing a single type of alternative (i.e., conveyance, detention, or floodplain management) throughout the watershed. As each set of alternatives was optimized, some improvement options were noted to perform hydraulically better than others, in terms of achieving greater flood protection benefit for relatively small changes in improvement size or quantity. As a result, the Ohio Turnpike 3rd Lane Expansion evaluation investigated a combination of improvements, which generally used the most effective solution for each flooding problem area. The following combination improvements were developed for the Ohio Turnpike 3rd Lane Expansion flooding problem area experiencing flooding:

- Conveyance improvements along Tributary 3.1, including replacement of the Valley Parkway culvert (Alternative A-1), along with channel widening and culvert replacement upstream and downstream of the Edgerton Road / Bennett Road intersection (Alternatives A-2 and A-3)

- Installation of two detention basins along Tributary 3.2, one immediately upstream of Valley Parkway (Alternatives B-3) sized to prevent flooding of Valley Parkway and contribute to downstream flood control during the 25-year design storm, and one smaller detention basin between Valley Parkway and Edgerton Road (Alternative B-4), providing sufficient additional storage to prevent downstream flooding. If this alternative is selected, alternative sites in this general vicinity should be examined based upon property owner considerations.

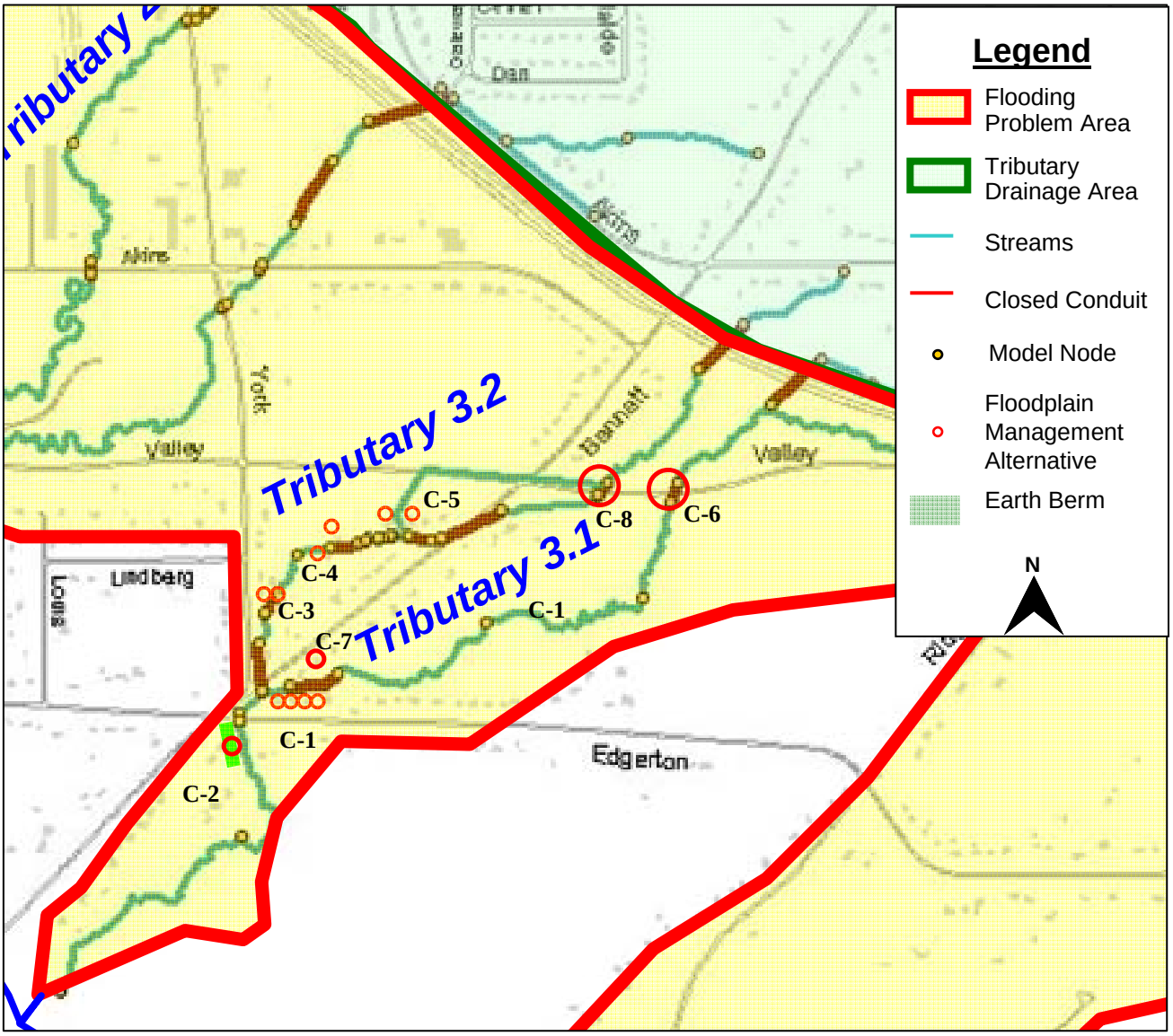


Figure 4-3. Location of Improvement Options on Tributary 3 for Floodplain Management Alternative.

Table 4-3. Estimated Capital Cost of Improvement Options under Alternative C: Floodplain Management

Improvement ID	SWMMID	Location	Improvement Option	Unit	Unit Cost	Quantity	Total Cost
C1	T31001047	8884 Edgerton Rd	Property Acquisition	EA	$328,183	1	$328,183
	T31001047	8896 Edgerton Rd	Property Acquisition	EA	$266,389	1	$266,389
	T31001047	8908 Edgerton Rd	Property Acquisition	EA	$347,162	1	$347,162
	T31001045	8920 Edgerton Rd	Property Acquisition	EA	$277,266	1	$277,266
C2	T31001020	16551 Bennett Rd	2-4-ft Earth Berm	FT	$108	300	$32,402
	T31001020	16551 Bennett Rd	Floodproof Structure	EA	$40,116	1	$40,116
C3	T32001030	15965 York Rd	Property Acquisition	EA	$340,218	1	$340,218
	T32001030	15953 York Rd	Property Acquisition	EA	$268,934	1	$268,934
C4	T32001060	16212 Bennett Rd	Floodproof Structure	EA	$40,116	1	$40,116
	T32001050	16214 Bennett Rd	Floodproof Structure	EA	$40,116	1	$40,116
C5	T32001120	15918 Bennett Rd	Property Acquisition	EA	$362,437	1	$362,437
	T32001120	15906 Bennett Rd	Property Acquisition	EA	$496,672	1	$496,672
C6	T31001070	Valley Parkway (2nd culvert east of Bennett Rd)	Road Raising (2-4 feet high)	LIN FT	$117	235	$27,599
	T31001070	Valley Parkway (2nd culvert east of Bennett Rd)	Road Raising (5-7 feet high)	LIN FT	$168	150	$25,166
	T31001070	Valley Parkway (2nd culvert east of Bennett Rd)	Road Raising (8-10 feet high)	LIN FT	$218	175	$38,169
	T31001070	Valley Parkway (2nd culvert east of Bennett Rd)	0.8 acre Land Acquisition for berm (~60-ft for 560-feet)	ACRE	$335,552	0.8	$258,828
C7	T31001047	4-ft CMP that outlets at property boundary along 8908 Bennett Road	4-foot Earthen Flood Berm (Allows 1-ft freeboard)	LIN FT	$168	324	$54,359
	T31001047	4-ft CMP that outlets at property boundary along 8908 Bennett Road	0.5 acre Land Acquisition for berm (4x4+8+4x4 = 40-foot berm width)	ACRE	$335,552	0.3	$99,834
C8	T32001150	Valley Parkway (1st culvert east of Bennett Road)	Road Raising (2-4 feet high)	LIN FT	$117	325	$38,169
	T32001150	Valley Parkway (1st culvert east of Bennett Road)	Road Raising (5-7 feet high)	LIN FT	$168	100	$16,778
	T32001150	Valley Parkway (1st culvert east of Bennett Road)	Road Raising (8-10 feet high)	LIN FT	$218	100	$21,811
	T32001150	Valley Parkway (1st culvert east of Bennett Road)	0.7 acre Land Acquisition for berm (~60-ft for 525-feet)	ACRE	$335,552	0.7	$242,651
						Total Estimated Construction Cost:	**$3,663,377**

The total estimated capital cost of Alternative D is approximately $2,300,000, requiring new or improved infrastructure on property owned by the City, Cleveland MetroParks, and numerous private property owners. **Figure 4-4** shows the combination improvements proposal to resolve flooding problems in the Ohio Turnpike 3rd Lane Expansion flooding problem area. Additional combination alternatives incorporating floodplain management measures should also be considered if property acquisition values are lower and/or funding becomes available from an outside agency (e.g., FEMA).

4.3 Evaluation of Alternatives

The previous section defined each alternative, its component improvement options, estimated cost (design and construction costs) and projected effectiveness at resolving the drainage problems described in **Section 3.4**. This section evaluates each alternative based on its cost, effectiveness, and implementation factors. Each of the alternatives developed for the Ohio Turnpike 3rd Lane Expansion flooding problem area were evaluated qualitatively on a watershed-wide basis according to the following six criteria:

- ***Capital and Operational Cost*** – Alternatives B and D have the lowest capital cost ($2,300,000) while capital cost of Alternatives A and C is roughly 50 percent higher.

- ***Drainage Improvement Effectiveness*** – All four alternative provide an equal level of flood control, addressing all projected flooding of buildings and roadways during the 25-year design storm.

- ***Compatibility with Community Interests*** – All four alternatives achieve community objectives to control flooding. Alternative C is least compatible with community interest as it requires property acquisition and/or other improvements to private residences. Alternative B requires that two major detention basins be placed within the Cleveland MetroPark, potentially degrading the park unless additional improvements were incorporated to create wetlands or other natural habitat within this facility. Alternative A requires extensive coordination among multiple property owners, many of whom have installed conveyance improvements and/or encroached into the floodplain.

- ***Consistency with Regulatory Requirements*** – The capital cost of conveyance improvements under Alternative A assume that Section 404 permitting will require restoration of natural habitat as part of the channel improvements. Alternative B requires creation of in-stream detention facilities, triggering Section 404 permitting, but also provide opportunities to incorporate storm water quality control features in the facility to trap sediment-born pollutants and retard erosive velocities. Alternative C should not require significant regulatory action.

- ***Water Quality Enhancement*** – Alternatives A, B, and D provide opportunities for storm water pollution control and/or stream restoration (for an additional cost) while Alternative C does not incorporate any water quality enhancement.

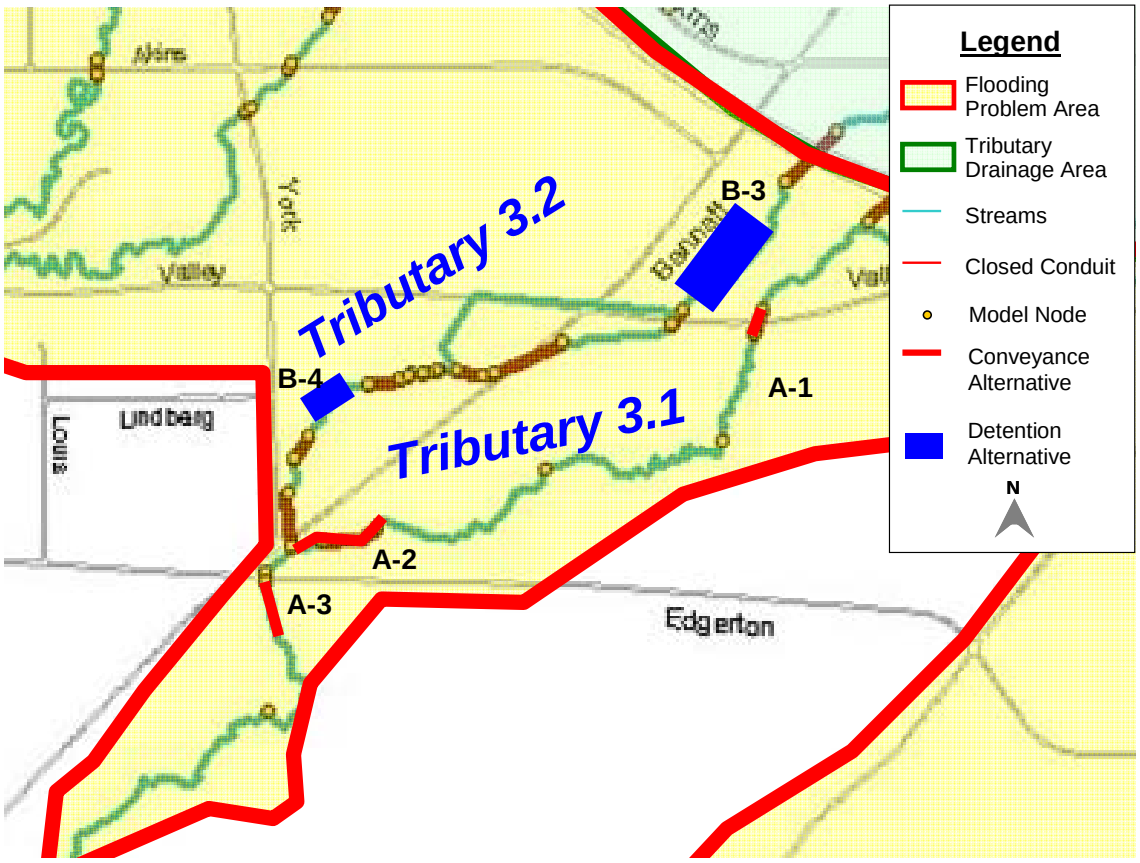


Figure 4-4 Combination Improvements Proposal To Resolve Flooding Problems In The Ohio Turnpike 3rd Lane Expansion Flooding Area.

***Implementation Issues*—** All four alternatives require extensive coordination with Cleveland MetroParks and/or private property owners.

Alternatives B and D are the least expensive alternative, provide opportunities to control storm water pollutants, and present the lowest level of disruption to the community. Alternative D has less impact on the MetroPark. The cost-effectiveness of other alternatives is lower if alternatives are sized to control flooding during a 25-year design storm. Relaxing the level of service criteria outside the public right-of-way may yield a more cost-effective alternative, pending property owner review and comment.

4.4 Conclusions and Recommendations

The purpose of the Ohio Turnpike 3rd Lane Expansion Investigation Project is to determine the validity of the assertion that the expansion of the Turnpike has caused or contributed to increased property flooding and to make recommendations to the City on alternatives available to address resident flooding concerns in this area. Concerns about chronic flooding in the area south of the Turnpike were heightened by the major flooding that occurred in this area on May 10, 2003 and May 20 through 22, 2004, followed by another flooding event on June 9, 2004. Eighty-one (81) concerns were reported to the City within the Ohio Turnpike 3rd Lane Evaluation flooding problem area during the May 10, 2003, May 22, 2004, and June 9, 2004 storm events. Review of published rainfall frequency statistics indicate that both storm events had a 2-year to 10-year rainfall recurrence interval during periods of peak intensity most closely associated with flooding in small urban watersheds. Additional information about reported flooding was gathered through a neighborhood meeting, in resident questionnaires and interviews, through field reconnaissance surveys, and through hydrologic/hydraulic modeling of the drainage system. Hydrologic / hydraulic evaluation of the drainage system indicates that peak flood stages during the June 9, 2004 event were somewhat more severe than flooding on May 10 or May 22, falling between those projected during the 5-year, 24-hour design storm and the 10-year, 24-hour design storm.

CDM evaluated a series of design storm events to quantify the location and severity of flooding within the Ohio Turnpike 3rd Lane Expansion study area and tributary drainage area under existing conditions. Three development scenarios were evaluated under these design rainfall events:

- ***Pre-3rd Lane expansion*** – We established a baseline condition representing hydrologic/hydraulic conditions during 1993 prior to the 3rd lane expansion of the Ohio Turnpike.

- ***Post-3rd Lane Expansion with 1993 Development*** – In order to isolate the impact of Ohio Turnpike expansion from the impact of other development in the City, we developed a hypothetical scenario consisting of post-3rd lane conditions along the Ohio Turnpike right of way overlain onto 1993 development conditions within the remainder of the City.

- ***Post-3rd Lane expansion*** – We depicted land cover based upon 2002 aerial photographs and design drawings from the 3rd lane expansion of the Ohio Turnpike to represent conditions during the 2004 flood events.

The hydrologic/ hydraulic evaluation determined that most flooding problems existed under 1993 land cover conditions, and that with a few isolated exceptions, flood severity has not increased significantly since 1993. Flooding can be attributed to three major factors:

- Increased runoff from the Ohio Turnpike 3rd Lane expansion and upstream development within the City of North Royalton,

- Siltation of existing culverts that may be related to erosion caused by higher, more persistent peak runoff velocities, and

- Encroachment into the floodplain and/or miscellaneous drainage improvements on private property that do not have adequate capacity to convey peak flows during the 25-year design storm.

The area most significantly affected by the Ohio Turnpike 3rd Lane Expansion is Tributary 3.1, where flood stages are projected to increase by about 0.1 feet throughout its reach. As a result, the study developed and evaluated alternative drainage improvements to relieve these flooding problems along Tributary 3, including:

- Baseline measures common to all alternatives that maintain the capacity of the existing drainage system, including operation and maintenance measures that reduce drainage obstructions, preserve existing floodplains, provide detention for future development, and frame recommendations for solving local drainage problems

- Alternative capital improvement projects to address flooding of buildings and roadways during the 25-year design storm, including conveyance improvements (Alterative A), detention alternatives (Alternative B), floodplain management alternatives (Alternative C), and a combination of improvement options examined under the other three alternatives (Alternative D).

Capital costs for the alternatives ranged between $2.3 million and $3.7 million, with each alternative providing an equivalent level of flood control. Other alternative evaluation considerations included community impacts, regulatory and water quality compatibility, and implementation issues. Based on this evaluation, Alternative D is recommended for resolving flooding and erosion along the Ohio Turnpike 3rd Lane Expansion flooding problem area. While this alternative appears to present the most cost-effective way of addressing flooding, detention alternative B provides an equivalent level of flood control and is only slightly less cost-effective.

APPENDIX A

City of North Royalton
Ohio Turnpike 3rd Lane Expansion Flood Investigation Study
Flooding Complaint Database

Number	Resident Name	Address	Street Name	Outside of Designated Problem Area?	Date of Historical Flooding Complaint	Task 1 - Filled out Questionnaire	Task 2 - Conducted Resident Interview	Type of Flooding	Comments
1		12770	Abbey	X	5/10/2003			Street	
2		Intersection	Bennett and Akins		6/9/2004			N/A	Flooding
3	Sheila McCormick	14244	Bennett Road	X	6/9/2004			Yard	Flooded yard
4	James Hollo	14600	Bennett Road	X	6/9/2004			N/A	
5		14682	Bennett Road	X	6/9/2004			N/A	Chuck holes
6	Rosemary Berwald	14961	Bennett Road	X	6/9/2004			Building	Basement
7	Rosemary Berwald	14961	Bennett Road	X	5/22/2004			N/A	
8	Elaine Nawal	15551	Bennett Road			4/20/2005	4/4/2005	Yard	Turnpike culvert backs up and flood discharges along Bennett Road. Debris maintenance last year by turnpike resulted in no flooding.
9	Elaine Nawal	15551	Bennett Road		5/10/2003			Street	
10	Scherer	15562	Bennett Road		5/10/2003			Street	
11	Scherer	15562	Bennett Road		6/9/2004			N/A	Ditch filled
12	Joe Bettinazzi	15650	Bennett Road		6/9/2004			N/A	
13		15660	Bennett Road		5/10/2003			N/A	
14	Joan Morris	15823	Bennett Road			4/20/2005	7/13/2005	Turnpike Debris, Basement Flooding	Concerned with basement flooding (5/10/03, 5/21/04, 6/9/04). Also, car debris accumulation occurs along neighbor's backyard (15811 Bennett Road). Neighbor noticed debris 2-years ago.
15	Fiala	15838	Bennett Road		5/10/2003			Building, Street	
16	Marilyn Fiala	15838	Bennett Road		6/9/2004			N/A	Debris in culvert pipe

City of North Royalton
Ohio Turnpike 3rd Lane Expansion Flood Investigation Study
Flooding Complaint Database

Number	Resident Name	Address	Street Name	Outside of Designated Problem Area?	Date of Historical Flooding Complaint	Task 1 - Filled out Questionnaire	Task 2 - Conducted Resident Interview	Type of Flooding	Comments
17	Wayne Fiala	15838	Bennett Road		6/9/2004			Yard	Creek off catch basin in front yard from turnpike
18	Madalena Eisnloeffel	15906	Bennett Road			4/20/2005	7/13/2005	Yard	Indicated in-ground pool flooded 3 times in 15-years. Drainage from Metroparks is beyond backyard tile culvert capacity and floods property. They learned that previous neighbor culverted front yard stream.
19	Keltner	15918	Bennett Road		5/10/2003			Street, N/A	
20	Kim Keltner	15918	Bennett Road			4/20/2005	5/19/2005	Building and Street Flooding, Channel Erosion	Driveway culvert has overtopped 4-5 times. Neighbor's backyard tile culvert surcharges and overflow drains onto property along side house causing flooding. Significant stream erosion along front yard. Channel has Gas Line Exposed during 5/19/05 Field Visit
21	Debra Zahand	15930	Bennett Road		6/9/2004			Yard	Storm water in yard
22		15941	York Road		5/10/2003			Yard	
23	Jeff Alman	15942	Bennett Road				5/19/2005	Backyard Flooding, Channel Erosion	Flooding and erosion has become problem over past 3-years
24	Dennis Knopf	16214	Bennett Road			4/20/2005	7/13/2005	Building, Street Flooding	Barn and street flooding started in 2000, after Ohio Turnpike 3rd lane expansion.
25	Robert Sambor	16219	Bennett Road			4/20/2005	5/12/2005	Garage	Creek used to be dry in summer (1993), but isn't anymore. Backyard culvert overtops anytime it rains. Resident installed step channels to help stabilize stream from further eroding.
26		16257	Bennett Road		5/10/2003			Street	
27	Bill Kessler	16551	Bennett Road			4/20/2005	4/29/2005	Yard, Building	Dry-weather stream flow has increased over the years. Edgerton Road culvert overtopped during 6/9/04 storm event.
28		16671	Bennett Road		5/10/2003			Building	
29	Jean Stadnik	16701	Bennett Road		6/9/2004			Building	Basement

City of North Royalton
Ohio Turnpike 3rd Lane Expansion Flood Investigation Study
Flooding Complaint Database

Number	Resident Name	Address	Street Name	Outside of Designated Problem Area?	Date of Historical Flooding Complaint	Task 1 - Filled out Questionnaire	Task 2 - Conducted Resident Interview	Type of Flooding	Comments
30	John Szakas	16716	Bennett Road	X		4/20/2005	4/29/2005	Yard, Building	Property located along East Branch of Rocky River. Flooding has occurred over past 2-years, but no flooding occurred the 8-years before that. Light rains result in backyard flooding (6 times/ year); Heavy rains result in front yard, backyard, garage flooding (5/22/04, 6/9/04 storm events).
31	Mrs. Rodriguez	16756	Bennett Road	X		4/20/2005	4/29/2005	Yard, Building	Property is two houses away from the riverbed of the E. Branch of the Rocky River. Her yard floods every time it rains.
32		8702	Center Drive		5/10/2003			Street	
33	James Harrison	17464	Creek Side Circle		6/9/2004			Street	Cul-de-sac flooded
34	Joan Gazzo		Creek Side Circle		6/9/2004			Street	Oval full of mud
35		8443	Dan Drive	X	5/10/2003			Street	
36	William Vincle	8736	Dan Drive	X	6/9/2004			Street	Check street for deep holes
37	Mr. Trample	8802	Dan Drive	X	6/9/2004			N/A	Car hole-needs barrells
38		Intersection	Edgerton and Louis Drive		6/9/2004			N/A	
39	Len & R. Chipchak	4153	Edgerton Road		6/9/2004			N/A	
40		4459	Edgerton Road		5/10/2003			Yard	
41		4546	Edgerton Road		5/10/2003			Street	
42	Linda Breech	4696	Edgerton Road		6/9/2004			Building	Basement
43	Gerald Szpak	4708	Edgerton Road			4/20/2005	4/29/2005	Yard, Street	Has occurred over past few years; backyard floods, side culvert surcharges, frontyard inlet surcharges flooding property and Edgerton Rd. Driveway has sunk 2 inches.

City of North Royalton
Ohio Turnpike 3rd Lane Expansion Flood Investigation Study
Flooding Complaint Database

Number	Resident Name	Address	Street Name	Outside of Designated Problem Area?	Date of Historical Flooding Complaint	Task 1 - Filled out Questionnaire	Task 2 - Conducted Resident Interview	Type of Flooding	Comments
44	Pat Gresock	5228	Edgerton Road				4/29/2005	Driveway Culvert slowly moving downstream	Driveway culvert constructed within the past 10-years. Since construction, culvert has been pushed downstream 3 - 4 feet. House does not flood, but neighbor's house (5240 Edgerton Rd) does flood.
45	Doris Londraville	5240	Edgerton Road		6/9/2004			N/A	
46	Doris Londraville	5240	Edgerton Road			4/20/2005	7/19/2005	Yard, Garage, House	Yard frequently floods. 6/9/04 garage flooded up to 4-feet. Garage now floods up to two times per year. Flooding began in the 1980's, but no house flooding occured until the 3rd lane of the turnpike has been constructed. Driveway culvert next to property was installed in the 1960s.
47	Mr. and Mrs. Prybor	5242	Edgerton Road			4/20/2005	7/15/2005	Yard	Yard flooding has worsened since the 3rd lane of the turnpike was constructed. Additionally, front yard flooding now occurs and is partially attributed to waterbridge drainage overtopping unmaintained detention basin crossing over Edgerton Road onto property. Resident hasn't observed maintenance at Watebridge subdivision since it was constructed.
48	Mr, Mrs. Placek	5244	Edgerton Road		6/9/2004			N/A	Flooding
49	Laura Placek	5244	Edgerton Road		6/9/2004			Building	Basement
50	James Polacek	5244	Edgerton Road			4/20/2005	4/29/2005	Street, Building	6/9/04 - 3-ft. of flooding at barn located near stream. House flooded, which was the first time they can recall it ever flooding. Resident has video of a rain event
51	Kempransky	5250	Edgerton Road		5/10/2003			Building, Street, Yard	
52	Kempransky	5250	Edgerton Road			4/20/2005	7/13/2005	Building	Provided video taken of Turnpike culvert and Valley Pkwy.
53		8112	Edgerton Road		5/10/2003			Building	
54	Bonita Zyaica	8129	Edgerton Road		6/9/2004			N/A	
55		8140	Edgerton Road		5/10/2003			Yard	

City of North Royalton
Ohio Turnpike 3rd Lane Expansion Flood Investigation Study
Flooding Complaint Database

Number	Resident Name	Address	Street Name	Outside of Designated Problem Area?	Date of Historical Flooding Complaint	Task 1 - Filled out Questionnaire	Task 2 - Conducted Resident Interview	Type of Flooding	Comments
56	Renner	8140	Edgerton Road		5/22/2004			Yard	Storm drain in yard eroding
57		8140	Edgerton Road		6/9/2004			N/A	Flooding
58	Harris	8152	Edgerton Road		6/9/2004			Yard	End of drive needs gravel
59		8382	Edgerton Road		5/10/2003			Street	
60		8583	Edgerton Road		6/9/2004			N/A	
61	David Petit	8860	Edgerton Road				6/1/2005	Yard, Channel Erosion	As devlopment has occurred upstream, frequency and duration of flooding has increased. Several trees along stream channel are being lost due to erosion.
62	David Bania	8884	Edgerton Road		5/10/2003			Yard	
63	David Bania	8884	Edgerton Road		6/9/2004			N/A	
64	David Bania	8884	Edgerton Road			4/20/2005	7/13/2005	Flooding	Flooding occuring since Willow Lake Development and Pumping station at Parkway and Ridge. Yard flooding has occurred 3 to 4 times over the past 5-years.
65	M.Maichl/D. Aynik	8896	Edgerton Road		5/10/2003			Yard	
66	M.Maichl/D. Aynik	8896	Edgerton Road		6/9/2004			N/A	
67	Max, Dolores Aynik	8896	Edgerton Road			4/20/2005	7/13/2005	Building, Yard	House and backyard flood when backyard culvert surcharges. Pumping Station has increased runoff to propoerty. Video given to Eng. Dept. in 2001
68	Linda Scott	8903	Edgerton Road		6/9/2004			N/A	
69	Scott	8908	Edgerton Road		5/22/2004			Building	Garage/basement flooding

City of North Royalton
Ohio Turnpike 3rd Lane Expansion Flood Investigation Study
Flooding Complaint Database

Number	Resident Name	Address	Street Name	Outside of Designated Problem Area?	Date of Historical Flooding Complaint	Task 1 - Filled out Questionnaire	Task 2 - Conducted Resident Interview	Type of Flooding	Comments
70	Linda & Gerry Scott	8908	Edgerton Road		6/9/2004			N/A	Flooding
71	Gerald, Linda Scott	8908	Edgerton Road			4/20/2005	6/1/2005	Building, Street	Provided video. 4-feet of water flows over backyard. 4-foot culvert drains stream underneath backyard. When culvert surcharges both her backyard and house flood.
72	Irene & George Sopko	8920	Edgerton Road		6/9/2004			Building	Flooding - home
73	George, Irene Sopko	8920	Edgerton Road			4/20/2005	6/1/2005	Building, Street	Front yard swale floods and drains down driveway into garage. 6/9/04 garage flooded about 18-inches. 5/22/04 home did not flood. Also concerned about artesian well located along Edgerton Rd. near Ridge Rd. Edgerton Road flooded during 5/10/03, 5/22/04, 6/9/04 storm events.
74	Mark Sims	11510	Edgerton Road		6/9/2004			N/A	Ditching
75	Dale Nemec	11944	Edgerton Road		6/9/2004			N/A	
76	Brian Bailey	11968	Edgerton Road		6/9/2004			Detention Basin overtopping	Fountain Pointe lake overflowing
77		Ridge Road to Bennett Road	Edgerton Road		5/10/2003			Street	
78		Ridge Road to Bennett Road	Edgerton Road		6/9/2004			N/A	Flooding - storm sewers cleaned
79	M/M Oberst	14251	Hillside Drive	X	6/9/2004			N/A	Flooded
80	Pat Baxey	14387	Hillside Drive	X	6/9/2004			Yard	Front yard like Niagra Falls
81		14429	Hillside Drive	X	5/10/2003			Yard	
82	Helmy Awad	14471	Hillside Drive	X	6/9/2004			N/A	Storm water
83	Helmy Awad	14471	Hillside Drive	X	6/9/2004			N/A	Water coming down hill and problem w/storm sewer-resident cleaned pipe in backyard and property owner to east cleaned waterway of all debris

City of North Royalton
Ohio Turnpike 3rd Lane Expansion Flood Investigation Study
Flooding Complaint Database

Number	Resident Name	Address	Street Name	Outside of Designated Problem Area?	Date of Historical Flooding Complaint	Task 1 - Filled out Questionnaire	Task 2 - Conducted Resident Interview	Type of Flooding	Comments
84		9656	Lindberg	X	5/22/2004			N/A	
85	G. & D. Scolaro	15312	Martin		6/9/2004			N/A	
86	Wojcik	4161	N. Akins Road	X	5/10/2003			N/A	Ponded water
87	Wojcik	4161	N. Akins Road	X	5/22/2004			N/A	Ponded water
88	Denny Wojcik	4161	N. Akins Road	X	6/9/2004			Building	Fooding - home
89	Mau	4387	N. Akins Road	X	6/9/2004			N/A	Culvert washed out
90	Carol Sterley	4420	N. Akins Road	X	6/9/2004			N/A	Storm ditch blocked
91	Homer Dunkin	5312	N. Akins Road	X	5/10/2003			Building	
92	Dunkin	5312	N. Akins Road	X	5/22/2004			N/A	Flooding problem with culvert
93	Homer Dunkin	5312	N. Akins Road	X	6/9/2004			Building	Basement - Mike pumped
94		5360	N. Akins Road	X	6/9/2004			Building	Flooding
95	Mr. Cato	5360	N. Akins Road	X	6/9/2004			N/A	Hole in yard, drive undermined
96	Mrs. Nagy	5884	N. Akins Road	X	6/9/2004			N/A	Culvert pipe needs cleaned
97	Elizabeth Strube	6270	N. Akins Road	X	6/9/2004			Building	Storm water basement-electric outage where sump pumps won't work - never had this problem before
98	Kay Costaras	6373	N. Akins Road	X	6/9/2004			N/A	Storm water
99	Mrs. Barbeck	6388	N. Akins Road	X	6/9/2004			Yard	Flooded yard from soccer fields

City of North Royalton
Ohio Turnpike 3rd Lane Expansion Flood Investigation Study
Flooding Complaint Database

Number	Resident Name	Address	Street Name	Outside of Designated Problem Area?	Date of Historical Flooding Complaint	Task 1 - Filled out Questionnaire	Task 2 - Conducted Resident Interview	Type of Flooding	Comments
100	Ms. Sandora	6462	N. Akins Road	X	6/9/2004			Building, Yard	Yard, basement
101		7253	N. Akins Road	X	5/10/2003			N/A	
102		7415	N. Akins Road	X	5/10/2003			Street	
103		7463	N. Akins Road	X	5/10/2003			N/A	
104		7561	N. Akins Road	X	5/10/2003			N/A	
105	Chris Zawie	7572	N. Akins Road	X	6/9/2004			N/A	
106	Barbara Erb	7606	N. Akins Road	X	6/9/2004			N/A	Sewer line lifted
107	George Richards	7630	N. Akins Road	X	6/9/2004			N/A	Fooding problem
108	Rudy Palider	7631	N. Akins Road	X	6/9/2004			N/A	Gravel washed into sewer
109		7667	N. Akins Road		5/10/2003			Street	
110	Albert Paliwoda	7667	N. Akins Road			4/20/2005	7/13/2005	Yard	Large area with standing water on neighbor's property, resulting in mosquitos. Would like to improve area to drain better.
111		7679	N. Akins Road		5/10/2003			N/A	
112	David Egizil	7679	N. Akins Road			4/20/2005	7/13/2005	Yard	Concerned for lack of maintenance at OTC culvert
113	David Egizil	7679	N. Akins Road				7/19/2005	Yard	During field visit resident showed where stream stops and undefined drainage area begins before reaching turnpike culvert inlet. Resident indicated current situation is a combination of neighbor filling in land during property improvements and CEI conducting maintenance with heavy equipment during wet event.

City of North Royalton
Ohio Turnpike 3rd Lane Expansion Flood Investigation Study
Flooding Complaint Database

Number	Resident Name	Address	Street Name	Outside of Designated Problem Area?	Date of Historical Flooding Complaint	Task 1 - Filled out Questionnaire	Task 2 - Conducted Resident Interview	Type of Flooding	Comments
114	Paul Rodjom	8224 ,8226	N. Akins Road			4/20/2005	7/13/2005	Flooding	Drainage ditch in front yard and stream bank in backyard both overtop frequently. Garage floods, which is 20-30 feet away from backyard stream. Problem has existed for the past 6-years. Property has a sink hole along east side of property between N. Akins and house.
115	Amy Rice	8236	N. Akins Road		6/9/2004			Building	Flooded garage
116		8280	N. Akins Road		5/10/2003			Street	
117	Tricia Buettner	8392	N. Akins Road		6/9/2004			N/A	
118	Barb Buettner	8394	N. Akins Road		6/9/2004			N/A	
119	Ellen Verk	8481	N. Akins Road		6/9/2004			N/A	Flooding
120	Ellen Verk	8481	N. Akins Road		6/9/2004			Building	Water in condo
121	Vickie Anderson	8507	N. Akins Road		6/9/2004			N/A	
122	Frank Delaney	8682	N. Akins Road		6/9/2004			N/A	
123		Royal Court Condos	Royalton Road		5/10/2003			Building	
124		Royal Court Condos	Royalton Road		5/22/2004			N/A	
125	Nancy Werner	Royal Court Condos	Royalton Road		6/9/2004			Building	Water out of toilets
126	Mrs. Werner	Royal Court Condos	Royalton Road		6/9/2004			Building	Water in condo/basement
127	Nancy Werner	Royal Court Condos	Royalton Road		6/9/2004			N/A	
128	Sarah Werner	Royal Court Condos	Royalton Road		6/9/2004			N/A	

City of North Royalton
Ohio Turnpike 3rd Lane Expansion Flood Investigation Study
Flooding Complaint Database

Number	Resident Name	Address	Street Name	Outside of Designated Problem Area?	Date of Historical Flooding Complaint	Task 1 - Filled out Questionnaire	Task 2 - Conducted Resident Interview	Type of Flooding	Comments
129		Royal Court Condos	Royalton Road		6/9/2004			N/A	Flooding
130	Joyce Zehe-mgr	Royal Court Condos	Royalton Road		6/9/2004			Building	6 units flooded
131		Intersection	N. Akins Road and State Road	X	6/9/2004			N/A	Flooding
132		15396	Ridge Road	X	5/10/2003			Street	
133		5325	Riverview Drive		5/10/2003			N/A	
134	Wanda Griffy	8337	Royalton Road	X	6/9/2004			Building	Water in basement
135	Frank Hulnapy	8377	Royalton Road	X	6/9/2004			N/A	Creek washed away down to stone & mesh-advised Engineering
136	Al Novak	8395	Royalton Road	X	6/9/2004			N/A	
137	Ann Fleckenstein	9009	Royalton Road	X	6/9/2004			Yard	Backyard flood (creek)
138	Ann Fleckenstein	9009	Royalton Road	X	6/9/2004			Building	Basement
139	Ann Fleckenstein	9009	Royalton Road	X	6/9/2004			Building, Yard	Basement, backyard eroded
140	Vasilica Turbatu	9021	Royalton Road	X	6/9/2004			N/A	Flooding
141		12027	Royalton Road		5/10/2003			Building	
142	Josef Krist	8700	S. Akins Road			4/20/2005	7/15/2005	Flooding	Property is a commercial parcel. Backyard receives drainage from turnpike 12-inch RCP. Area ponds up in backyard for over a day after it rains. 6/9/04 N. Akins storm sewer surcharged, resulting in property flooding.

City of North Royalton
Ohio Turnpike 3rd Lane Expansion Flood Investigation Study
Flooding Complaint Database

Number	Resident Name	Address	Street Name	Outside of Designated Problem Area?	Date of Historical Flooding Complaint	Task 1 - Filled out Questionnaire	Task 2 - Conducted Resident Interview	Type of Flooding	Comments
143	Milan Skorepa	9188	S. Akins Road				5/13/2005	Channel Erosion, Yard Flooding	County owns property upstream and culverted stream, which receives flow from turnpike. Erosion has increased significantly over the past few years. County has sheet flow onto property, which has killed 4 trees in backyard due to property flooding.
144	Mrs. Moore	10096	S. Akins Road			4/20/2005	7/13/2005	Yard	No building flooding concerns. After 6/9/04 resident noticed stream received a lot of debris and backs up, but far north of house.
145	Bob and Anna Bratsch	10801	S. Akins Road			4/20/2005	7/13/2005	Yard	Akin Road Culvert clogs and causes flooding
146		11600	S. Akins Road		5/10/2003			Street	
147	Barb Buettner	9031	S. Gateway Drive	X	5/22/2004				
148	Eric, Don Port	14598	S. Gateway Drive				5/13/2005	Street, Yard	Akin Road culvert clogs and causes flooding severe flooding, which drains slowly. Neighbor immediately east has a basement and floods almost anytime it rains.
149	Susan Dzurec	16193	Sandy Springs Drive				7/19/2005	Yard	No building flooding. In 1998, stream had erosion and poor drainage. Resident worked with Cuyahoga SWCD, and US Army Corp to design and construct stream improvements, which including considering 100-year floodplain. Beaver creates significant debris barriers along stream just downstream of property, resulting in some backwater effects.
150	Mrs. Dolezal	14244	State Road	X	6/9/2004			Building, Street	
151	Mrs. Dolezal	14244	State Road	X			7/19/2005	Building	6/9/04 garage flooded 2-feet. Debris issue along State Rd swale and culvert. Drainage from swale ponds on front yard. Stream overtops streambank up to driveway approximately 2 times per year.
152	Debbie Radzewick	15027	State Road	X	6/9/2004			Building	basement
153	Metro Sinkl	15039	State Road	X	6/9/2004			Building	basement
154	Dave Peth	15315	State Road	X	6/9/2004			N/A	culvert plugged

City of North Royalton
Ohio Turnpike 3rd Lane Expansion Flood Investigation Study
Flooding Complaint Database

Number	Resident Name	Address	Street Name	Outside of Designated Problem Area?	Date of Historical Flooding Complaint	Task 1 - Filled out Questionnaire	Task 2 - Conducted Resident Interview	Type of Flooding	Comments
155	Mr. Cebula	15881	State Road	X			7/19/2005	Yard	Neighbor to the north recently added new buildings on property, which drain onto property and cause yard flooding. City only permitted resident to provide an additional 1-foot of fill to help prevent additional yard flooding.
156		16850	State Road		5/10/2003			N/A	
157	Carol Meade	3450	Valley Parkway		6/9/2004			N/A	
158	Carol Meade	3450	Valley Parkway				6/28/2005	Basement, Yard	Lived at current residence since 3/17/80. Resident had property and basement flooding during 5/22/04 and 6/9/04 rain events. Resident was not aware of any flooding on property before either of the two 2004 storm events. Additionally, resident mentioned well water water quality and quantity issue.
159		5160	Waterbridge		5/10/2003			N/A	Fooding
160		5230	Waterbridge		5/10/2003			N/A	Fooding
161		5230	Waterbridge		6/9/2004			N/A	Fooding
162	Greg Camarato	17358	Waterbridge		6/9/2004			N/A	
163	Lisa Meyer	6716	Willow Lake		6/9/2004			N/A	Flooding
164		13800	York Road		5/10/2003			Street	
165	Mrs. Shipley	15965	York Road		6/9/2004			N/A	Flooded
166	Ken Shipley	15965	York Road			4/20/2005	7/13/2005	Street, Yard	Believes swales and driveway culverts along roads result in street and property flooding
167	Steve Carver	15981	York Road				6/1/2005	Street	Catch Basin inlet located on Bennett Road just opposite of property (near intersection with Edgerton Road) clogs and causes street flooding. Steet floods during heavy rains.
168		Intersection	York Road and Royalton Road		6/9/2004			N/A	Flooding

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Flooding Complaint Database

Number	Resident Name	Address	Street Name	Outside of Designated Problem Area?	Date of Historical Flooding Complaint	Task 1 - Filled out Questionnaire	Task 2 - Conducted Resident Interview	Type of Flooding	Comments
169	Moms Restaurant	Intersection	York Road and Royalton Road		6/9/2004			Street	Flooded creek, parking lot

APPENDIX B

Appendix B
Unit Cost Summary for Stormwater Management Options

Improvement Option Category	Construction Unit Costs (2002 Dollars)				Additional Costs (% of Construction Costs)				Estimated Unit Construction Cost (2005 Dollars)
	Subcategory or Description	Average Unit Construction Cost	Unit	Data Source and Date	Contingency (Engineering, Legal, and Unknown)	Subtotal (Unit Cost + Contingency)	Administration	Total	
DETENTION		2002			**40%**		**7%**		**12%**
Detention Basin:	Extended Dry Detention [1]	10.33 * V ^0.78	Cu. Ft.	National Menu of Best Management Practices; USEPA					
	Examples for Detention Basin:								
	Ext. Dry Detention for 1 MG	$0.10	GAL	National Menu of Best Management Practices; USEPA	$0.04			$0.14	$0.16
	Ext. Dry Detention for 5 MG	$0.07	GAL	National Menu of Best Management Practices; USEPA	$0.03	$0.10	$0.01	$0.11	$0.12
	Ext. Dry Detention for 10 MG	$0.06	GAL	National Menu of Best Management Practices; USEPA	$0.02			$0.09	$0.10
	Ext. Dry Detention for 20 MG	$0.05	GAL	National Menu of Best Management Practices; USEPA	$0.02	$0.07	$0.01	$0.08	$0.09
	Ext. Dry Detention for 30 MG	$0.05	GAL	National Menu of Best Management Practices; USEPA	$0.02			$0.07	$0.08
Underground Detention	Underground Detention	$2.00	GAL	NEORSD RIDE Estimations	$0.80	$2.80	$0.20	$3.00	$3.36
Street Detention	Hydrobrake	$250.00	Each	NEORSD RIDE Estimations	$100	$350	$25	$375	$419
Excavation	Excavation and disposal of soil	$7.50	CU YD	Rouge River Project & Means	$3.00	$10.50	$0.74	$11.24	$12.58
CONVEYANCE									
Conveyance Tunnels in Rock:	~10' diameter pipe in rock:	$1,989	LIN FT	Historical NEORSD Cost Data	$795	$2,784	$195	$2,979	$3,336
	~6'-8' diameter pipe in rock:	$1,392	LIN FT	Historical NEORSD Cost Data	$557	$1,949	$136	$2,085	$2,335
	~20' diameter pipe in rock:	$3,977	LIN FT	NEORSD RIDE Estimations	$1,591	$5,568	$390	$5,958	$6,672
	Any Diameter	y=198.85 x D(ft)	LIN FT	M&E Cost Est. Summary for Easterly & Southerly	=0.40 x $			1.4 x $	
	Access Shaft	$8,000	Vert Ft	NEORSD RIDE Estimations	$3,200	$11,200	$784	$11,984	$13,422
Soft Ground Tunnels	Any Diameter in Soft Ground	212.81xD-612.19	LIN FT	M&E Cost Est. Summary for Easterly & Southerly	=0.40 x $			1.4 x $	
Storm Sewer New or Replacement:	12" diameter (in soil)	$50	LIN FT	Year 2000 ODOT Cost Summary	$20	$70	$5	$75	$84
for <10 foot deep installations	18" diameter (in soil)	$55	LIN FT	Year 2000 ODOT Cost Summary	$22	$77	$5	$82	$92
includes MH, Catch basins & roadwork	24" diameter (in soil)	$65	LIN FT	Year 2000 ODOT Cost Summary	$26	$91	$6	$97	$109
	36" diameter (in soil)	$90	LIN FT	Year 2000 ODOT Cost Summary	$36	$126	$9	$135	$151
	48" diameter (in soil)	$300	LIN FT	Ohio BID Tabs	$120	$420	$29	$449	$503
	60" diameter (in soil)	$400	LIN FT	Ohio BID Tabs	$160	$560	$39	$599	$671
	72" diameter (in soil)	$500	LIN FT	Ohio BID Tabs	$200	$700	$49	$749	$839
Storm Sewer New or Replacement:	12" diameter (in soil)	$75	LIN FT	Year 2000 ODOT Cost Summary	$30	$105	$7	$112	$126
for 10 to20 foot deep installations	18" diameter (in soil)	$83	LIN FT	Year 2000 ODOT Cost Summary	$33	$116	$8	$124	$138
or within roads with	24" diameter (in soil)	$98	LIN FT	Year 2000 ODOT Cost Summary	$39	$137	$10	$146	$164
difficult access or utility issues	36" diameter (in soil)	$135	LIN FT	Year 2000 ODOT Cost Summary	$54	$189	$13	$202	$226
includes MH, Catch basins & roadwork	48" diameter (in soil)	$450	LIN FT	Ohio BID Tabs	$180	$630	$44	$674	$755
	60" diameter (in soil)	$600	LIN FT	Ohio BID Tabs	$240	$840	$59	$899	$1,007
	72" diameter (in soil)	$750	LIN FT	Ohio BID Tabs	$300	$1,050	$74	$1,124	$1,258
	96" diameter (in soil)	$900	LIN FT	Ohio BID Tabs	$360	$1,260	$88	$1,348	$1,510
	relief sewer approx. 12'x8' Box (in soil)	$1,500	LIN FT	Col Ohio Bliss Run Trunk Sewer	$600	$2,100	$147	$2,247	$2,517
	relief sewer approx. 20'x10' Box (in soil)	$2,250	LIN FT	NEORSD RIDE Estimate based upon increased size from Bliss Run	$900	$3,150	$221	$3,371	$3,775

Appendix B
Unit Cost Summary for Stormwater Management Options

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Improvement Option Category	**Subcategory or Description**	**Average Unit Construction Cost**	**Unit**	**Data Source and Date**	**Contingency (Engineering, Legal, and Unknown)**	**Subtotal (Unit Cost + Contingency)**	**Administration**	**Total**	**Estimated Unit Construction Cost (2005 Dollars)**
Stream Bank Protection & Restoration:	riprap:	$70	SQ YD	Year 2000 ODOT Cost Summary	$28	$98	$7	$105	$117
	Bank Vegetation:	$5,000	ACRE	NEORSD RIDE Estimations & Denver, CO projects	$2,000	$7,000	$490	$7,490	$8,389
	Bank Vegetation:	$1.03	SQ YD	NEORSD RIDE Estimations & Denver, CO projects	$0.41	$1	$0	$1.54	$2
	crushed aggregate slope protection:	$30	CU YD	Year 2000 ODOT Cost Summary	$12	$42	$3	$45	$50
	concrete slope protection:	$78	SQ YD	Year 2000 ODOT Cost Summary	$31	$109	$8	$116	$130
	rock channel protection:	$40	SQ YD	Year 2000 ODOT Cost Summary	$16	$56	$4	$60	$67
	natural stream restoration: (relocation & vegetation etc)	$550	LIN FT	NEORSD RIDE Estimations & Denver, CO projects	$220	$770	$54	$824	$923
	natural stream restoration: (vegetation etc)	$466	LIN FT	Doan Brook	$186	$652	$46	$698	$782
	Reinforced Concrete retaining wall	$500	CU YD	Ted Johnson (CDM Denver)	$200	$700	$49	$749	$839
	Articulated Concrete Matting	$7.50	SQ FT	Milwaukee CDM MMSD WCMP	$3.00	$11	$1	$11	$13
	Concrete Lined Channel (8" thick)	$100.00	SQ YD	2002 Means per JPS	$40.00	$140	$10	$150	$168
	H-Piles with wood sheeting	$20	SQ. FT	RS Means Heavy Construction Cost Data 2000 - pg. 48	$8	$28	$2	$30	$34
Stream Widening & Stablilization:	Depth = 4 feet ; Both Sides of channel	$187	LIN FT	NEORSD RIDE Estimations	$75	$262	$18	$280	$314
	Depth = 8 feet ; Both Sides of channel	$375	LIN FT	NEORSD RIDE Estimations	$150	$525	$37	$562	$629
	Depth = 12 feet ; Both Sides of channel	$562	LIN FT	NEORSD RIDE Estimations	$225	$787	$55	$842	$943
Stream or Lake Dredging	Dredging of Lake or Stream inlcuding disposal but not dewatering or bypass pumping	$40	CU YD	Contractor Estimates	$16	$56.00	$3.92	$60	$67
Re-Channelize Streams:	All inclusive channel relocation	750	LIN FT	NEORSD NEORSD RIDE Estimations & Denver, CO projects	$300	$1,050	$74	$1,124	$1,258
Bridge Replacement:	all inclusive bridge removal & replacement:	$211	SQ FT	ODOT Cost Estimating Memo (1995) [adj to 2002 $]	$84	$295	$21	$315	$353
Trenchless Tunnel Culvert	All inclusive (less than 200' in length)								
	5 to 7 feet in diameter	$1,900	LIN FT	Columbus Southerly Detention Basin	$760	$2,660	$186	$2,846	$3,188
	8 to 10 feet in diameter	$2,500	LIN FT	Columbus Southerly Detention Basin + Means	$1,000	$3,500	$245	$3,745	$4,194
	Box Culvert 8 x 18 feet	$3,750	LIN FT	Assumed 150% of 8-10 dia. Pipe	$1,500	$5,250	$368	$5,618	$6,292
Culvert Replacement:	**Precast box structure**								
	(6'x4' to 8'x4'):	$1,100	LIN FT	ODOT Office of Estimating Report (1996)	$440	$1,540	$108	$1,648	$1,846
These costs are for typical short	(12'x5' to 14'x4'):	$1,925	LIN FT	ODOT Office of Estimating Report (1996)	$770	$2,695	$189	$2,884	$3,230
stream crossings 30 to 100 feet long.	(18'x5' to 20'x8'):	$2,900	LIN FT	ODOT Office of Estimating Report (1996)	$1,160	$4,060	$284	$4,344	$4,866
	Pipe structures (RCP)								
	48" to 60" diameter:	$690	LIN FT	ODOT Office of Estimating Report (1996)	$276	$966	$68	$1,034	$1,158
	66" to 78" diameter:	$1,100	LIN FT	ODOT Office of Estimating Report (1996)	$440	$1,540	$108	$1,648	$1,846
	84" to 108" diameter:	$1,920	LIN FT	ODOT Office of Estimating Report (1996)	$768	$2,688	$188	$2,876	$3,221
Catch Basins:	ODOT No. 3	$2,600	EACH	Year 2000 ODOT Cost Summary	$1,040	$3,640	$255	$3,895	$4,362
	ODOT No. 3A	$1,875	EACH	Year 2000 ODOT Cost Summary	$750	$2,625	$184	$2,809	$3,146
	ODOT No. 4	$2,550	EACH	Year 2000 ODOT Cost Summary	$1,020	$3,570	$250	$3,820	$4,278
Inlets:	ODOT No. 3B50	$5,250	EACH	Year 2000 ODOT Cost Summary	$2,100	$7,350	$515	$7,865	$8,808
	ODOT No. 2-A-6	$2,700	EACH	Year 2000 ODOT Cost Summary	$1,080	$3,780	$265	$4,045	$4,530
	ODOT No. 2-A-8	$3,650	EACH	Year 2000 ODOT Cost Summary	$1,460	$5,110	$358	$5,468	$6,124
Manholes	ODOT Manhole No.1	$3,000	EACH	Year 2000 ODOT Cost Summary	$1,200	$4,200	$294	$4,494	$5,033

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	ODOT Manhole No. 3	$2,895	EACH	Year 2000 ODOT Cost Summary	$1,158	$4,053	$284	$4,337	$4,857
	ODOT Manhole No. 5	$4,400	EACH	Year 2000 ODOT Cost Summary	$1,760	$6,160	$431	$6,591	$7,382

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Improvement Option Category	**Subcategory or Description**	**Average Unit Construction Cost**	**Unit**	**Data Source and Date**	**Contingency (Engineering, Legal, and Unknown)**	**Subtotal (Unit Cost + Contingency)**	**Administration**	**Total**	**Estimated Unit Construction Cost (2005 Dollars)**
MISCELLANEOUS									
Pavement Replacement & Road Raising									
	Remove & Replace Road with C&G	$3.00	SQ FT	Bid Tabs from Ohio Projects	$1.20	$4.20	$0.29	$4.5	$5.03
	Curb & Gutter Remove & Replace	$30	LIN FT	Bid Tabs from Ohio Projects	$12	$42.00	$2.94	$45	$50.33
	Compacted Clay Backfill for Road	$15	CU YD	Bid Tabs from Ohio Projects	$6	$21.00	$1.47	$22	$25.17
	Compacted Granular Backfill for Road	$25	CU YD	Bid Tabs from Ohio Projects	$10	$35.00	$2.45	$37	$41.94
	Compacted 1foot deep Granular Backfill for Road	$1.00	SQ FT	Bid Tabs from Ohio Projects	$0.40	$1.40	$0.10	$1.50	$1.68
	Concrete driveway and sidewalk removal and replacement	$6	SQ. FT	Bid Tabs from Ohio Projects	$2.40	$8.40	$0.59	$9	$10.07
	New Bike Trail Asphalt 4" thick	$12.00	SQ YD	NEORSD RIDE Estimations using 2002 RS Means	$4.80	$16.80	$1.18	$18	$20.13
Demolition	Reinforced Concrete Demolition & Disposal	$30	Cu. Ft.	NEORSD RIDE Estimations using 2002 RS Means	$12	$42	$2.94	$45	$50.33
	Clearing / Grubbing / Stripping	$5,800	ACRE	CDM Milwaukee Study	$2,320	$8,120	$568	$8,688	$9,731
	Remove Concrete Channel	$22.50	SQ YD	CDM Milwaukee Study	$9	$32	$2	$34	$37.75
	Remove Concrete Channel (6-in thick)	$5	Cu. Ft.	CDM Milwaukee Study	$2.00	$7	$0	$7.49	$8.39
	Bridge Removal	$120,000	EACH	CDM Milwaukee Study	$48,000	$168,000	$11,760	$179,760	$201,331
FLOODPLAIN MANAGEMENT & PROPERTY ACQUISITION									
Floodwalls/Levees:	Concrete Flood Wall (2-4 feet high)	$120	LIN FT	NEORSD RIDE Fact Sheets	$48	$168	$12	$180	$201
	Concrete Flood Wall (5-7 feet high)	$150	LIN FT	NEORSD RIDE Fact Sheets	$60	$210	$15	$225	$252
	Earthen Flood Berm (2-4 feet high)	$70	LIN FT	NEORSD RIDE Fact Sheets	$28	$98	$7	$105	$117
	Earthern Flood Berm (5-7 feet high)	100	LIN FT	NEORSD RIDE Fact Sheets	$40	$140	$10	$150	$168
Land Acquisition: [2]	Typical Property Acquistion	Cty Auditor Value x 1.5	EACH	NEORSD RIDE Assumptions based on unknown actual value of property	40% contingency			Subtotal + Contingency + Admin	
	Single family residence in Chevy Branch Watershed	$112,500	EACH	Cuyahoga County Auditor	$45,000	$157,500	$11,025	$168,525	$188,748
	Big Creek Commercial/Industrial	$100,000	ACRE	Cuyahoga County Auditor	$40,000	$140,000	$9,800	$149,800	$167,776
Easement Acquisition: [3]	Underground Pipe Easement	$100,000	ACRE	City of Dublin	$40,000	$140,000	$9,800	$149,800	$167,776
	Underground Pipe Easement	$40	LF	Columbus, OH, Dayton OH	$16	$56	$4	$60	$67

Footnotes:
1. The extended dry detention costs are base upon the EPA National Menu of BMP Practices and equations developed by Brown and Schueler in The Economics of Stormwater BMPs in the Mid-Atlantic Region Final Report.
   The 1996 equation for cost = 8.16 Vs ^0.78 was updated to 2002 dollars by multilpying by 1.04^6 so that the final equation is 10.33Vs ^0.78 where Vs is volume of detention in cubic feet.
2. The cost estimate for property acquistion is based upon the County Auditor property value; This value is multiplied by a factor of 1.5 for unknown property value and demolition costs;
   This subtotal for the property cost is then multipled by 1.4 for the standard NEORSD RIDE contingency which will cover legal fees and engineering fees for designing the demolition.
3. Easement acquisition and purchase of vacant land is based upon $175,000 per acre plus a 40% contingency.
   Per linear foot costs are based upon approximately 20-foot easement widths; For wider easments, use $100,000 per acre
4. The 40% Contingence includes legal, surveying, geotechnical, engineering design and a contingency for unknown factors
5. The 7% Administration Cost is to administer the stormwater program