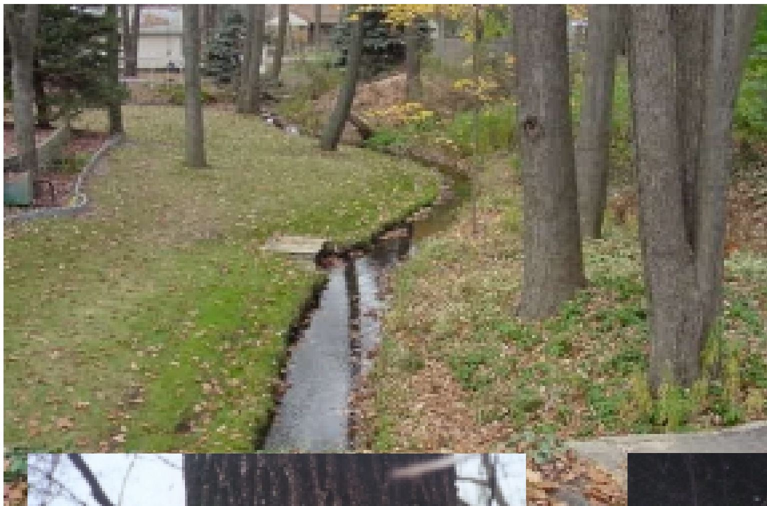
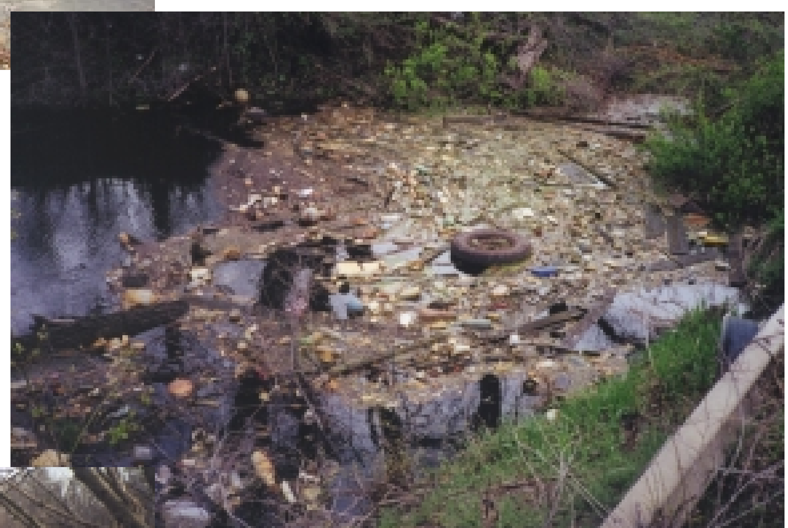
A Hydrologic Study of the

Ryerson Creek Watershed





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Summary

A hydrologic model of the Ryerson Creek watershed, Figure 1, was developed jointly by the Hydrologic Studies Unit (HSU) of the Michigan Department of Environmental Quality (MDEQ) and Westshore Consulting using the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS). Results from that model were included in a report titled *Stormwater Management Plan for the Ryerson Creek Watershed, Muskegon County, Michigan* dated December 2000, and prepared by Westshore Consulting. The report was completed with a Muskegon Conservation District grant from the Great Lakes Commission to support the local Remedial Action Plan process for the Muskegon Lake Area of Concern.

To assist in improving that model, watershed monitoring data were collected from May 8 to November 1, 2000, and were released by this office on April 16, 2001. This report discusses the refinements of the model based on additional information and the calibration of the model to the monitoring data. Appendices A, B, and C are attached, which list the refined model parameters, detail the calibration process, and compare the results from the previous and current model versions.

The model has been calibrated and further refined in many ways, adding confidence to the model's predictions and highlighting the value of the wetland complex downstream of Home Street in reducing peak flows. The refinements to the model described in this report do not change the findings in the December 2000 report. The overall trends described in that report of increasing stormwater runoff volumes and peak flows have not changed, although the specific numerical values have been refined.

The predicted increases in stormwater runoff volume and peak flows from current conditions (1997) to build-out conditions are of interest to stormwater managers in the Ryerson Creek watershed. Modeled predictions of this land use change show significant increases in the percent change in runoff volumes and peak flows for all three design storms analyzed. Peak flows, Figure 2, and runoff volumes, Figure 3, from the 50 percent chance, (2-year) 24-hour storm are predicted to increase more, on a percentage basis, than flows from the 10 percent chance (10-year), 24-hour storm or the 1 percent chance (100-year), 24-hour storm. Increases in peak flows from the 50 percent chance storm will increase the channel forming flow, which could cause excessive and extensive erosion. Increases in runoff volumes from the 10 and 1 percent chance storms will affect flood elevations. These projected increases can be moderated through the use of effective stormwater management. Opportunities to improve stormwater management would be most useful in the upper half of the watershed.

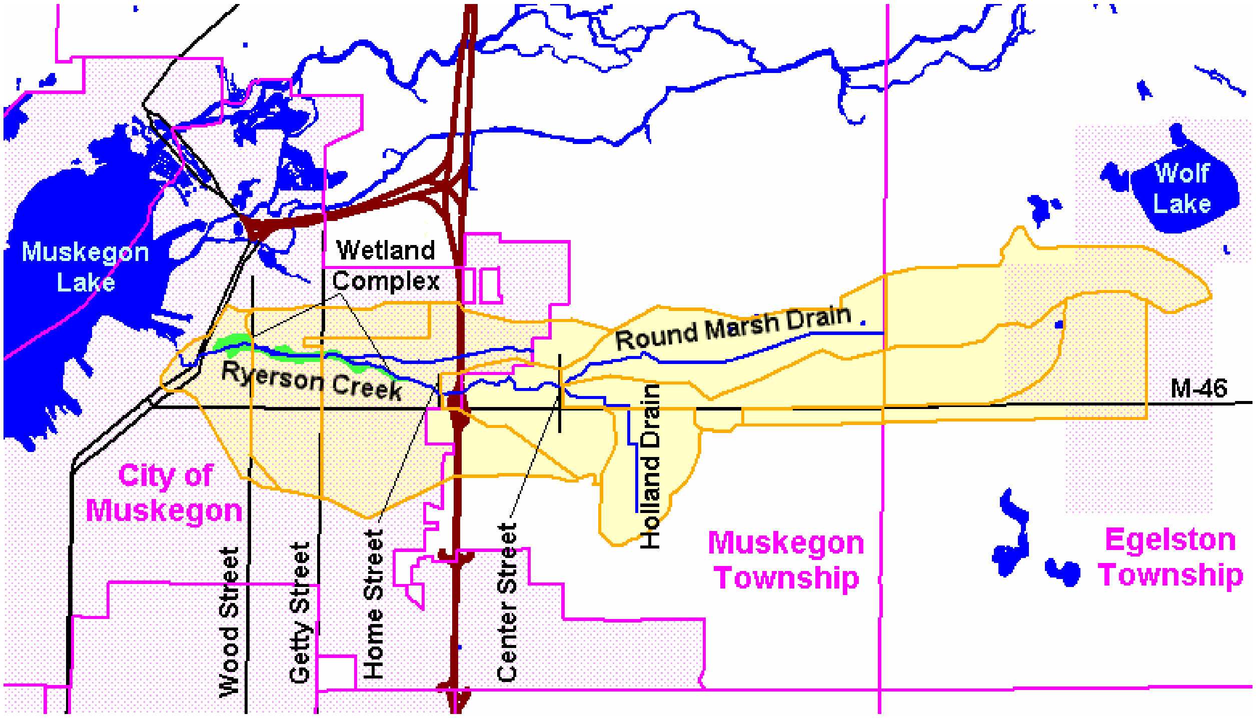

Figure 1: Location of Watershed

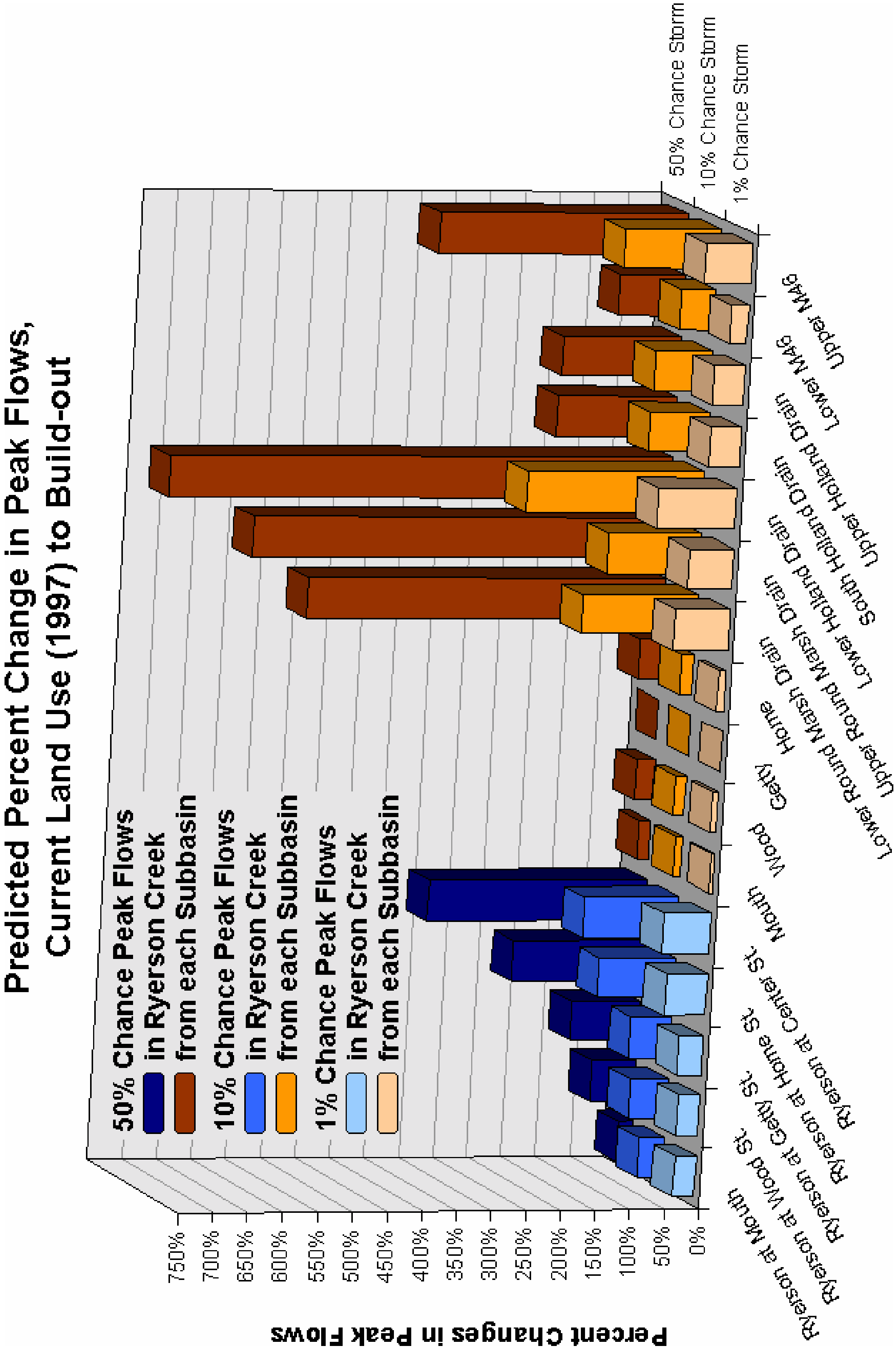

Figure 2: Predicted peak flow changes from current land use to build-out conditions

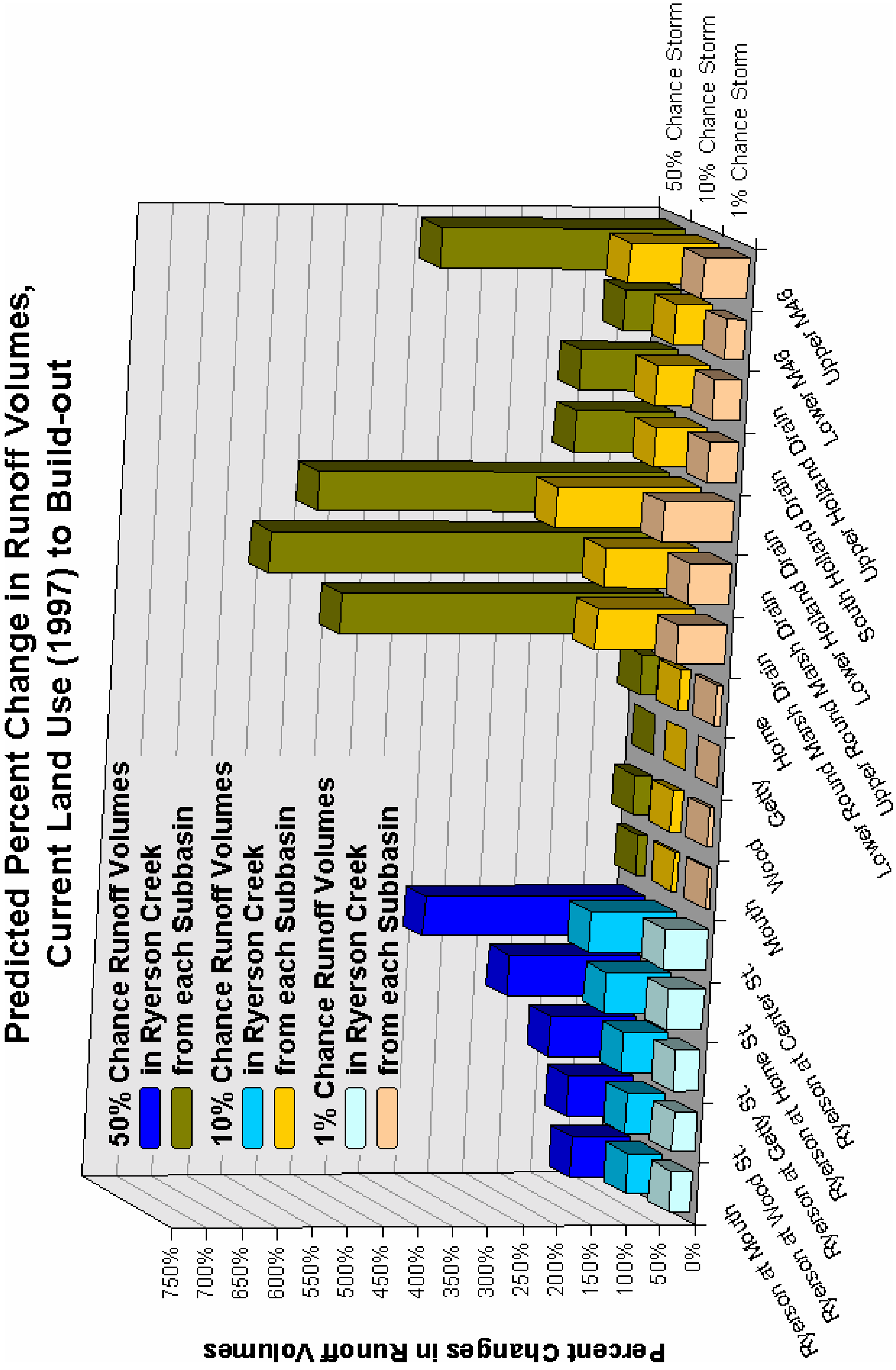

Figure 3: Predicted runoff volume changes from current land use to build-out conditions

Project Goals and Findings

This hydrologic study was initiated in support of a Muskegon River watershed project, which is funded in part by a United States Environmental Protection Agency (USEPA) Part 319 grant administered by the MDEQ. The goal of the watershed project is to better understand the Ryerson Creek watershed's hydrology and the impact of continued development so that plans can be developed to address and improve the water quality in the watershed. More specifically, the objectives of the watershed project were to:

- Assess the Ryerson Creek watershed to determine its potential for achieving and maintaining the highest level of water quality and functionality.
- Delineate and characterize the watershed, the creek, and its major tributaries.
- Study the land use patterns relative to hydrology, with emphasis on land use changes and stormwater flow.
- Perform a basic analysis of the stormwater infrastructure.
- Identify areas of possible critical concern with respect to stormwater quantity and water quality management.
- Develop recommendations for stormwater management in the watershed, including improvements to the infrastructure and engineering, local ordinances and programs, the implementation of Best Management Practices (BMPs), and increased public understanding and educational efforts.
- To initiate and pilot a model approach for the Muskegon Community to respond to the new USEPA and the MDEQ requirements for stormwater management.

The major findings listed in the December 2000 report, *Stormwater Management Plan for the Ryerson Creek Watershed, Muskegon County, Michigan*, include:

- Predicted increases in impervious surfaces, especially in the upper portion of the watershed, will continue to degrade Ryerson Creek unless management of the system is improved. Without the development and use of a number of sound management tools, the creek and watershed will suffer.
- Existing infrastructure in the upper portion of the watershed appears to be inadequate to manage the quantity of stormwater that will likely be generated in the future. Flooding problems, already apparent in certain areas in Muskegon Township, could be exacerbated by increasing urbanization.
- Water quality throughout the system suffers and will likely continue to degrade without greater efforts to manage both the quality and the quantity of stormwater runoff.
- Sudden increases in stormwater flow after a rain event (i.e., the peak flow conditions) are adversely impacting the quality of Ryerson Creek.
- The local governments lack the necessary tools to address watershed and stormwater issues.

The refinements to the model described in this report do not change these findings. The overall trends described in that report of increasing stormwater runoff volumes and peak flows have not changed, although the specific numerical values have been refined. The model has been refined in many ways, adding confidence to the revised predictions. One significant improvement is the addition of the stormwater storage function of the wetland complex below Home Street to the hydrologic model. Without this function, the model could not replicate the observed flows. Because of this, we offer one additional finding:

- The wetland complex downstream of Home Street is critical to the control of peak flows and flood stages in these reaches.

Watershed Description and Model Parameters

The 8.1 square mile Ryerson Creek watershed outlets to Muskegon Lake, as shown in Figures 1 and 4. It includes major portions of the City of Muskegon, Muskegon Township, and Egelston Township in the County of Muskegon, Michigan. The watershed study divides the watershed into eleven subbasins, as shown in Figure 5.

Our analysis of the watershed uses the curve number technique to calculate surface runoff volumes and peak flows. This technique, developed by the Natural Resources Conservation Service (NRCS) in 1954, represents the runoff characteristics from the combination of land use and soil data as a runoff curve number. The curve numbers for each subbasin, listed in Appendix C, were recalculated based on available digital soil and land use data using Geographic Information Systems (GIS) technology.

Land use maps based on the MDEQ data for 1800 and 1978, are shown in Figures 6 and 7, respectively. Land use maps based on Grand Valley State University's Water Resource Institute's analysis of 1997 aerial photos and zoning information are shown in Figures 8 and 9. The build-out analysis assumes land use is developed to the maximum allowed under zoning regulations. The zoning map, shown in Figure 9, coded the wetland complex below Home Street as open space. The coding is used to calculate the curve numbers and is the reason that the curve numbers for these watersheds decreased slightly for the build-out scenario shown in the December 2000 report. This analysis restored the wetland coding to this area, as shown in Figure 10. There are a few locations throughout the watershed where business land uses are reclassified as residential in the build-out data. We have made no attempt to validate these changes.

Table 1 is a comparison of the curve numbers calculated for the prior model as described in the December 2000 report, *Stormwater Management Plan for the Ryerson Creek Watershed, Muskegon County, Michigan*, and the recalculated values for the equivalent areas.

Table 1: Curve Number Comparison

Subbasin	1978		1997		Build-out	
	Prior	Revised	Prior	Revised	Prior	Revised
Mouth	79	79	78	79	77	81
Wood	75	75	75	75	75	78
Getty	75	65	76	66	78	66
Home	79	73	81	74	84	77
Round Marsh Drain	*56	53	*61	55	*80	66
Holland Drain	*70	66	*72	65	*87	80
M46	64	59	66	61	83	74

**These values are reversed in Table 4 of the "Stormwater Management Plan for the Ryerson Creek Watershed, Muskegon County, Michigan."*

The NRCS soils data for the watershed is shown in Figure 11. Where the soil is given a dual classification, B/D for example, the soil type was selected based on land use. In these cases, the soil type is specified as D for natural land uses or the alternate classification (A, B, or C) for developed land uses.

The time of concentration for each subbasin, which is the time it takes for water to travel from the hydraulically most distant point in the watershed to the design point, was calculated from the United States Geological Survey (USGS) quadrangles. The HSU of the MDEQ defines the storage coefficient, used in the Clark unit hydrograph method, as 1.0 times the time of concentration for Michigan. Lag values for each reach, which is the travel time of water within each section of the creek, and the storage functions for the two reaches between Home Street and Wood Street, were also calculated from the USGS quadrangles. The final values are listed in Appendix C.

These parameters were then incorporated into a HEC-HMS model to compute runoff volume and flow. The modeled precipitation events were the 50, 10, and 1 percent chance (2-, 10-, and 100-year), 24-hour storms.

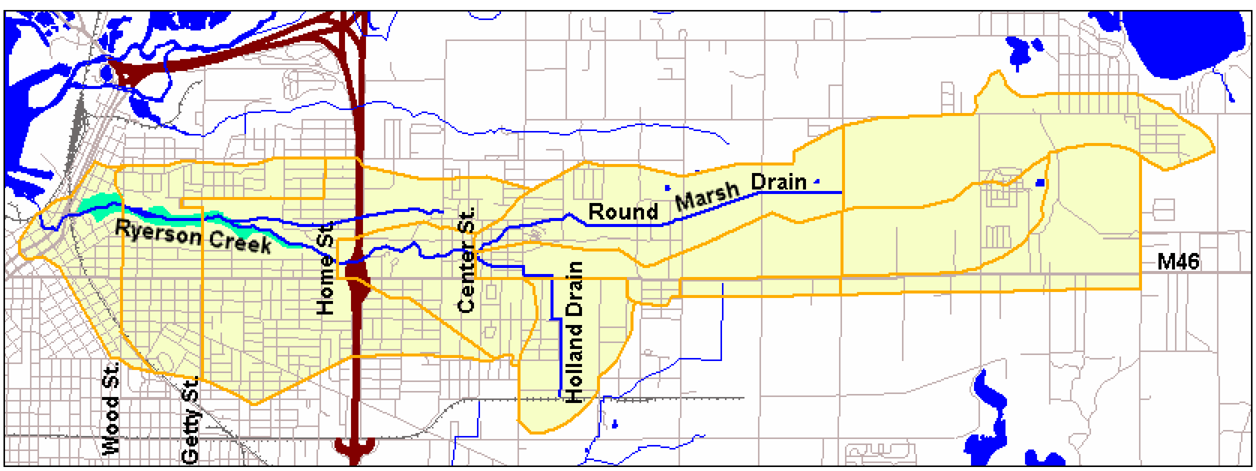

Figure 4: Delineated Ryerson Creek Watershed

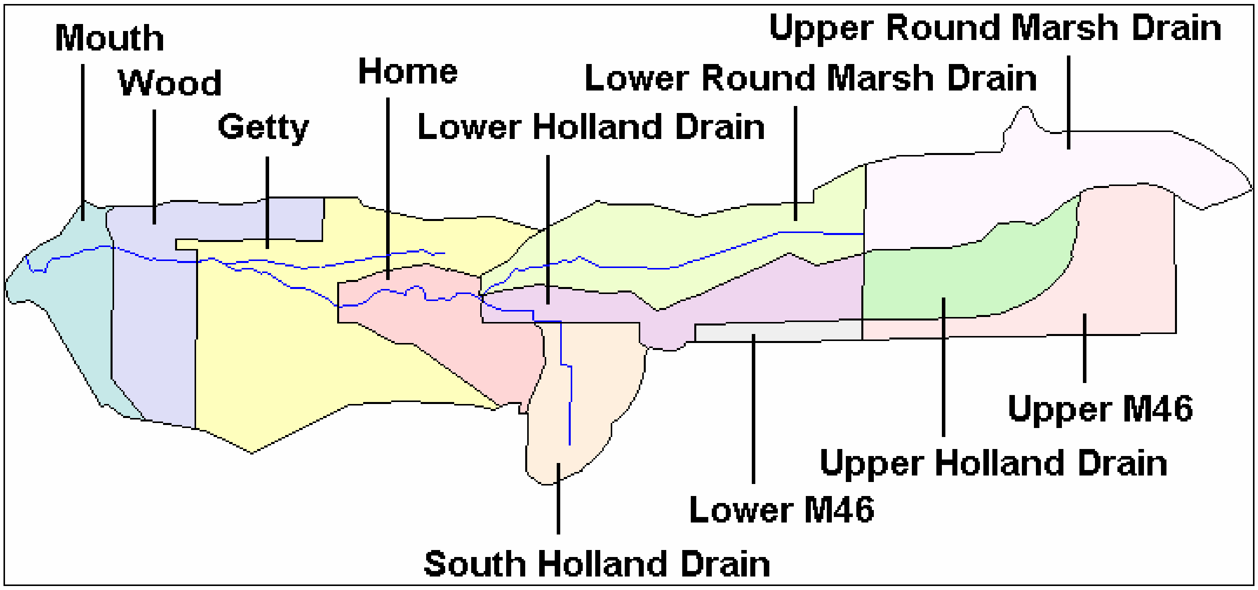

Figure 5: Subbasin Names

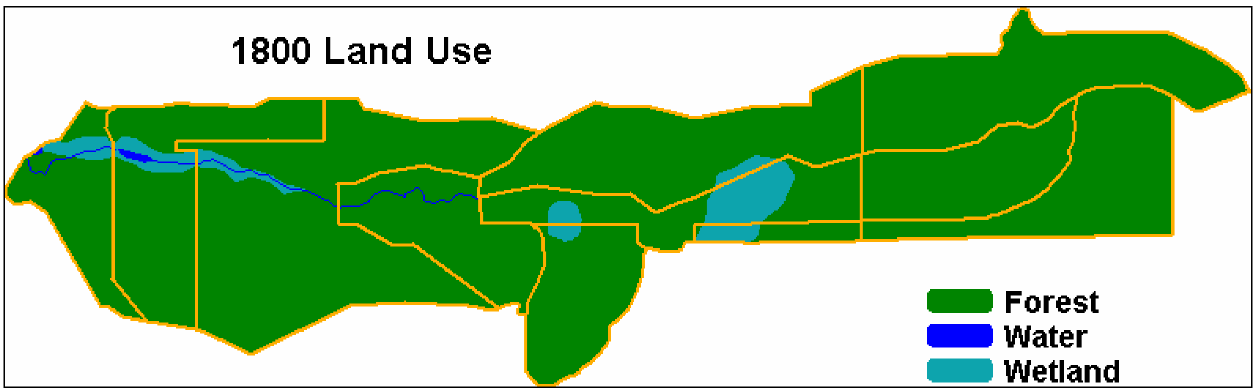

Figure 6: 1800 Land Use Data

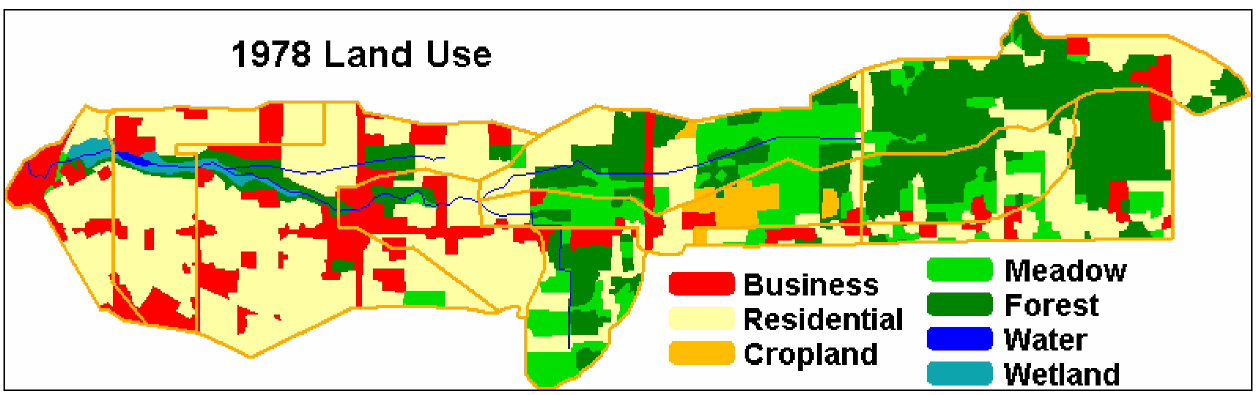

Figure 7: 1978 Land Use Data

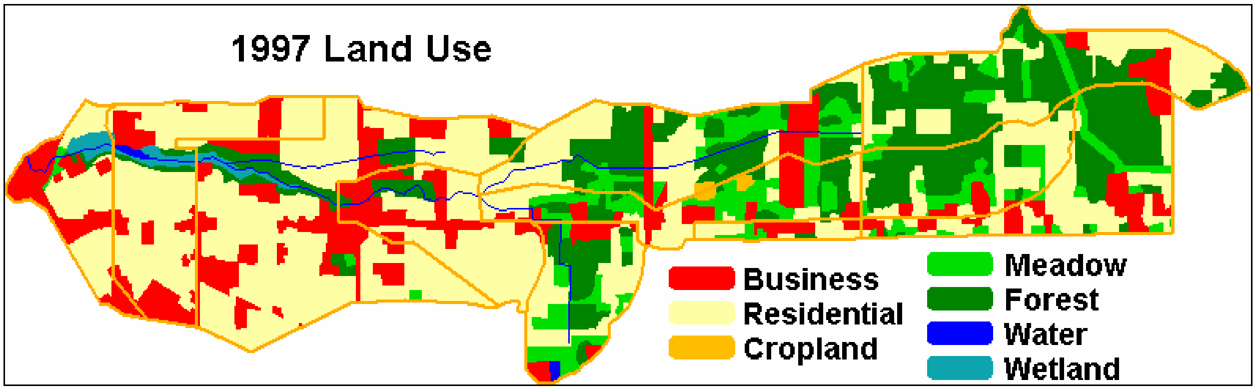

Figure 8: 1997 Land Use Data

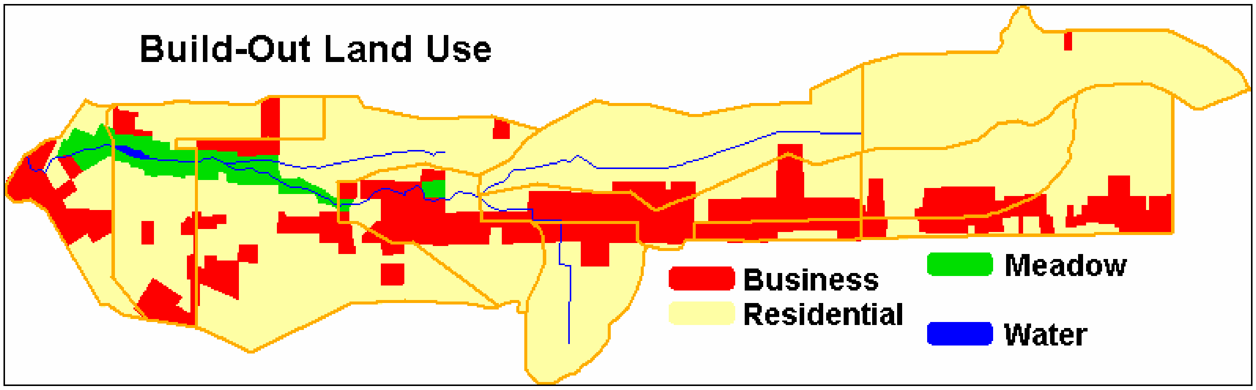

Figure 9: Zoned, or Build-Out, Land Use Data

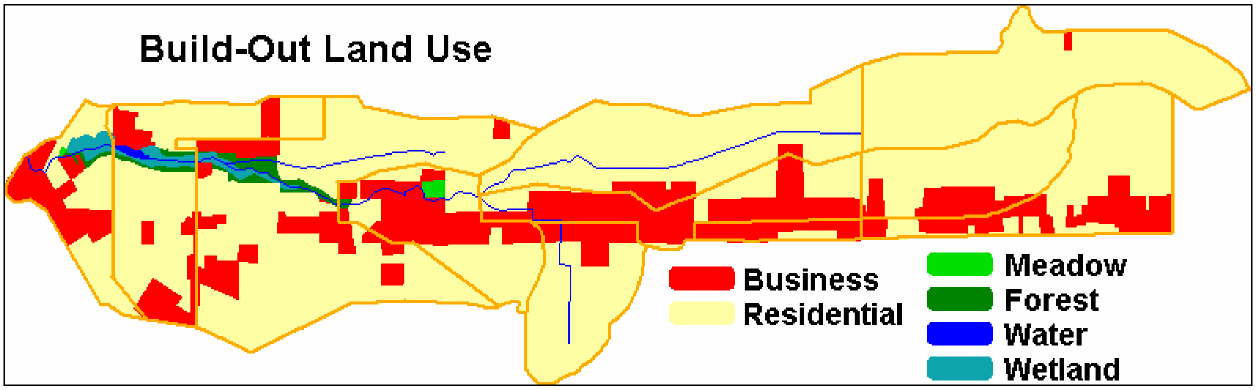

Figure 10: Revised Zoned, or Build-Out, Land Use Data

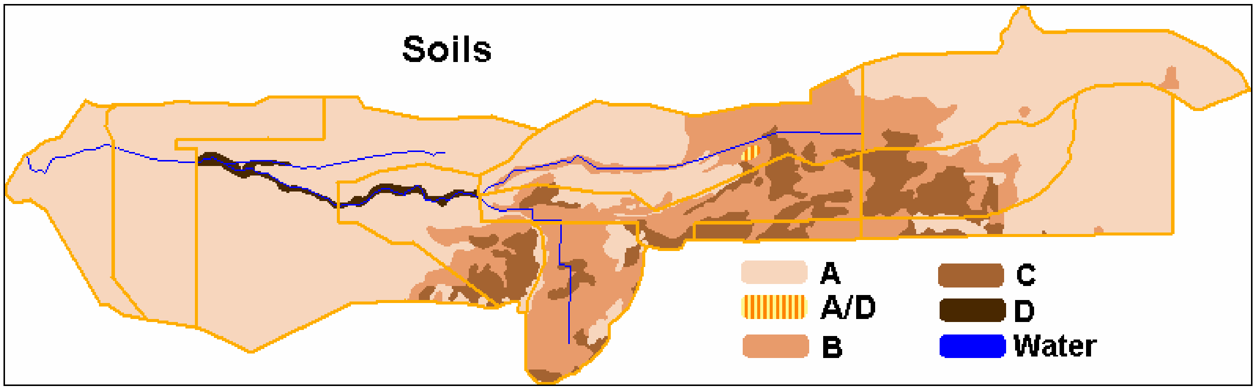

Figure 11: NRCS Soils Data

Model Refinements

The curve numbers were recalculated using our GIS-based system. The land use and soils GIS data used to calculate the curve numbers were reviewed before calculating the curve numbers. The revised curve numbers are shown in Appendix A.

Other changes to the model include:

- In the previous model, the watershed was divided into seven subbasins. Because the upper portions of the upper subbasins tend to be flatter with sandier soils, the subbasins in the upper watershed were divided further to improve accuracy. The refined model has eleven subbasins.
- The times of concentration for all of the subbasins were recalculated.
- The lag values for all of the reaches were recalculated.
- The routing of the two reaches between Home Street and Wood Street was changed to include the storage function of the wetland complex.
- The original curve numbers for the lower watershed decreased slightly for the build-out scenario due to reclassification of the wetland and forest along the creek as open space. It is our understanding that this area is in public ownership, so the GIS data were revised to restore the wetland and forest classifications.
- Curve numbers were recalculated for all of the subbasins. The original calculations assumed that all the residential land use had a lot size of 1/8 acre. The revised calculations assume a lot size of 1/4 acre upstream of Getty Street.
- The storage coefficient was changed to 1.0 times the time of concentration. Research has indicated that this better replicates average Michigan conditions.
- The initial loss was changed to the equation available in HEC-HMS that is based on the curve number.
- The precipitation values were updated using the design rainfall values tabulated in *Rainfall Frequency Atlas of the Midwest*, Bulletin 71, Midwestern Climate Center, 1992, pp. 126-129, and summarized for this site in Appendix A. Except for the 1 percent chance 24-hour storm, the updated rainfall values are lower than the prior values, as shown in Table 2.
- A pre-development scenario was added, based on 1800 land use. This information is for reference only. The MDEQ does not expect or recommend that the flow regime calculated from 1800 land use to be used as criteria for BMP design or as a goal for watershed managers.

Table 2: Precipitation Values used in Ryerson Creek Model

Precipitation Event	Prior Model	Current Model
50% chance (2-year)	2.57”	2.26”
10% chance (10-year)	3.81”	3.35”
1% chance (100-year)	5.62”	6.07”

Model Results

The modeled results for the 50, 10, and 1 percent chance, 24-hour storms and the 1800, 1978, 1997, and build-out land use scenarios are shown in Tables 3 through 6 and Figures 12 and 13. Table 3 compares the predicted peak flows from each subbasin. These values represent the peak flow contribution from the subbasins, not the flow in the creek. Table 4 compares the predicted runoff volumes from each subbasin. Table 5 and Figure 12 compare the predicted peak flows for selected locations in the creek. Table 6 and Figure 13 compare the predicted runoff volumes discharged through selected locations in the creek. A comparison of the results of this model to the prior model is included in Appendix C.

Table 3: Peak flows per subbasin

Subbasin	Peak Flow (cfs) from 50% chance, 24-hour storm				Peak Flow (cfs) from 10% chance, 24-hour storm				Peak Flow (cfs) from 1% chance, 24-hour storm			
	1800 land use	1978 land use	1997 land use	Build out	1800 land use	1978 land use	1997 land use	Build out	1800 land use	1978 land use	1997 land use	Build out
Mouth	0	44	44	52	6	113	113	125	57	265	265	280
Wood	0	21	21	26	5	57	57	66	36	143	143	156
Getty	0	15	17	17	9	62	66	66	71	195	203	203
Home	2	32	35	46	22	101	107	126	118	271	280	558
Lower Round Marsh Drain	1	3	2	14	13	21	18	48	65	86	77	138
Upper Round Marsh Drain	0	1	1	3	3	6	6	14	19	28	28	46
Lower Holland Drain	8	12	6	48	33	43	28	100	106	124	97	207
South Holland Drain	3	6	7	19	17	24	26	48	61	76	79	114
Upper Holland Drain	2	5	6	15	14	21	23	42	56	70	73	105
Lower M46	4	9	10	19	13	23	24	36	38	53	55	69
Upper M46	0	1	2	9	3	9	11	26	22	38	42	70

Table 4: Runoff volumes per subbasin

Subbasin	Runoff Volume (acre-feet) from 50% chance 24-hour storm				Runoff Volume (acre-feet) from 10% chance 24-hour storm				Runoff Volume (acre-feet) from 1% chance 24-hour storm			
	1800 land use	1978 land use	1997 land use	Build out	1800 land use	1978 land use	1997 land use	Build out	1800 land use	1978 land use	1997 land use	Build out
Mouth	0	16	16	19	4	39	39	42	24	88	88	93
Wood	0	23	23	28	6	60	60	69	42	146	146	159
Getty	0	20	22	22	13	73	78	78	87	218	226	226
Home	1	14	15	19	12	38	40	46	48	97	100	109
Lower Round Marsh Drain	1	4	3	17	16	26	22	53	73	94	85	144
Upper Round Marsh Drain	0	1	1	9	7	15	15	35	48	70	70	111
Lower Holland Drain	7	11	6	35	26	33	23	71	78	90	72	145
South Holland Drain	4	7	7	18	17	23	25	43	56	68	70	99
Upper Holland Drain	3	6	7	16	16	23	24	42	57	70	73	101
Lower M46	2	5	5	9	7	11	11	17	18	25	25	32
Upper M46	0	2	3	15	6	16	20	45	38	65	71	117

Table 5: Peak flows in Ryerson Creek

Location	Peak Flow (cfs) from 50% chance 24-hour storm				Peak Flow (cfs) from 10% chance 24-hour storm				Peak Flow (cfs) from 1% chance 24-hour storm			
	1800 land use	1978 land use	1997 land use	Build out	1800 land use	1978 land use	1997 land use	Build out	1800 land use	1978 land use	1997 land use	Build out
at mouth	6	44	44	53	37	113	113	154	181	344	341	448
at Wood	6	32	32	53	37	100	100	154	181	343	340	447
at Getty	8	31	31	62	47	110	109	173	210	356	351	477
at Home	15	40	36	104	78	128	115	241	285	371	350	558
at Center	12	22	18	75	63	90	80	189	234	290	270	455

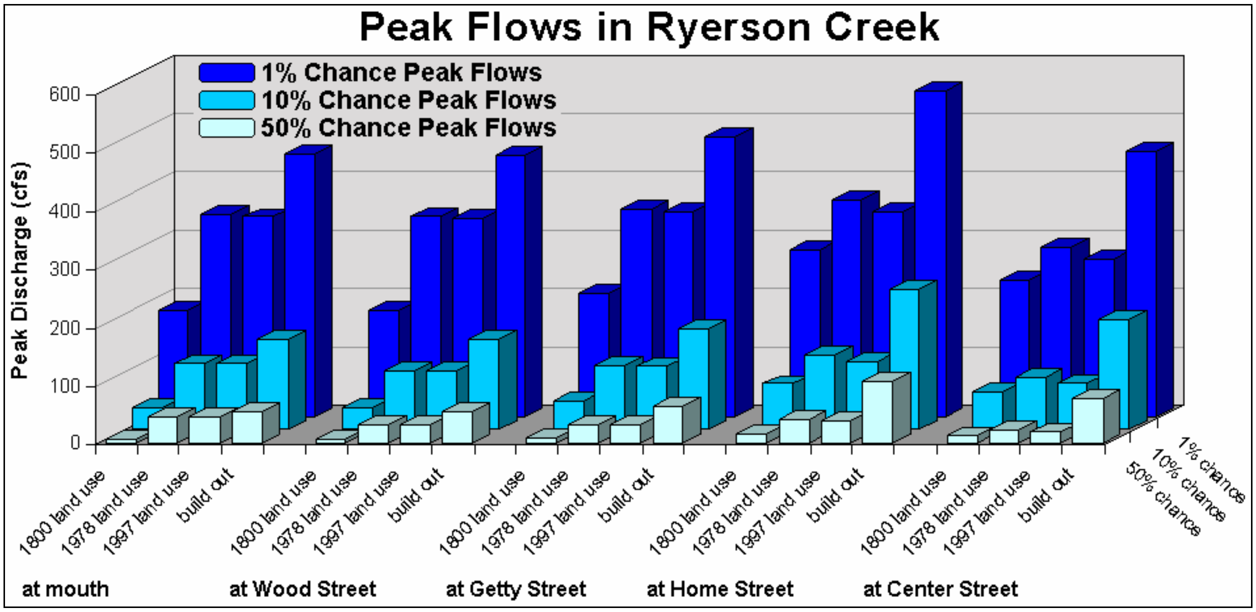

Figure 12: Peak flows in Ryerson Creek

Table 6: Runoff volumes in Ryerson Creek

Location	Runoff Volume (acre-feet) from 50% chance 24-hour storm				Runoff Volume (acre-feet) from 10% chance 24-hour storm				Runoff Volume (acre-feet) from 1% chance 24-hour storm			
	1800 land use	1978 land use	1997 land use	Build out	1800 land use	1978 land use	1997 land use	Build out	1800 land use	1978 land use	1997 land use	Build out
at mouth	17	103	102	186	114	330	329	486	508	949	946	1229
at Wood	17	87	87	169	110	294	293	449	489	868	865	1145
at Getty	18	67	67	151	113	248	247	407	477	761	758	1037
at Home	19	50	47	136	106	186	180	350	415	576	565	856
at Center	15	29	24	94	82	120	109	243	311	390	369	599

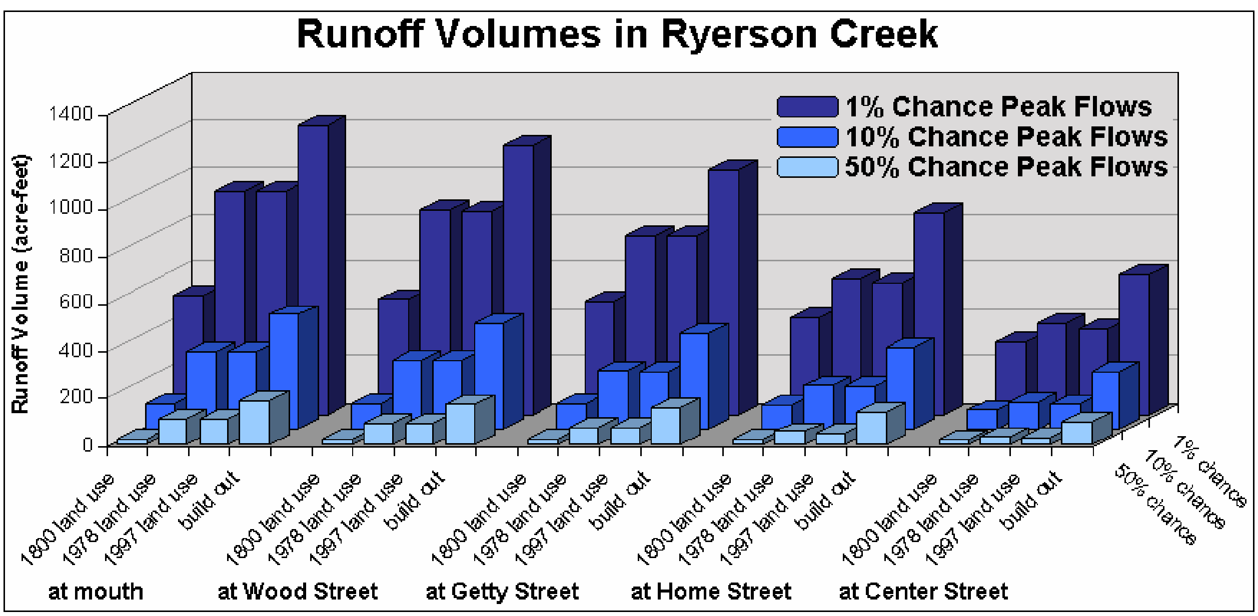

Figure 13: Runoff volumes in Ryerson Creek

Appendices

Appendix A: Ryerson Creek Hydrologic Model Parameters

This appendix is provided so that the model may be recreated by an engineering consultant, or others, if desired. Table A1 provides the design rainfall values specific to the region of the state where Ryerson Creek is located. Figures A1 and A2 summarize the hydrologic elements in the HEC-HMS model. Table A2 provides the parameters that were specified for each of these hydrologic elements. Table A3 provides the reach parameters for the routing methods. The control specified in HEC-HMS was for a three day duration using a five-minute time interval. The storage coefficient is 1.0 times the time of concentration. The initial loss field is left blank so that HEC-HMS uses the default equation based on the curve number.

Table A1: Design Rainfall Values for Muskegon County (Region 5)

Rainfall Duration	**24-hour rainfall (inches) for given recurrence interval***					
	2-year (50%)	**5-year (20%)**	**10-year (10%)**	**25-year (4%)**	**50-year (2%)**	**100-year (1%)**
24-hour	2.28	3.00	3.60	4.48	5.24	6.07
12-hour	1.98	2.61	3.13	3.90	4.56	5.28
6-hour	1.71	2.25	2.70	3.36	3.93	4.55
3-hour	1.46	1.92	2.30	2.87	3.35	3.88
2-hour	1.32	1.74	2.09	2.60	3.04	3.52
1-hour	1.07	1.41	1.69	2.11	2.46	2.85
15-minute	0.62	0.81	0.97	1.21	1.41	1.64
5-minute	0.27	0.36	0.43	0.54	0.63	0.73

Table A2: Subbasin Parameters

Subbasin	**Area (sq. mi.)**	**Curve Number**				**Time of Concentration (hours)**	**Clark Storage Coefficient**
		1800	**1978**	**1997**	**Build-out**		
Mouth	0.44	48	79	79	81	*1.59	*1.59
Wood	0.82	47	75	75	78	*6.42	*6.42
Getty	1.71	47	65	66	66	*6.93	*6.93
Home	0.58	55	73	74	77	1.72	1.72
Lower Round Marsh Drain	0.98	53	58	56	69	6.51	6.51
Upper Round Marsh Drain	1.03	47	53	53	63	19.84	19.84
Lower Holland Drain	0.61	65	69	63	86	4.14	4.14
South Holland Drain	0.51	61	66	67	78	5.30	5.30
Upper Holland Drain	0.57	59	64	65	75	6.00	6.00
Lower M46	0.12	70	80	81	91	2.46	2.46
Upper M46	0.75	47	56	58	71	11.62	11.62
Total	**8.12**						

**Values include an adjustment for ponding*

Table A3: Channel Reach Parameters

Reach Description	Lag (hours)	Reservoir	
		Storage (acre-feet)	Discharge (cfs)
RMW (mouth to Wood Street)	1.67		
		0	0
RWG (Wood Street to Getty Street)	*	80	100
		320	600
		0	0
RGH (Getty Street to Home Street)	*	120	100
		480	600
RH46 (Home Street to M46 storm sewer outfall)	0.50		
R46Center (M46 storm sewer outfall to Center Street)	0.53		
RRM (Round Marsh Drain)	3.84		
RHDa (lower end of Holland Drain)	1.16		
RHDb (upper end of Holland Drain)	2.52		
R46a (lower end of M46 storm sewer)	0.53		
R46b (upper end of M46 storm sewer)	1.00		
R46c (M46 drain)	1.54		

**The lag routing method does not adequately account for the effect of the wetland complex. The storage function is modeled using reservoirs with the specified storage discharge relationships.*

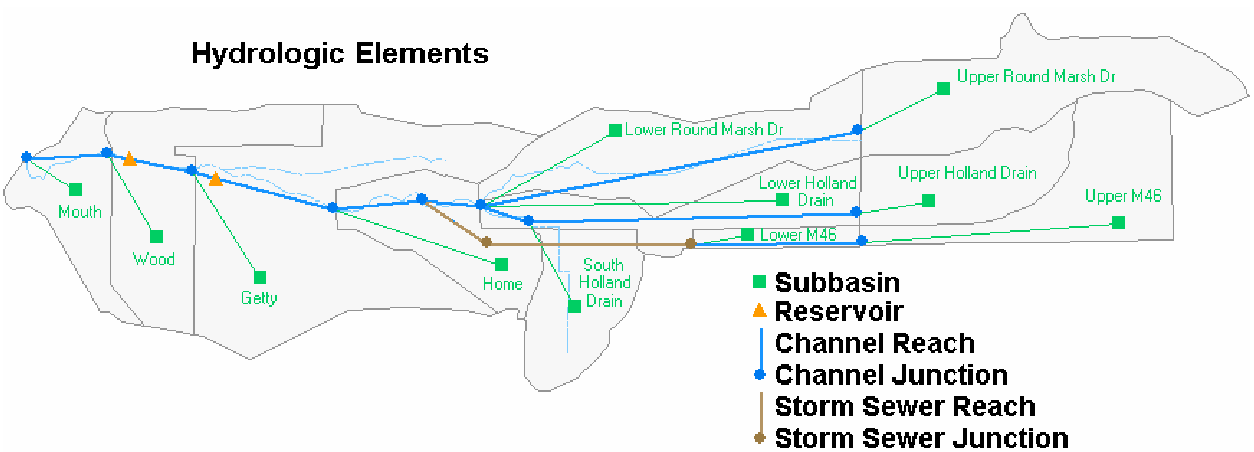

Figure A1: Hydrologic Elements defined for HEC-HMS model

Appendix B: Hydrologic Model Calibration Technical Information

River stage was monitored at Wood and Home Streets from April 12 to June 21, 2000, and at Home and West Streets from August 16 to October 31, 2000, using Isco 4230 Bubblers. Precipitation was monitored at one location within the watershed, on Carlton Street, and supplemented with data from the National Oceanic and Atmospheric Administration's Weather Station at Muskegon Airport. The locations of the gages are shown in Figure B1.

Storms used to calibrate a hydrologic model in Michigan are most useful if they have a single intense rainfall event and if the total rainfall is approximately equal to or greater than a 1-year, 24-hour storm, or approximately 1.77 inches for this region of Michigan. The largest rainfall event in the Home and West Streets calibration data set occurred on September 22-23, 2000. The storm total was 1.29 inches, but is really two storms of 0.68 inches and 0.61 inches separated by four hours, as recorded by the rain gage in the watershed. A single intense storm occurred on August 17 with 0.82 inches of rainfall, preceded by 0.26 inches on August 15, as recorded at Muskegon Airport. In both cases, the model under-predicts peak flows and runoff volumes. This is because the storms are not large enough to generate runoff from the entire watershed. The observed flows, or hydrographs, shown in Figures B2 through B5, represent runoff from the directly connected impervious areas. Since the model averages the land uses and soils into one runoff curve number, it cannot replicate a storm that generates runoff only from the paved portions of the watershed. Because the observed flows in Figures B2 through B5 represent the stormwater that rapidly flows off the paved surfaces directly into the storm sewers, the observed flows also peak before the modeled flows. Calibration data from larger storms would be more useful to determine the validity of the modeled parameters, but the results from this data set are consistent with what we would expect for smaller storms.

The largest rainfall for the Wood and Home Streets dataset occurred on May 17, 2000. This storm had 2.03 inches, as recorded at the Muskegon Airport. The model accurately predicts the timing and peak flow at Home Street, but noticeably over-predicts runoff volume by approximately 13 acre-feet, represented by the area under the curve, as shown in Figure B6. Without additional information, we cannot determine if the curve numbers for one or more of the eight subbasins above Home Street are too high, there was less rainfall in the upper watershed than at the Muskegon Airport, or if there was an error in our calculation of flow from water elevation data.

The calibration process at Wood Street demonstrated the value of the wetland complex downstream of Home Street in attenuating peak flows. The hydrologic model initially routed flow through the river reaches using the lag method. The lag method translates flows based on water velocity through the reach, but does not attenuate the peak flow. Using the lag method, the modeled peak flow was 148 percent higher than the observed peak, as shown in Figure B7. The predicted runoff volume is within 10 percent of the observed volume. The routing of the two reaches between Home Street and Wood

Street was changed to include reservoirs to mimic the storage function of the wetland complex. Predicted peak flow is within the uncertainty in the data.

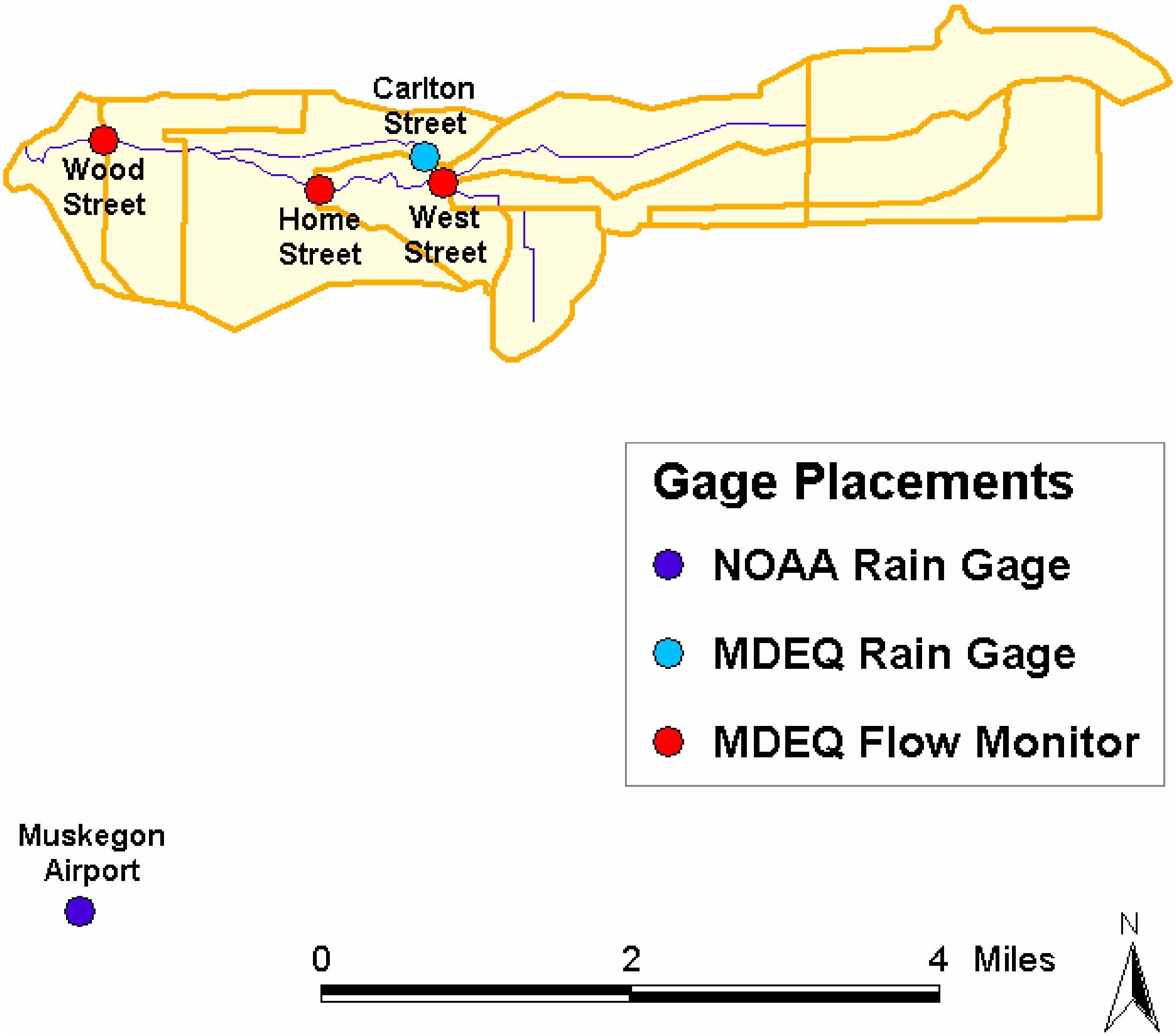

Figure B1: Gage Placements

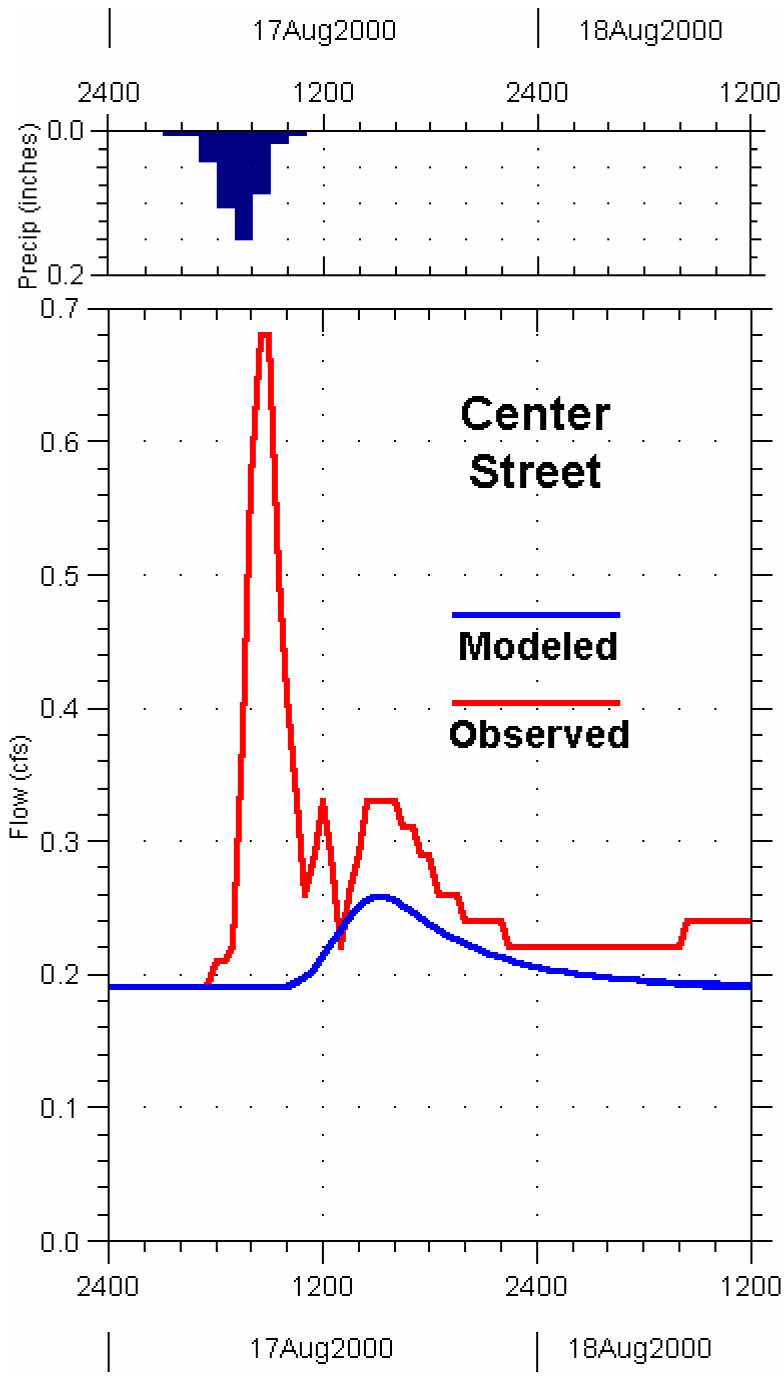

Figure B2: Center Street: August 17, 2000 storm

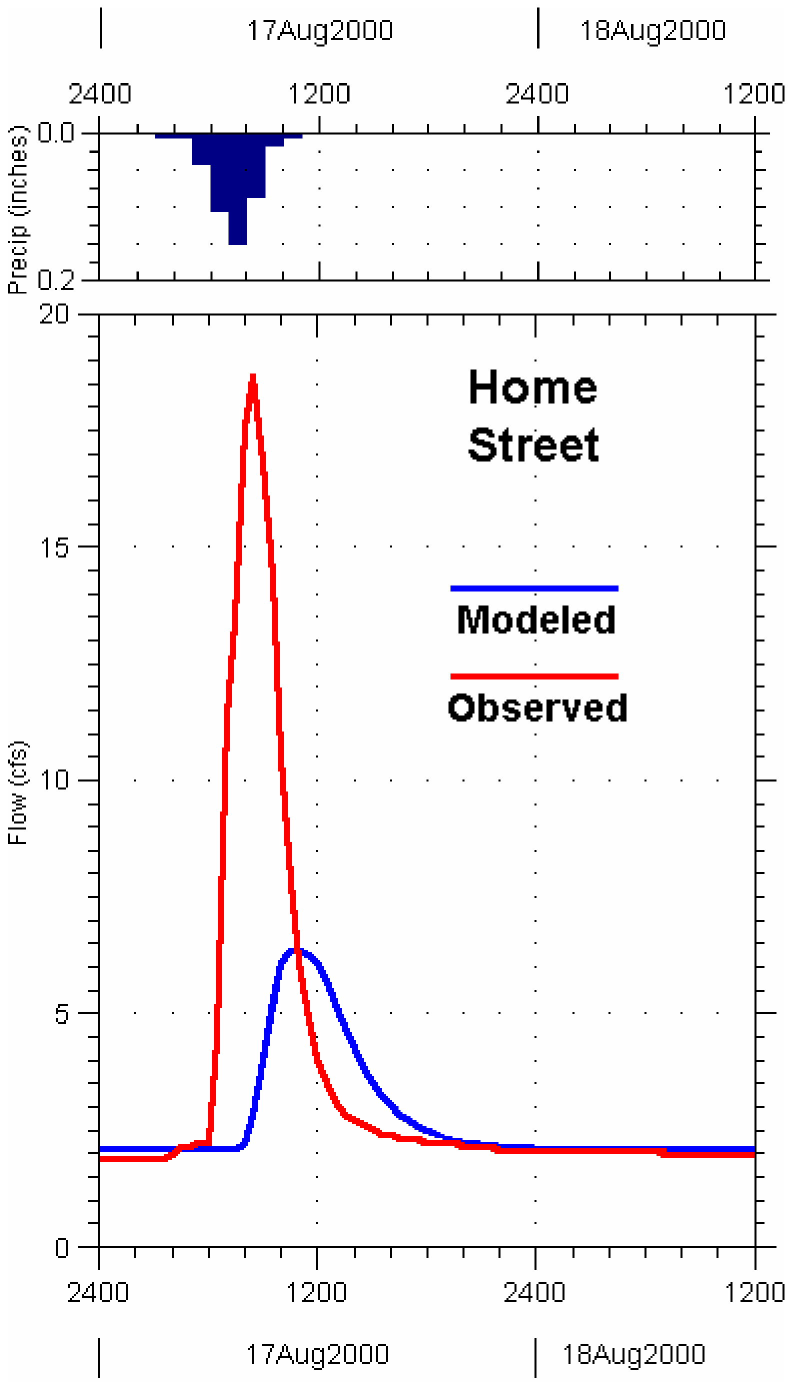

Figure B3: Home Street: August 17, 2000 storm

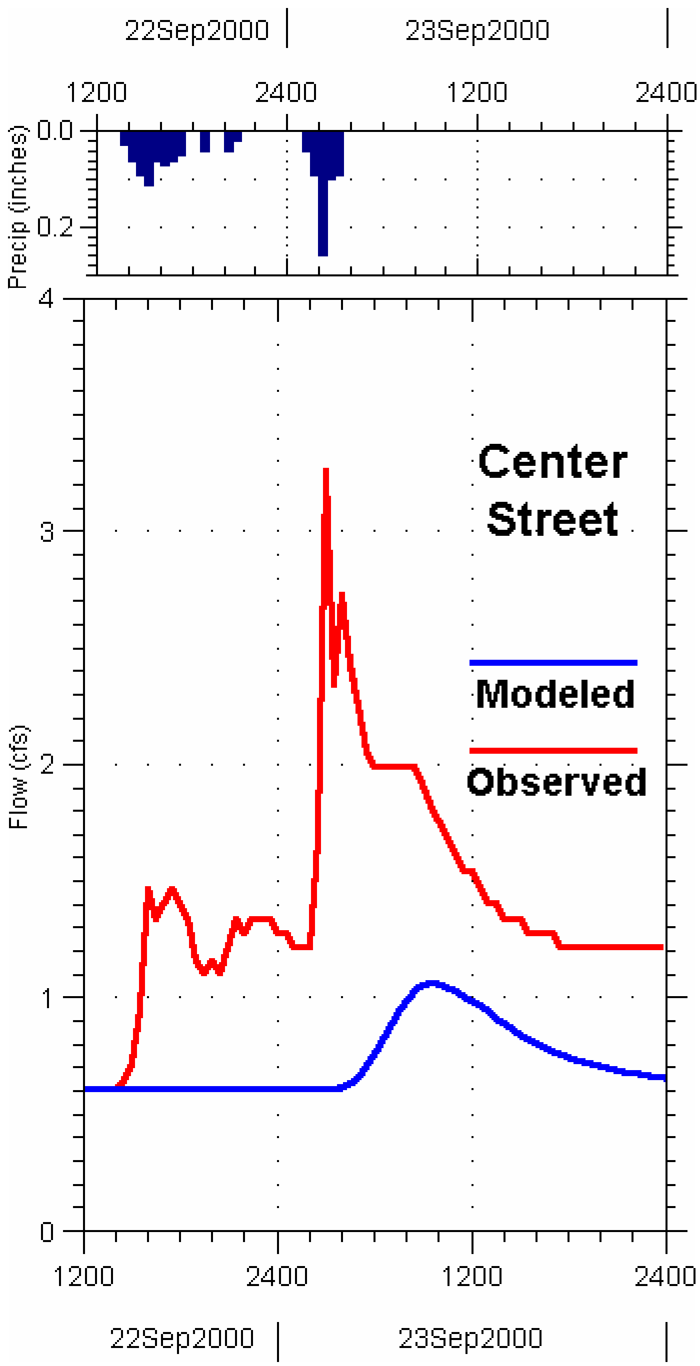

Figure B4: Center Street: September 22-23, 2000 storm

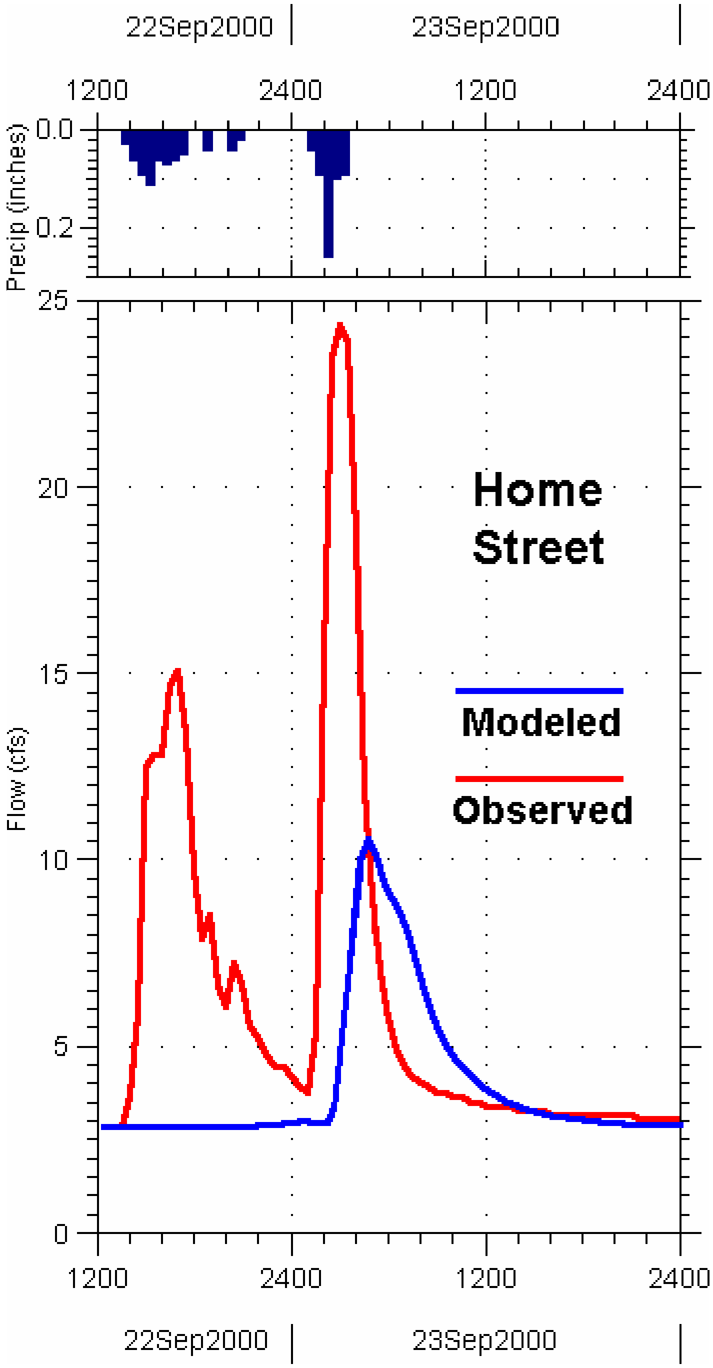

Figure B5: Home Street: September 22-23, 2000 storm

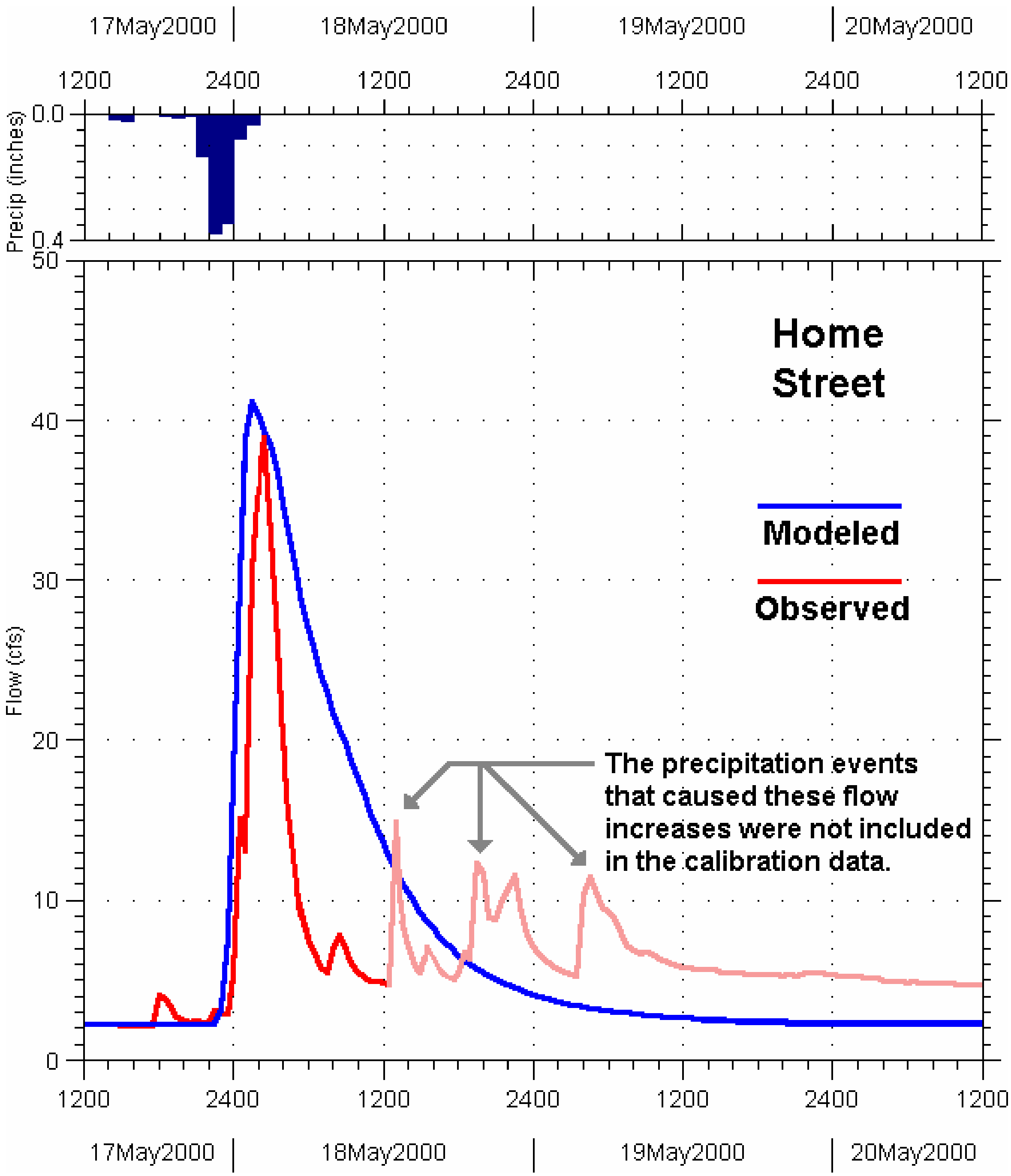

Figure B6: Home Street: May 17-18, 2000 storm

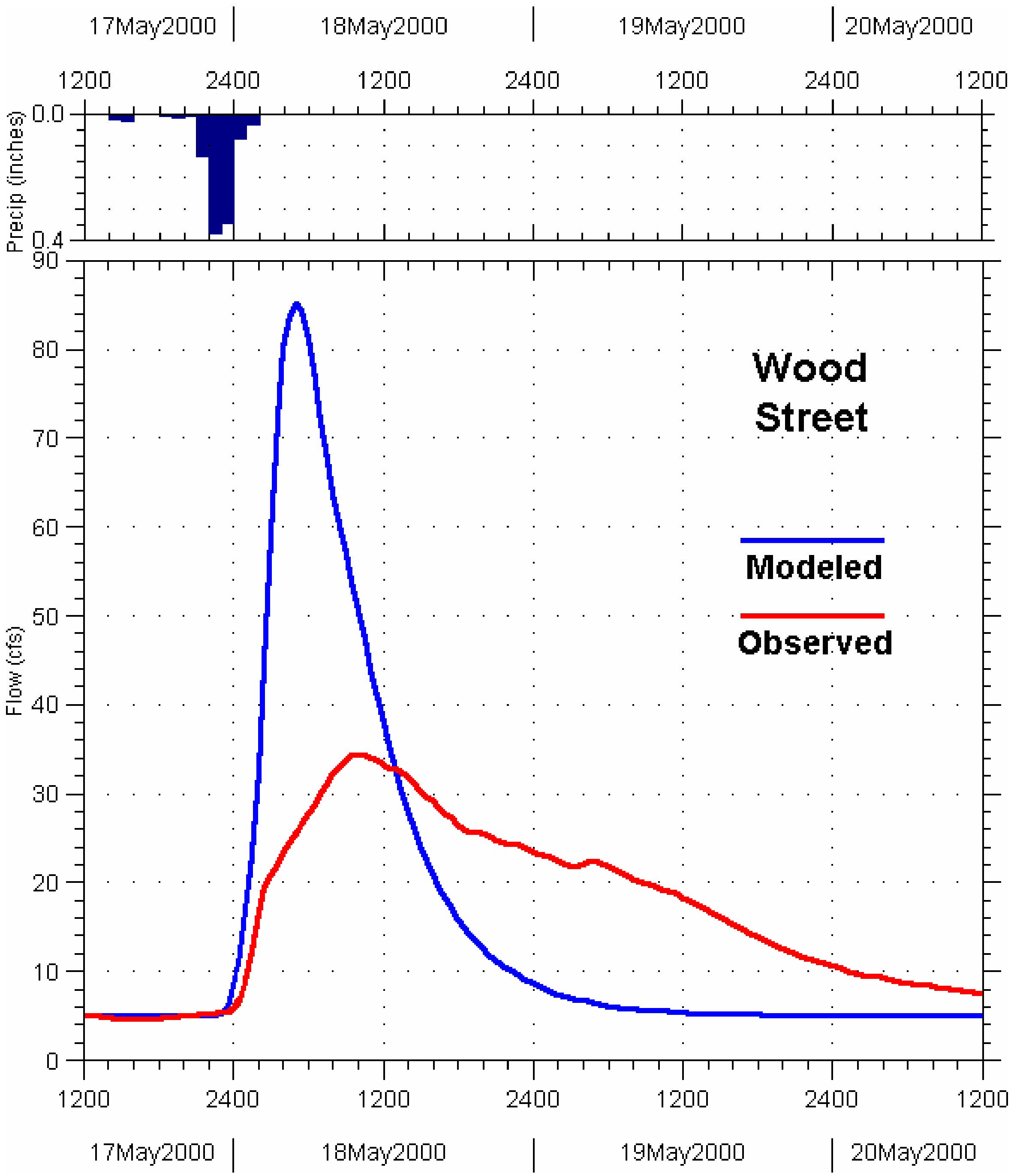

Figure B7: Wood Street: May 17-18, 2000 storm; lag routing method (no wetland storage)

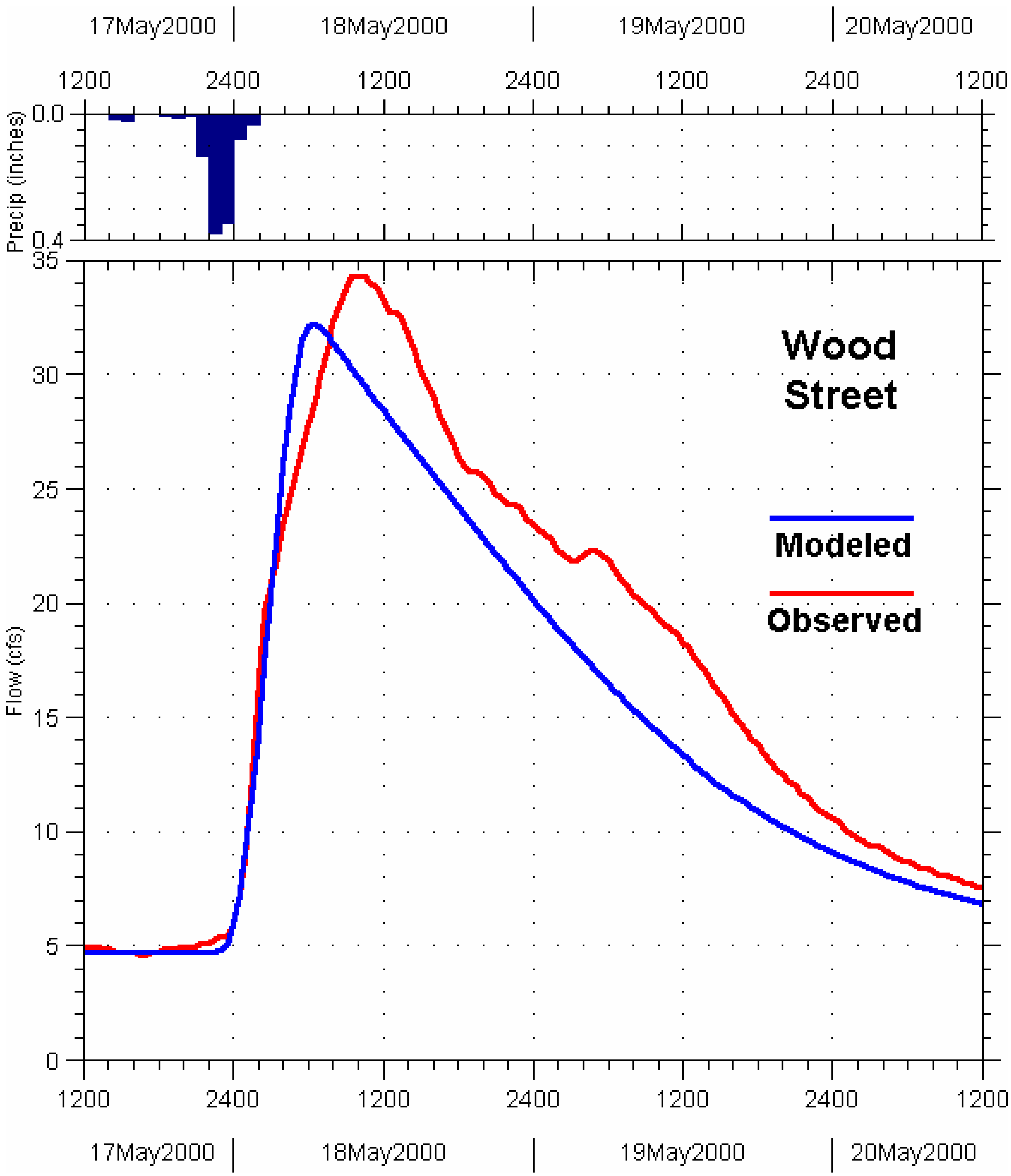

Figure B8: Wood Street: May 17-18, 2000 storm, wetland storage function added

Appendix C: Comparison of Current Model and Prior Model Results

Tables C1 through C6 are a comparison of the model results for the current version of the Ryerson Creek model as compared to the results published in the December 2000 report *Stormwater Management Plan for the Ryerson Creek Watershed, Muskegon County, Michigan*.

Tables C1 through C3 compare the predicted peak flows from each subbasin for the 1978, 1997, and build-out land use scenarios, respectively. These values represent the peak flow contribution from the subbasins, not the flow in the creek. Direct comparisons of the results from the Round Marsh Drain, Holland Drain, and M46 subbasins are not possible since these subbasins were split in the current model.

Tables C4 through C6 compare the predicted peak flows in Ryerson Creek for the 1978, 1997, and build-out land use scenarios, respectively. These flows represent the peak flow for selected locations in the creek.

The current model generally predicts lower peak flows than the former model. This is due to reduced total rainfall values for most of the precipitation events, increased modeled values for the storage coefficient and initial loss, the addition of the storage functions of the wetlands, and modeled refinements in the curve numbers, times of concentration, and lag values.

Table C1: Predicted Peak Flows from each Subbasin, 1978 Land Use

Subbasin	Peak Flow (cfs) from 50% chance 24-hour storm		Peak Flow (cfs) from 10% chance 24-hour storm		Peak Flow (cfs) from 1% chance 24-hour storm*	
	Current model	Prior model	Current model	Prior model	Current model	Prior model
Mouth	44	67	113	140	265	257
Wood	21	119	57	274	143	536
Getty	15	225	62	529	195	1045
Home	32	128	101	272	271	504
Lower Round Marsh Drain	3	26	21	67	86	143
Upper Round Marsh Drain	1		6		28	
Lower Holland Drain	12	4	43	16	124	44
South Holland Drain	6		24		76	
Upper Holland Drain	5		21		70	
Lower M46	9	25	23	83	53	204
Upper M46	1		9		38	

**The model does not include the hydraulic capacity of the storm sewers, which are generally sized to handle a 10 percent chance storm.*

Table C2: Predicted Peak Flows from each Subbasin, 1997 Land Use

Subbasin	Peak Flow (cfs) from 50% chance 24-hour storm		Peak Flow (cfs) from 10% chance 24-hour storm		Peak Flow (cfs) from 1% chance 24-hour storm*	
	Current model	Prior model	Current model	Prior model	Current model	Prior model
Mouth	44	63	113	134	265	250
Wood	21	119	57	275	143	536
Getty	17	243	66	555	203	1079
Home	35	146	107	296	280	533
Lower Round Marsh Drain	2	35	18	82	77	164
Upper Round Marsh Drain	1		6		28	
Lower Holland Drain	6	7	28	23	97	55
South Holland Drain	7		26		79	
Upper Holland Drain	6		23		73	
Lower M46	10	31	24	95	55	223
Upper M46	2		11		42	

**The model does not include the hydraulic capacity of the storm sewers, which are generally sized to handle a 10 percent chance storm.*

Table C3: Predicted Peak Flows from each Subbasin, Build-out Land Use

Subbasin	Peak Flow (cfs) from 50% chance 24-hour storm		Peak Flow (cfs) from 10% chance 24-hour storm		Peak Flow (cfs) from 1% chance 24-hour storm*	
	Current model	Prior model	Current model	Prior model	Current model	Prior model
Mouth	52	59	125	128	280	243
Wood	26	119	66	275	156	536
Getty	17	281	66	609	203	1146
Home	46	175	126	333	558	575
Lower Round Marsh Drain	14	84	48	149	138	250
Upper Round Marsh Drain	3		14		46	
Lower Holland Drain	48	29	100	58	207	105
South Holland Drain	19		48		114	
Upper Holland Drain	15		42		105	
Lower M46	19	116	36	225	69	395
Upper M46	9		26		70	

**The model does not include the hydraulic capacity of the storm sewers, which are generally sized to handle a 10 percent chance storm.*

Table C4: Predicted Peak Flows at Selected Ryerson Creek Locations, 1978 land use

Location	Peak Flow (cfs) from 50% chance 24-hour storm		Peak Flow (cfs) from 10% chance 24-hour storm		Peak Flow (cfs) from 1% chance 24-hour storm	
	Current model	Prior model	Current model	Prior model	Current model	Prior model
Mouth	44	273	113	679	344	1319
Wood Street	32	254	100	657	343	1275
Getty Street	31	225	110	586	356	1138
Home Street	40	49	128	272	371	505
Center Street	22	27	90	73	290	160

Table C5: Predicted Peak Flows at Selected Ryerson Creek Locations, 1997 land use

Location	Peak Flow (cfs) from 50% chance 24-hour storm		Peak Flow (cfs) from 10% chance 24-hour storm		Peak Flow (cfs) from 1% chance 24-hour storm	
	Current model	Prior model	Current model	Prior model	Current model	Prior model
Mouth	44	333	113	711	341	1361
Wood Street	32	320	100	692	340	1319
Getty Street	31	292	109	622	351	1183
Home Street	36	146	115	296	350	534
Center Street	18	38	80	91	270	186

Table C6: Predicted Peak Flows at Selected Ryerson Creek Locations, Build-out land use

Location	Peak Flow (cfs) from 50% chance 24-hour storm		Peak Flow (cfs) from 10% chance 24-hour storm		Peak Flow (cfs) from 1% chance 24-hour storm	
	Current model	Prior model	Current model	Prior model	Current model	Prior model
Mouth	53	381	154	780	448	1453
Wood Street	53	368	154	761	447	1414
Getty Street	62	340	173	691	477	1279
Home Street	104	176	241	340	558	600
Center Street	75	95	189	173	455	293