Chapter 4: Urban Areas Analysis

4.1 Introduction to the Evaluation of the Cass River Urban Areas

In the Cass River Watershed a decision was made to determine the effects of the urban areas in this rural watershed. The majority of the landuse in the watershed is agriculture (57%), the urban/residential area accounts for 7.6% of the landuse. The urban areas selected to be studied were (in upstream to downstream order) Village of Cass City, City of Caro, City of Marlette, City of Vassar, Village of Millington, City of Frankenmuth, and Bridgeport Charter Township. The communities of Ubly and Tuscola were not considered in this section of the report because of their location at the headwaters of the watershed and small urban area impact, respectively. The assessment of the effect of urban areas on the Cass River was done by use of EPA-SWMM and a Survey of managerial and structural BMPs in the selected communities.

The computer models would provide an opportunity to determine the hydrologic and hydraulic impacts to the river at the urban locations or in the drains that lead from the urban area to the river as is the case with Marlette and Millington. They would also provide a simulation tool to determine stormwater impacts from urban areas.

The survey of managerial and structural best management practices was done to provide a baseline for what practices were existing in the watershed. After assessment the opportunity is then present to determine what additional, low cost practices could be used to decrease urban stormwater impacts on the Cass River and its watershed.

4.2 Hydrologic and Hydraulic Model Development

One goal of the Cass River Watershed Management Plan (WMP) was to determine the impact developed areas had on the watershed. By defining the stormwater contributions of these developed areas within the watershed, a relative level of impact could be ascertained. To create such an analysis, models were constructed to estimate outflow hydrographs for each of the developed areas within the watershed under various precipitation scenarios. The following sections outline the methodology used to develop these models.

a. Available Data

Key to any model is the data used to create it. For the Cass River WMP, the first step in model development was identifying what information was available. Information for communities in the Cass River Watershed included USGS topographic information, aerial photography, and drainage maps. Table 4.1 shows what information was available for each of the communities analyzed.

Table 4.1: Available background information for communities in the Cass River Watershed.

Developed Area	Available Data		
	USGS Maps	Aerials	Drain Maps
Bridgeport	Yes	Yes	Digital
Cass City	Yes	Yes	Paper
Caro	Yes	Yes	Paper
Frankenmuth	Yes	Yes	Digital
Mayville	Yes	Yes	No
Millington	Yes	Yes	No
Vassar	Yes	Yes	No

In those areas without drainage maps, field visits were conducted to identify the approximate location and size of main-line storm sewers and outfalls. It is important to note that pipe invert elevations were not readily available for any of the communities examined. Furthermore, the amount of field survey required to obtain pipe inverts in all of the developed areas was found to be prohibitively expensive. Modeling decisions and assumptions were made to compensate for incomplete data. The following section outlines the process used to select a computer model capable of estimating stormwater runoff from developed areas in the Cass River Watershed.

b. Model Selection

There are several computer programs which can be used to calculate runoff from urban development. A list was compiled of hydraulic and hydrologic models which could be considered for calculating urban runoff. This list, shown below in Table 4.2, compared each of the programs based on their individual capabilities. These capabilities were broken down into individual aspects of urban runoff calculations which included hydrology, flow routing, hydraulics, and infiltration.

Table 4.2: Capabilities of computer modeling programs.

Capability	Microsoft Excel Spreadsheet	HEC-RAS	Culvertmaster & Flowmaster	HY-8	EPA SWMM	Civil 3D Storm & Sanitary Analysis
Hydrology	Modified Rational	N/A	Rational	N/A	SCS Curve Number	Rational
			Peak Discharge		Excess Precipitation	Modified Rational
			SCS Curve Number			DeKalb Rational
						SCS Curve Number
						Excess Precipitation
						TR-20
						TR-55
						Santa Barbra UH
						HEC-1
Flow Routing	Steady Flow	Steady Flow			Steady Flow	Steady Flow
		Kinematic Wave			Kinematic Wave	Kinematic Wave
					Dynamic Wave	Dynamic Wave
Hydraulics	Manning's	Manning's	Manning's	Manning's	Manning's	Manning's
		Weir	Darcy-Weisbach	Weir	Weir	Weir
		Energy	Hazen-Williams	Energy	Darcy-Weisbach	Darcy-Weisbach
		Momentum	Kutter's Formula		Hazen-Williams	Hazen-Williams
			Energy		Energy	Energy
					Momentum	Momentum
Infiltration	N/A	N/A	N/A	N/A	Green-Ampt	Green-Ampt
					Horton	Horton

To select a model, a set of criteria was developed which could be used to rank each of the computer programs listed in Table 4.2. These criteria included model flexibility, available hydrology methods, hydraulic and flow routing capabilities, ease of use, familiarity and acceptance by the professional community, ease of system alteration, applicability to future projects, output quality, ease of comprehension by the public, and ability to incorporate available data. These criteria were then ranked on a scale of 1-10 as shown below in Table 4.3.

Table 4.3: Selection criteria for available urban stormwater models.

Criterion	Microsoft Excel Spreadsheet	HEC-RAS	Culvertmaster & Flowmaster	HY-8	EPA SWMM	Civil 3D Storm & Sanitary Analysis
Flexibility	3	3	1	4	8	10
Hydrology Methods	1	1	1	1	8	10
Hydraulics/Routing	1	6	8	8	10	10
Familiarity/Acceptance	8	10	7	8	10	6
Ease of Alteration	8	3	10	9	7	8
Future Applicability	3	1	2	2	10	8
Output Quality	1	5	2	3	7	9
Ease of Comprehension	4	5	7	7	8	8
Data Incorporation	4	1	7	7	9	10
Total	**33**	**35**	**45**	**49**	**77**	**79**

Based on the selection process outlined above in Table 4.3, AutoCAD Civil 3D Storm and Sanitary Analysis (AutoCAD SSA) was selected as the optimum program for developing stormwater models for developed areas in the Cass River Watershed. This program used the EPA SWMM platform and expanded it to include additional hydrologic computation methods. Furthermore, AutoCAD SSA provided a simpler graphical user interface than SWMM and allowed for simple integration of AutoCAD files as design base maps. This allowed existing CAD storm sewer maps to be easily scaled and included in the model development. An added benefit is that the AutoCAD SSA file could be saved in a SWMM format. This would allow virtually anyone to view the models using EPA SWMM which is available free from the Environmental Protection Agency (EPA).

c. Model Parameters

Development of stormwater models required certain key parameters be identified which impact runoff from storm events. The most obvious of these was rainfall data. The AutoCAD SSA model allowed for user-defined rainfall hyetographs to be input and converted to runoff on an time-varied basis. Total runoff volumes were contingent on the area over which rainfall was applied and the imperviousness of the land surface. Imperviousness and subsequent runoff volumes can be computed in several different ways as shown in Table 4.2. Next, AutoCAD SSA required individual sub-basins to be identified. These sub-basins were then assumed to convey overland flow to a specific design point such as a catchbasin inlet. Flow was then routed through the system via a pipe network developed from a combination of site inspections and available storm sewer maps. The following sections provide a more detailed explanation of the processes used for calculating runoff.

d. Hydrology

AutoCAD SSA, like EPA SWMM, calculated runoff based on excess rainfall. This was done by calculating an infiltration rate for a specific catchment and subtracting the infiltration rate from the rainfall rate. The difference in these values was assumed to be converted to runoff. Therefore, the two key factors which impacted runoff were rainfall rate and soil infiltration rate. For the Cass River Watershed, a 24-hour SCS Type II rainfall distribution was selected as is commonly used in Michigan. Total rainfall volumes for each of the storms analyzed was taken from Midwestern Climate Center, Bulletin 71 titled "Rainfall Frequency Atlas of the Midwest." Rainfall was converted to runoff volume using the SCS curve number method. Runoff volume was then applied to a dimensionless unit hydrograph to obtain an outflow hydrograph. The standard SCS unit hydrograph used a peaking factor of 484 however, this peaking factor has been shown to be lower in Michigan due primarily to the flat slopes prevalent in the lower part of the state. The unit hydrograph selected for the Cass River Watershed was obtained from the Michigan Department of Environmental Quality (DEQ) spreadsheet for to estimating high flow hydrographs in Michigan waterways. When entered into the AutoCAD SSA program, the peaking factor was shown to be 367.81 with 28.5% of total rainfall volume occurring on the rising limb of the hydrograph.

It is important to note the manner in which AutoCAD SSA utilized the DEQ unit hydrograph. In each sub-basin, separate SCS calculations were performed for each time step and for each incremental rainfall volume in the rainfall hyetograph. Each of these incremental rainfall volumes was then applied to a unit hydrograph. The composite of all of the unit hydrographs was then produced as the outflow hydrograph for that particular sub-basin. The difference between total rainfall volume and runoff volume was assumed to be infiltration. This calculation was performed simultaneously for all sub-basins in the model. Outflow hydrographs were then routed through the conveyance system constructed in the model to determine a composite hydrograph at the outlet. Note this method of applying the SCS method for individual sub-basins as opposed to determining a composite curve number for an entire watershed, tends to over-predict peak flows. However, this method was used as it can be easily adjusted to include infiltration best management practices (BMPs).

The routing calculation in AutoCAD SSA incorporates travel time into its determination of runoff volume. This travel time to a given point, also known as the "time of concentration," was determined based on the length of the longest flow path to the outlet. In rural areas, time of concentration was based on an average velocity of 1.0 ft/sec. For urban areas, the average velocity was increased to 2.0 ft/s and in those areas that were only partially urbanized, a velocity of 1.5 ft/s was used. Travel time in hydraulic conduits (e.g. - pipes and open channels) was calculated based on AutoCAD SSA's hydraulic calculations.

e. Hydraulics

AutoCAD SSA is capable of performing complex hydraulic calculations for large systems of pipes and channels. Flow and depth calculations in the models created for the Cass River WMP utilize the hydrodynamic wave equation (a.k.a. - full set of Saint-Venant equations). This is one of the most robust methods of calculating flow as it accounts for both energy and momentum when water surface elevations and slopes. In systems where water may split and flow in multiple directions, momentum is used to determine the relative amount of flow in each direction. In cases where pipes became pressurized, the model used the Hazen-Williams equation. Despite the precision of the equations used to calculate system hydraulics, model accuracy was ultimately limited by the data available and the assumptions made in regions where data were lacking.

f. Assumptions

Models developed for the Cass River Watershed Management Plan used the best data available. When possible, data gaps were filled through field verification and inspection. However, in some instances, project constraints made data gathering impractical. In such instances, assumptions were made to simplify the models while still maintaining model quality.

Pipe slope and invert data were not readily available for communities in the Cass River Watershed. Therefore, pipes were assumed to run at minimum slopes as outlined in Table 4.4. This method would tend to under predict hydraulic capacity during low-flows. However during large events where pipes were surcharged, hydraulic head would dictate pipe capacity and therefore, slope would have a less substantial impact on overall capacity. Also, in instances where field observation or available profile data made it obvious that slopes were steeper than the minimum, slopes were increased accordingly.

Table 4.4: Minimum pipe slopes.

Pipe Diameter (in)	Minimum Slope
6	0.0056
8	0.0044
10	0.0032
12	0.0026
15	0.0020
18	0.0016
21	0.0014
24	0.0012
>24	0.0010
Open Channel	0.0010

Another key assumption in the Cass River WMP models dealt with ground elevation and surface ponding. The ground surface was assumed to be 6.0 feet above the lowest pipe invert at a particular node. In instances where the pipe size or channel depth was greater than 6.0 feet, the ground elevation was assumed to be at the top of the pipe or channel. During large runoff events, flow often exceeded the capacity of drainage systems and water rose above the established ground surface elevation. If ponding were ignored in AutoCAD SSA, flow which surcharged above the ground surface would have been lost and would never have re-entered the system. Additionally, by ignoring ponding, the water surface elevation (hydraulic grade line) would never have been permitted to exceed the surface elevation. Therefore, as a typical assumption, ponding was allowed in the AutoCAD SSA models in an area of 300 ft^2 which is roughly equivalent to a circular area of 20 feet in diameter. Water was allowed to create head by rising within this 300 ft^2 above the ground surface (15 feet). The exception to this was when it was obvious a low area or detention pond provided storage for surcharged pipes. In these locations, a depth-storage relationship was developed based on visual observation and measurements on aerial photographs.

Assumptions also had to be made regarding the hydraulic characteristics of conduits within each drainage model. First, all conduits were assumed to be in good condition and unobstructed. Pipes were assumed to be concrete and have a Manning's coefficient of 0.013. Since most of the pipes in the models were part of municipal storm sewer systems rather than culvert crossings, corrugated metal pipe was uncommon. Though some small pipes were plastic, their Manning's coefficients were assumed to have relatively little deviation from that of concrete. Furthermore, large pipes which have the greatest impact on overall system discharge are generally concrete. For open channels, a Manning's coefficient of 0.035 was assumed. This indicated that channels were relatively well-maintained and did not have significant flow obstructions. All open channel banks were assumed to slope at 2 horizontal to 1 vertical. Based on visual observation, these assumptions appeared to have been accurate in most locations.

In addition to friction losses in conduits, head loss also occurs at entrance and exit locations. An entrance loss of 0.5 was assumed for all conduits which was typical of square-edged inlets and was estimated to be an average headloss situation. Exit losses were taken to be 1.0 at all junctions. This assumption meant that flow was assumed to stagnate in each junction and kinetic energy was not carried from one conduit to the next. This is generally true in areas where flow is not transferred in a straight line either due to turbulence, a bend, or backwater. Due to the complexity of the urban systems in the Cass River Watershed, it was reasonable to assume that multiple inlet pipes in manholes generally caused turbulence sufficient to create exit losses near 1.0. Additionally, backwater was prevalent in high-flow scenarios which would have impeded flow from one conduit to the next.

At locations where urban drainage systems connected to receiving waterways (e.g. - Cass River), outfalls were assumed to function at normal depth. By making this assumption, tailwater conditions were allowed to rise and fall with changing flows. It was important to note that some of the outfalls from communities located immediately adjacent to the Cass River have flap gates. When the Cass River is high at these locations, the flap gates will be closed and therefore, stormwater would not be able to exit the system by the force of gravity. For the purposes of developing general models for urban communities however, high tailwater conditions were not considered. Because small urban areas convey stormwater flows more quickly than large rural areas, it would be likely peak flows from urban areas would have passed into the Cass River before the river itself reached its peak. This is because the Cass River has a large contributing area relative to urban communities within its watershed and a similarly large time of concentration.

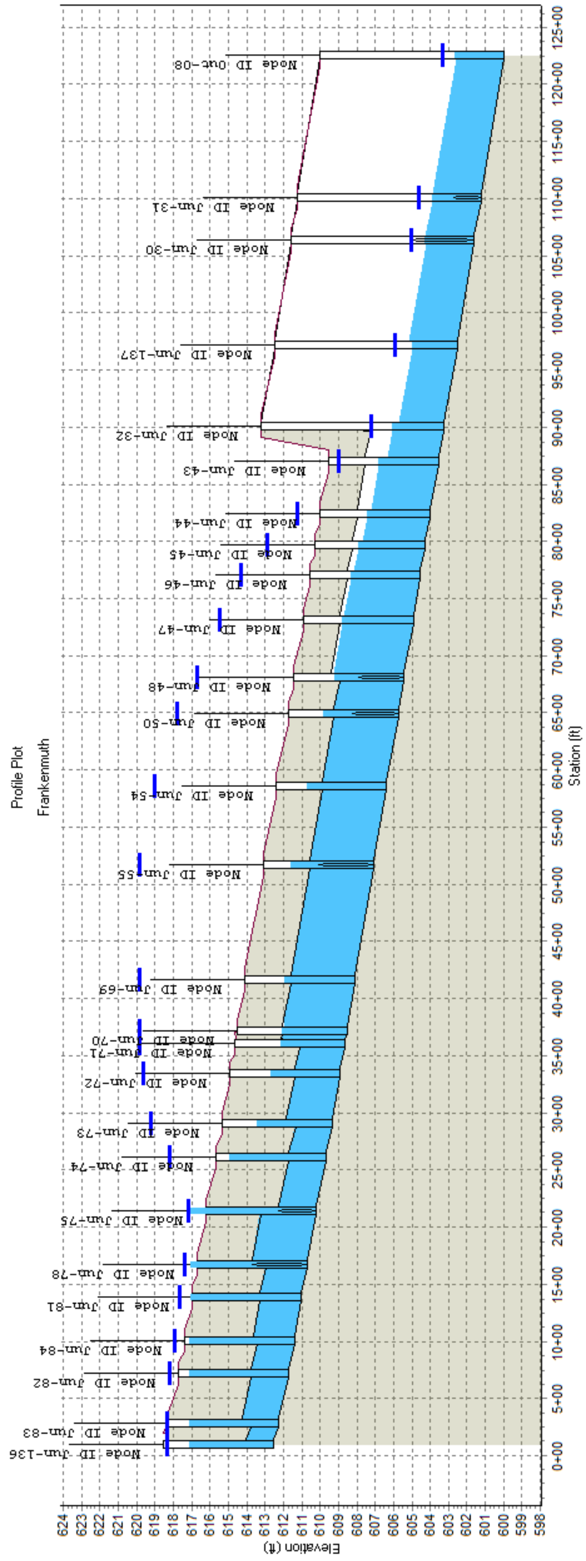
4.3 Model Results

With these assumptions and the methodology outlined above, stormwater models were developed using AutoCAD SSA. Specific results of this analysis are outlined in the following sections.

a. Hydraulic Profiles

As discussed previously, the intent of the AutoCAD SSA model was to show the relative level of stormwater impacts from each of the communities evaluated. Assumptions were made regarding pipe slopes and ground surface elevations were approximated. Therefore, hydraulic profiles generated in AutoCAD SSA do not accurately represent field conditions. They are, however, useful for determining locations where pipe restrictions are likely to cause flooding or to identify areas where high hydraulic head is needed to pass certain storm events. Additionally, hydraulic profiles can be used to verify the model is properly permitting nodes to surcharde and build hydraulic head. An example of a hydraulic profile generated by AutoCAD SSA is shown in Figure 4.1.

Figure 4.1: Sample hydraulic profile from AutoCAD SSA.



b. Urban Impact

There are three major facotrs impacting the volume and rate of runoff generated from urban areas: watershed area, hydraulic connectivity (time of concentration), and portion of water infiltrating (runoff curve number). These factors aggregate to create an outflow hydrograph from a given urban area. Table 4.5 shows the first of these factors: drainage area.

Table 4.5: Drainage area comparison.

Modeled Drainage Area (Acres)						
Bridgeport	**Caro**	**Cass City**	**Frankenmuth**	**Mayville**	**Millington**	**Vassar**
1,406	1,329	1,169	2,364	398	863	1,330

The second factor contibuting to cumulative outflow from a community is time of concentration. Areas with high levels of hydraulic connectivity cause runoff from various subwatersheds to quickly comingle and create high peak flows that occur over a short period of time. Conversely, areas with low connectivity, such as those with significant amounts of overland flow and meandering natural channels, have subwatershed peaks which generally do not coincide. Therefore, these systems with low connectivity will generally have a high time of concentration and reduced peak flow.

Figure 4.2 and Figure 4.3 show a comparison of a community with low connectivity (Bridgeport) and a community with high connectivity (Millington). The thin, light colored lines represent outflows from subwatersheds within the community and the thick dark colored lines represent composite community outflow hydrographs.

Figure 4.2: Subwatershed hydrographs (light lines) and composite outflow hydrograph (dark line) for Bridgeport.

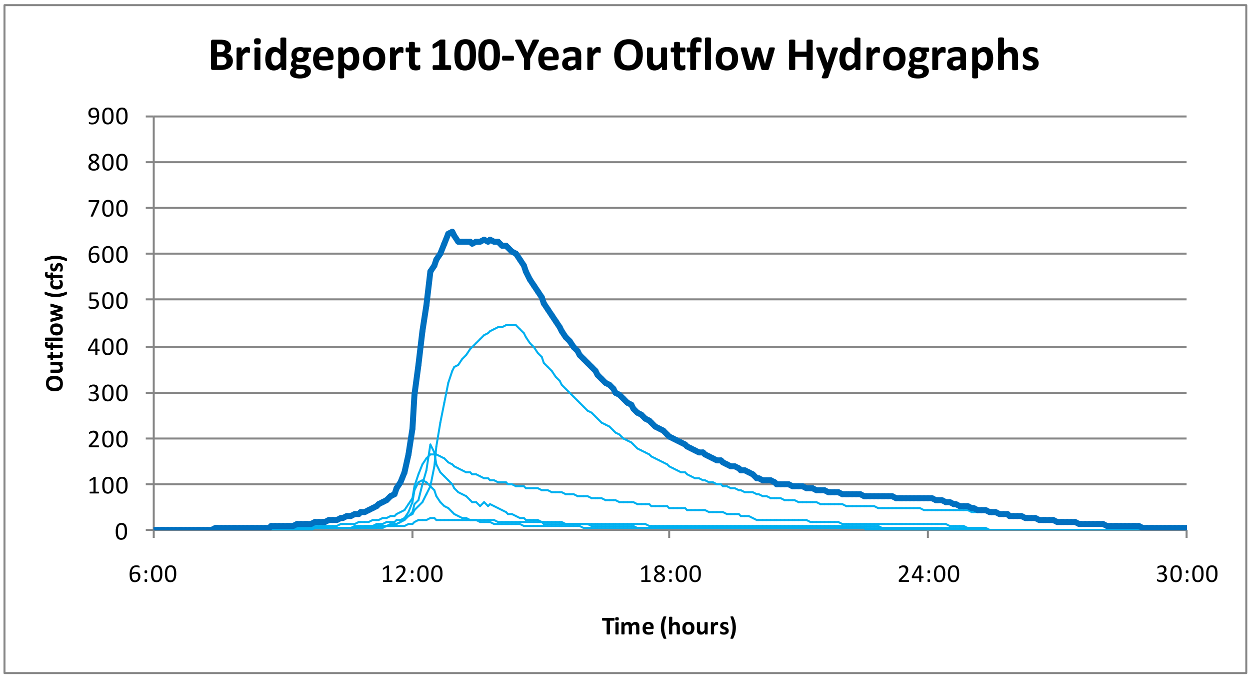
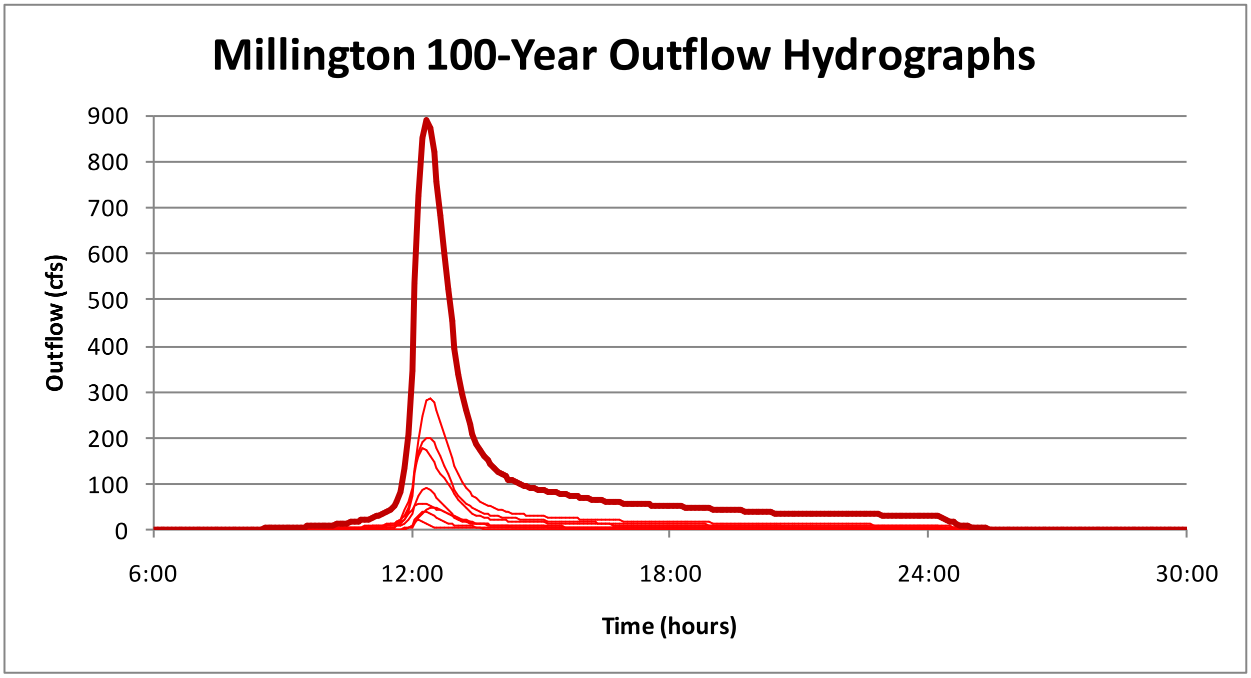


Figure 4.3: Subwatershed hydrographs (light lines) and composite outflow hydrograph (dark line) for Millington.



As shown in Table 4.5, Bridgeport has a drainage area nearly double that of Millington and also produces a greater total volume of runoff as demonstrated by the area under the composite hydrograph. Despite these facts, the stowm water models show a higher composite peak flow rate for Millington than Bridgeport. Since subwatersheds in the Millington model all have relatively short times of concentration, peaks occur at roughly the same and contribute to a higher overall peak flow rate.

The other factor contributing to both peak flow rate and runoff volume is the portion of rainfall that is allowed to infiltrate. Table 4.6 shows a comparison of runoff curve numbers which account for both impervious area and soil type. The curve numbers shown are a composite of subbasin curve numbers assigned throughut each community model.

Table 4.6 Runoff Curve number comparison

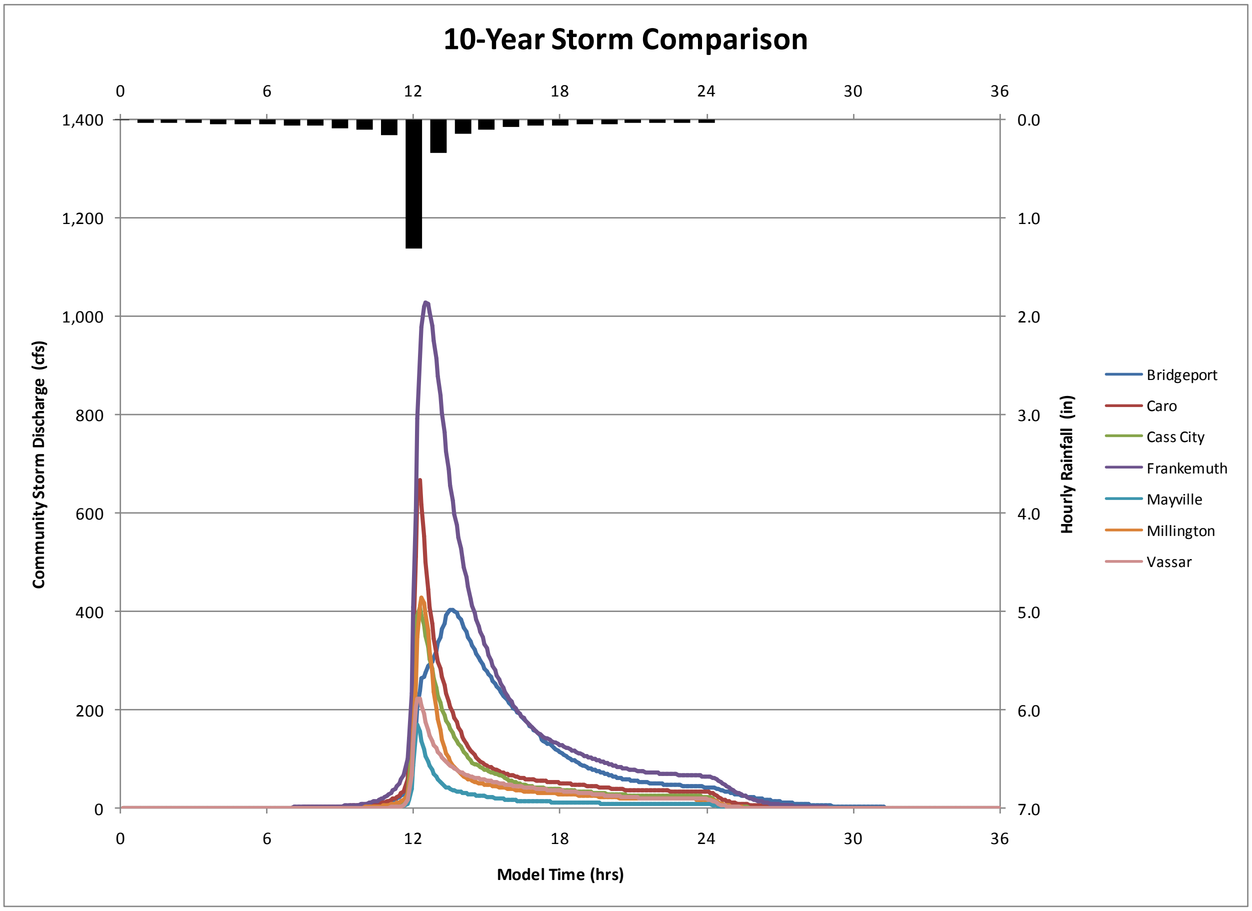
Composite Runoff Curve Number						
Bridgeport	**Caro**	**Cass City**	**Frankenmuth**	**Mayville**	**Millington**	**Vassar**
82.3	73.9	70.7	80.8	68.6	71.3	60.6

NOTE: The soils around Bridgeport are primarily from hydrologic soil groups C/D so impervious changes in percentage have little effect on the percent of stormwater runoff. Hydrologic soil groups of C & D are heavy soils that do not allow for much infiltration of stormwater runoff. Where as soil groups of A and B soils can readily absorb soils

c. Outflow Summary

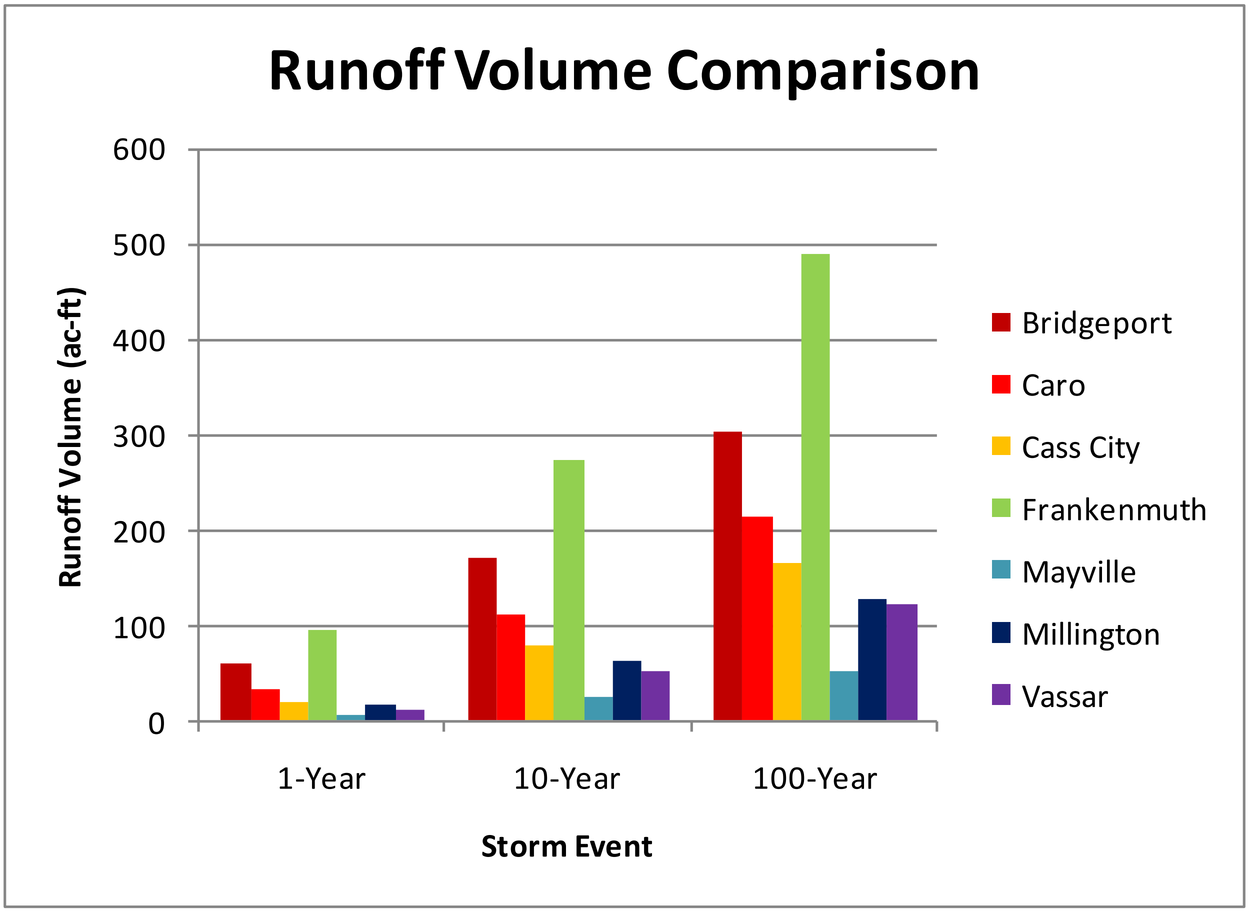
Overall outflow hydrographs for each community were generated by summing calculated discharges of all stormwater outfalls in a given community. The result of this analysis produced system-wide hydrographs for each of the communities. Hydrographs for the 10-year storm are shown to express the relative runoff of each of the municipalities evaluated. The remaining hydrographs are located in appendix D.

Figure 4.4: 10-year storm hydrographs from AutoCAD SSA.



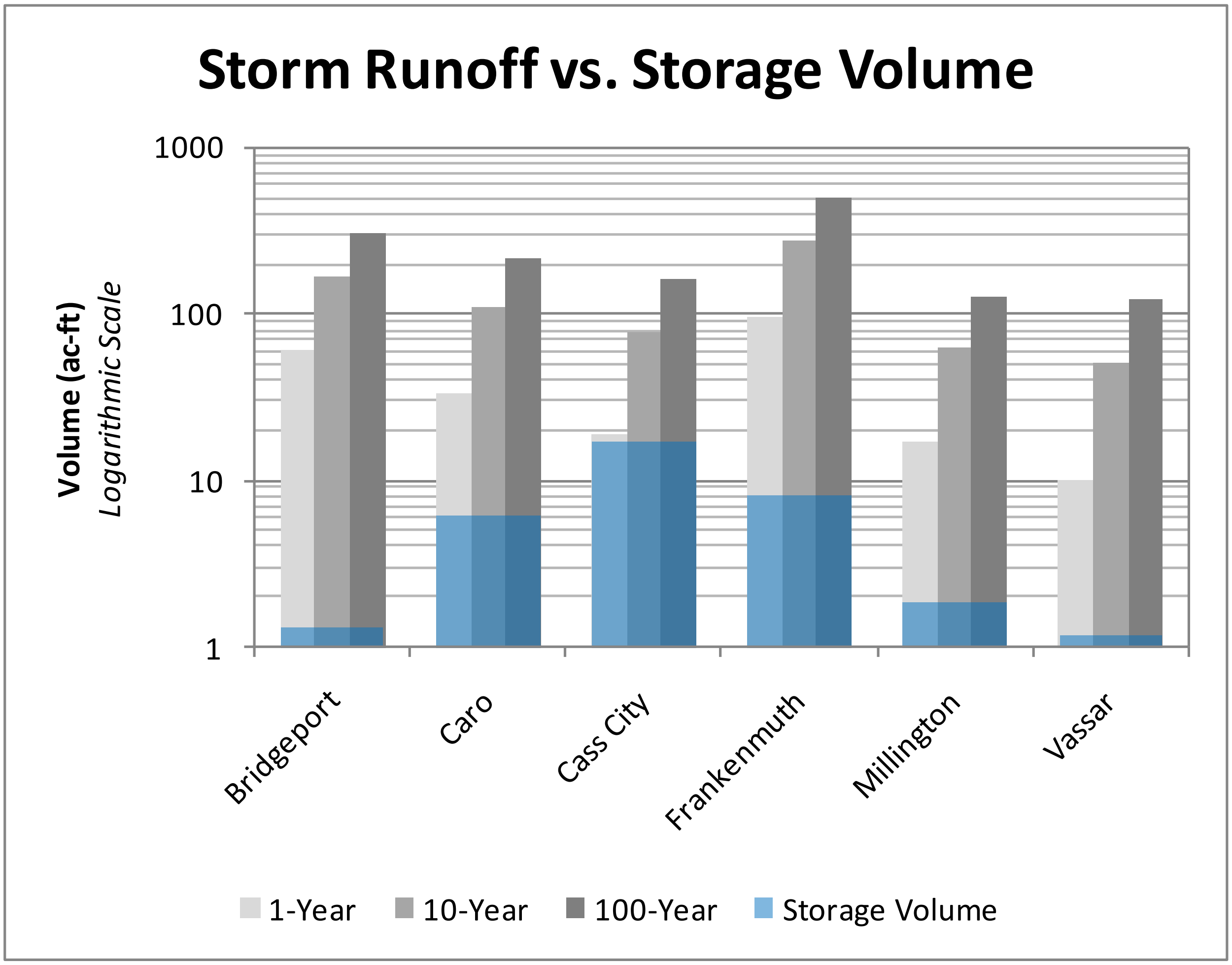
When evaluating the relative impact of each of the communities modeled, the hydrographs shown in Figure 4.4 demonstrate differences in peak flow (highest point on each curve) and total runoff volume (area under each curve). Figure 4.5 was developed to better show the relative volume of stormwater runoff from each community.

Figure 4.5: Comparison of runoff volumes from Cass River communities.



A field review of detention facilities allowed for an estimated volume of stormwater detention to be calculated for six (6) of the communities modeled. Figure 4.6 shows a comparison of various storm runoff volumes to estimated available detention volumes. In this figure, it is important to note the storage volume available in Cass City does not service all of the stormwater outfalls. Therefore, the amount of stormwater actually detained will be less than the total volume of storage available.

Figure 4.6: Comparison of modeled stormwater runoff to estimated detention capacity.



4.4 Urban Area Survey of Existing Managerial and Structural Best Management Practices

The urban areas surveyed were established communities in rural areas of the Cass River Watershed. The municipalities to be surveyed were determined by the steering committee. These communities were established in the mid to late 1800s and their populations range from 1,200 to 7,800 residents with the average of population of 3,600. The smallest community surveyed was Millington at 1,200 residents and the largest was Bridgeport Charter Township. Caro and Frankenmuth had the larger urbanized areas of the communities.

The survey included two phases, the first phase was a phone survey to discuss managerial practices in a community. The questions posed were to determine if there was a site review process in place that dealt specifically with storm water management. Results are summarized in Table 4.7.

- Did every site have a plan review for storm water management before construction?
- Was there an inspection of the site after construction by an engineer or the communities building or public works staff?

- Was there a specific ordinance or established regulatory procedure in place within the community?

The second phase consisted of a windshield survey of the community with a checklist sheet to determine which sites had storm water management practices in place when they were constructed. This portion of the survey was completed by a professional civil engineer with experience in developing storm water management plans for communities, reviewing site development plans for storm water management, and performing site inspections of storm water management plans after construction. The checklist for the survey was developed for the steering committee and presented for review and comments. The comments were incorporated into the survey sheet and then a field trial was completed and modifications to the form were completed based on field use and application. The survey forms, when completed for a community, then had the data placed into GIS to develop a map of the community showing the location of storm water BMPs and detention areas. Results are summarized in Table 4.8.

Table 4.7: Summary of storm water review process.

Urban Area	**Review & Approval Process**	**Post Construction Inspection**	**Written Design Standards** **MDOT - Michigan Dept. of Transportation** **TCDC – Tuscola County Drain Commissioner** **SCT - Saginaw Charter Twp.**	**Established discharge rate and detention volume**
Cass City	No (Yes for MDOT & TCDC)	No	Only MDOT & TCDC	Yes
Caro	Yes	Yes	City, MDOT, TCDC	Yes
Marlette	Unknown	No	Unknown	Unknown
Millington	Yes	No	MDOT; TCDC	Yes
Vassar	Yes	No	MDOT; TCDC	Yes
Frankenmuth	Yes	Yes	Yes - ordinance	Yes
Bridgeport	Yes	Yes	MDOT; SCT	Yes

Table 4.8 Summary of Urbanized Areas Windshield Survey, Cass River Watershed

Community (n)	Percent Impervious	Grading	Catch basins w/sumps	Vegetated swales	Inlet grates marked[6]	Erosion protection	Detention Basins	Storage Volume (ft^3)	Bio Swale/ Rain Garden
Bridgeport (92)	70%	95%	46%[5]	51%	1%	35%	10%	58,000	1%
Caro (43)	69%	98%	72%	70%	12%	65%	56%[1]	263,600	Yes[4]
Cass City (29)	51%	100%	72%	38%	3%	28%	24%	752,300[2]	No
Frankenmuth (79)	77%	99%	100%	19%	18%	87%	57%	349,300[3]	No
Marlette (26)	26%	96%	81%	38%	23%	15%	35%	102,000	No
Millington (14)	72%	86%	57%[5]	64%	0%	14%	29%	80,000	1%
Vassar (54)	73%	98%	38%[5]	49%	11%	32%	17%	51,000	No

[1] Included two retention basins that use infiltration practices on their sites.

[2] This number is high because of a discharge into a man-made lake with a lot of storage capacity; site could become a regional basin.

[3] Frankenmuth has a long history of storm water management planning and a significant amount of development since the planning has been in effect.

[4] Spicer Group designed one for a site in Caro; it was in residential area that was not surveyed.

[5] Many sites did not have catchbasins on them; they were small areas and were graded to drain to the street storm drains or to an offsite drainage system.

[6] Indicative of older vs newer development, the marked inlet grates did not make an appearance until after 2003, since approximately 2009 most inlet grates now have at least "Dump No Waste" as part of the casting. Therefore if a community has 0% it probably indicates little to no new development.

a. Existing managerial BMPs

The urban areas surveyed were familiar to the person completing the survey. There was existing knowledge of the procedures in place for new development or redevelopment in the communities that were assessed. In this review of new development and redevelopment in urban areas, it must be determined who has jurisdiction over the outlet for the area being developed. For example, if a development is along a state highway with a storm drain system; then the Michigan Department of Transportation (MDOT) has jurisdiction over the point source to assure the design capacity of the storm drain is not exceeded. If the stormwater discharge is to an established county drain, then the county drain commissioner, county public works commissioner or their designee has jurisdiction over the point source and can enforce their design guidelines to assure the design drain capacity is not exceeded. If within city or village limits and the site discharges to a municipal separated storm sewer system (MS4) then the city or village can invoke their established design guidelines. Some communities and counties have a Civil Engineering Consultant perform a review of plans to assure the storm water design criteria are met at the site. This review is typically done with an established written design guideline procedure; some reviews are completed based on “established engineering practices” which can vary widely based on the review engineers experience with stormwater reviews, knowledge of urban area, and other variables.

b. Structural Best Management Practices

These urbanized areas in the Cass River Watershed were basically all similar in the establishment of the best management practices for each community. The communities had a central urban core with a storm water collection system based on grading and collecting storm water runoff and moving it away from the commercial district. The systems were generally older drainage systems and probably nearing life expectancy. Some of the systems would be considered undersized by today’s design standards, but appeared to be functioning for most low frequency storm events.

Typically, what was visualized in the central urban areas were catch basins, with sumps to collect larger particles of sediment, the inlets were grated to prevent larger debris from entering the drainage system and being discharged to the river or county drain. Those communities that were in close proximity to the river, discharged directly to the river with no concerns for water quality, as that was not a concern when these areas developed their urban footprint. The river served as a means to convey the storm water away from the municipality.

The portions of the communities that developed in the late 1980s/early 1990s to present times displayed additional best management practices being utilized. The BMPs were providing a site plan review process for development for planned community growth. By implementing a storm water component in this site plan review process the following practices would become part of the review procedures:

- Establishing an allowable discharge rate for the site with outlet structures or restrictors in place.
- Establishing standard design criteria and a minimum design storm standard, e.g. 10yr (10% recurrence interval), 25yr (4% recurrence interval), 50yr (2% recurrence interval) or the 100yr (1% recurrence interval) design storms.
- Providing a standard method for determining detention/retention volumes to be stored on sites.
- Design standards for type of pipe, slopes and pipe sizing to assure conveyance of design storms.

These BMPs were primarily to assure drainage of new developments and to prevent flood or drainage problems as development occurred in the community. Some additional benefits to this type of planning occurred as the National Flood Insurance Program (NFIP) was implemented; communities could use their storm water planning to obtain discounts on flood insurance rates for their residents.

The newer construction from 2000 to the present demonstrates the use of more BMPs at sites. These site developments are on the approaches to the urban areas in the "outskirts" of the municipalities and tend to have grassed swales, more restrictive outlet structures for longer holding times, and the inlet grates that have "Dump No Waste", "Drains to River" in the casting as a permanent feature. Additionally, these newer sites tend to use more grading and additional catchbasins with sumps to capture and route storm water from the site to the collecting MS4. Some sites tend to use grading of parking lots that discharge to vegetated swales before entering the detention areas. The majority of these newer developments have completed a review process either from a municipal engineer, Tuscola County Drain Commissioner's office or the MDOT. There are some infiltrative practices in place but only two rain gardens were known to exist, one in Bridgeport and the other in Caro. See community maps in appendix D.

During this windshield survey for storm water BMPs, the detention basins were visible at the larger sites; some sites utilized parking lot detention if space for storage volume was at a premium. There were some sites that implemented underground storage, although these were in a community with high property values and an established storm water management ordinance in place for over 20 years. Underground storage is a good option when space is at a premium. The cost can be considerable and the developer needs to determine the economics of the site application. For example, the typical "open" detention basin has a cost of approximately $2.00 / cubic foot of storage volume; where as the underground system can range from $7.00 to $12.00 / cubic foot of storage.

4.5 Recommended BMPs for Storm Water Management

Communities go through great effort to manage their water and sanitary systems to assure they are developed in a manner consistent with future growth. However, stormwater is a forgotten utility, in many communities it is not planned adequately and is usually treated as an after-thought in site development. Many communities are now paying the price of having severely undersized stormwater conveyance systems or systems with mismatched pipe diameters or capacity issues. Engineers have experienced situations where a new development is discharging from a site with a 12 inch outlet into an 8 inch storm drain in the public street. Suddenly, there is flooding where none was present in the past.

The City of Frankenmuth addressed these issues in the 1990s and mapped the entire storm sewer system and determined the flow capacities of the existing system and their outlets to the Cass River. This planning effort has provided a detailed map of the community so when development occurs they know how much the development can safely discharge into the existing MS4 and how much stormwater must be detained on site and released slowly to prevent flooding. Many other communities are taking this approach as development has exceeded the capacity of existing MS4s.

a. Managerial BMPs

Municipalities and their planning commissions need to adapt storm water management guidelines for their community. There are many examples of basic managerial plans available, and an example of a storm water management plan and design guidelines is available in appendix D. Some local governments feel these guidelines hinder development. However, many communities have learned the hard way that unsupervised / unplanned development can quickly assure the utility infrastructure of a community is overwhelmed and inadequate for future growth.

In the watershed it is important for communities to develop a strategic growth/redevelopment plan for the older urban areas of a community. This provides opportunities to develop and implement storm water quality best management practices as redevelopment occurs in the downtown areas. This type of planning can help to wisely redevelop the business areas of small communities and address drainage problems that are present.

It is important that the communities have an active planning commission or a trained planning consultant who is familiar with watershed planning and how a community can impact a watershed. Additionally, the planning commissions or planning consultant must understand the economic and resource value of the watershed. They must become informed in order to establish a position of less urban area impact on the Cass River or the tributary system discharging into the Cass River.

Urbanized areas in the watershed should determine an allowable discharge rate for new development. This can be accomplished in a number of ways, but it is important to have an easily understood system to implement. It can be as simple as stating that no site shall discharge more than 0.15 cfs / acre and must detain the rest on site to slowly be released. Or, use the MDEQ recommended pre-development hydrology rates for the site as the release rate.

b. Recommended Managerial BMPs

Provide the municipal and township planning commissions with a short educational presentation on why storm water management is important to a community and the watershed.

Each Community should:

1. Plan and implement an Asset Management program for the storm water drainage system of the community. Funding is available for this under PA 511 of 2013 (see also HB 5673 of 2012). There is grant funds available for rural communities up to $1million with a 10% match
2. Implement a storm water management design guideline or procedures.
3. Develop a site review process that considers storm water quality and quantity; make sure the review process considers the water quality concerns of the Cass River Watershed Management plan. Have the site development or re-development’s storm water management plan reviewed by the municipal engineer.

4. Adopt storm water design standards and have them reviewed every 5 years for changes and adaptive management for the urban setting and watershed.
5. Determine the minimum BMP treatment train to improve storm water quality each new or redevelopment must have implemented on a site project to address:
    a. Quantity of discharge
    b. Quantity of storage
    c. Quality of storm water discharge (e.g. 80% sediment removal rate)
6. Have the design standards available on the community's website.
7. Inspect sites after construction is completed.
8. Each site must have an approved stormwater system maintenance plan.
9. Keep records of all site plan reviews.

In the site review process, communities should try to keep the process dynamic and look at some of the new evolving storm water technology developing across the United States. Or, research some of the innovative techniques being used in European urban areas. In Germany, it is typical to have zero discharge criteria for all parcels in a city. In other words the site cannot let stormwater leave its boundaries - it must collect and use the stormwater, not discharge it.

c. Structural Best Management Practices

Basic Best Management Practices

If a community adopts the basic storm water design guidelines then a minimum level of storm water BMPs will be established. Sites will be graded, have catch basins with sumps to collect sediment, inlet grates will have "Dump No Waste", "Drains to River" as part of the forging process. The rate of discharge and quantity stored will become standardized. The community can then look at types of detention structures and treatment systems and catch basin inlet filter systems and determine what an acceptable level of treatment to obtain for storm water runoff quality.

d. Current BMPs in urban areas

There are basic BMPs in use in the watershed for storm water management. All of the communities use grading to direct and collect storm water. They have catch basins with sumps to collect sediment and vegetated swales were common. It appears that most development from the mid 1990s to present have begun to detain storm water runoff on sites. It also appears that most of the development that occurred since about 2000 has gone through a site review process that dealt with stormwater management.

e. Proposed BMPs

On Site Storm Water Collection methods

It is proposed that urban areas look at management of storm water and how it is collected on a site. Proper site grading is essential for collection, however, the grading needs to incorporate more utilization of vegetation to help cleanse the storm water as it is collected. For example, collecting the storm water in parking lot islands or at the end of parking lots can help with water quality. These vegetated collection areas can then discharge cleaner storm water into a catch basin, with a sump, and then go to a vegetated detention area, or underground storage area for storm water to settle out any remaining sediment before discharge to surface waters.

Design of these types of systems is relatively simple and can be cost saving on a site as one stratetgy. Curb and gutter systems along streets are efficient collection systems, however they also move large quantities of debris, sediment and floatables that collect at the catch basin inlets, as shown below. Whereas, communities that use street side swales to collect stormwater generally do not have large quantities of debris at the catch basin inlets. The residents also spend time keeping these systems cleaner as they are associated with the residential lawn area. Many communities are now going back to residential areas with no curb and gutter. The catch basins are in the road right of way on either side of the road way.

Detention Basins or Underground storage

Each community should establish a design storm detention requirement for the community. If the community is in the floodplain of the Cass River, this best management practice will help obtain a discount on flood insurance for those having to purchase insurance. The detention volume should be able to contain the first flush and Bankfull storm events along with the Design storm detention. The detention basins should be vegetated and can either be wet or dry basins. Wet basins can be a good BMP to help reduce phosphorus in a watershed, however, they can become unsightly and can harbor invasive plant species if they are not watched carefully. Wet basins may need additional water quality requirement BMPs such as aerators to keep them aesthetically pleasing for the community.

A "dry" basin can filter out sediment, reducing phosphorus, and be a "mowable" surface that prevents the establishment of invasive species such as phragmites which could discharge seeds into drains and the Cass River Watershed.

Underground storage systems can be used when space is at a premium on a site. These systems are typically under the parking area of a site. They are structurally sound and when installed per specifications they can withstand vehicular loading.

Infiltration BMPs

An option for some storm water systems to explore is for infiltration in some areas for groundwater recharge. There were a few systems in place in the watershed where this infiltration practice was occurring. These areas had gravel veins close to the surface where they could place underground storage or open basin storage and let the stormwater infiltrate and discharge through the groundwater system rather than discharge to the local MS4 and ultimately the river. This helps to attenuate the peak runoff events and prevents drains or the river from experiencing "flashiness" or sudden peak flows.

The communities should look at use of infiltration BMPs whenever possible to help the riverine system with groundwater recharge to maintain a healthy baseflow for the Cass River. Care must be taken when utilizing this practice to assure the stormwater runoff is as clean as possible before infiltration begins. We do not want to inadvertently introduce pollutants to the groundwater table. With underground systems this can be accomplished by use of a stilling chamber or row to settle out soil particles before the stormwater moves into the chambers for infiltration.

Use of pavers as mentioned above also fit into this category of infiltration. There are numerous types of grass pavers also that can help with ancillary parking while saving green space and reducing heat signatures of urban areas.

Communities should offer incentives to developers that use low impact development techniques. For example, if your community wishes to detain the volume of the 100yr design storm in its standard design. If the developer will put in infiltration systems, bio swales, or rain gardens as part of the treatment train why not use the volume of the 25yr design storm as incentive.

Encourage businesses to run their roof water to a collection cistern to use as water for the landscape irrigation system. This will save the business paying for watering their lawns from municipal water systems. Encourage businesses with roofs close to each other to share in collecting this roof water for irrigation purposes.

Encourage the use of vegetative buffers paralleling waterways or corridors. Studies have shown that a minimum width of ten feet for a vegetative buffer strip can remove up to 70% of total suspended solids. Municipalities with river frontage should implement practices that allow for native plant buffer zones for at least a ten foot width along established county drains or natural watercourses to help with reduction of sediment and nutrient loading to the Cass River. (Kawkawlin Watershed Buffer Study, 2011)

Develop site planning options for shared parking to limit unnecessary impervious surfaces being developed. Determine if sites with historically large parking areas that are not used every day to the maximum extent can use alternative parking surfaces such at grass pavers, paving bricks and other innovative parking surfaces that allow stormwater to infiltrate the surface and not runoff the site. Pervious concrete and asphalt can store the peak runoff event and discharge over longer periods of time and have a long life expectancy.

Some argue that these pervious systems do not work in cold climates and that frost will heave the paving material, however, that is not true, these systems allow the water to pass through them and maintain a drier surface and subsurface than conventional systems. Arguments of pavers not working well for plowing should visit the Keweenaw Peninsula's Superior Block Company and see its entry drive shown below.

This driveway has been in service since the early 1990's and is traveled daily by fully loaded cement trucks and semi's delivering blocks to area construction sites. It is plowed routinely and is holding up very well.

f. Structural Best Management Practices

If a community adopts the basic storm water design guidelines then a minimum level of storm water BMPs and design practices will be established. Sites will be graded, have catch basins with sumps to collect sediment, inlet grates will have "Dump No Waste", "Drains to River" as part of the forging process. The rate of discharge and quantity stored will become standardized. The community can then look at types of detention structures and treatment systems and catch basin inlet filter systems and determine what an acceptable level of treatment to obtain for storm water runoff quality.

An option for some communities and storm water systems to explore is for infiltration in some areas to enhance groundwater recharge and baseflow opportunities for the Cass River. There were a few systems in place in the watershed where this infiltration practice was occurring. These areas had gravel veins close to the surface where they could place underground storage or open basin storage and let the stormwater infiltrate and discharge through the groundwater system rather than discharge to the local MS4 and ultimately the river. The communities should look at use of infiltration BMPs whenever possible to help the riverine system with groundwater recharge to maintain a healthy baseflow for the Cass River. Care must be taken when utilizing this practice to assure the stormwater runoff is as clean as possible before infiltration begins. We do not want to inadvertently introduce pollutants to the groundwater table. Therefore BMPs should be in place for vegetated buffers, waterways and swales. Certain sites such as refueling stations, automotive repair shops, large parking lots should consider the use of catch basin inserts to absorb petrochemicals and hydro-carbons to keep them out of the final detention and recharge areas.

The drainage collection system should have minimum structural BMPs in place such as:

- Stormwater Maintenance plans for each site to assure proper cleaning and care of the system.

- Sumps in all catch basins to decrease sediment loads
- Use of vegetated swales and detention basins to decrease sediment load whenever possible
- Use of absorbent "pillows" in catchbasins to collect and prevent spilled hydrocarbons and other petroleum products from reaching the riverine system.

Incentive Programs for BMP implementation

Communities should offer incentives to developers that use low impact development techniques. For example, if your community wishes to detain the volume of the 100yr design storm in its standard design. If the developer will put in infiltration systems, bio swales, or rain gardens as part of the treatment train why not use the volume of the 25yr design storm as incentive.

Encourage businesses to run their roof water to a collection cistern to use as water for the landscape irrigation system. This will save the business paying for watering their lawns from municipal water systems. Encourage businesses with roofs close to each other to share in collecting this roof water for irrigation purposes.

Encourage vegetative buffers along waterways. Studies have shown that a minimum width of ten feet for a vegetative buffer strip can remove up to 70% of total suspended solids. Municipalities with river frontage should implement practices that allow for native plant buffer zones for at least a ten foot width along established county drains or natural watercourses to help with reduction of sediment and nutrient loading to the Cass River.

4.6 Education Outreach Strategy for Urbanized Areas

Planning Consultants:

There needs to be an Information/Outreach strategy developed for the urban areas within the Cass River Watershed. This strategy should be directed to the planning commissions of each of the urbanized areas and townships within the watershed. The strategy should focus on providing information to each planning commission regarding the importance of the watershed to their respective community. A strategy needs to be developed to provide "Care for the Cass". The MSU Extension has been working in the Greater Saginaw Bay Watershed and should be involved in implementation with of planning initiatives. The focus should begin with education of consulting firms that provide planning services in the Cass River watershed. As community / county master and recreation plans are being developed or revised the consultants need to understand they must provide focus on the watershed in these plans. When master plans are developed there is usually some grant funded projects that will design an implement new downtown streetscapes. It is during this type of development that watershed principles need to be enforced. Information must be provided to the urban areas and townships that focus on the following points:

1. How to re-develop urbanized mid-town areas that do not have best management practices in place for clean stormwater runoff.
2. Re-use of "brownfield" areas in a community.
3. Use of smart or low impact design techniques.

In this component the planners of a community must be informed to make decisions that have a stormwater strategy that considers what impact the development will have on the Cass River and how that impact can be minimized through careful, responsible planning.
Once the consultants have been provided with information on what should be considered in development of community Master and Recreation Plans it would be best to determine if a formal review and comment process could be developed where an outside agency would review drafts of master and recreation plans and provide comment on how these plans would help improve the watershed. A plan review strategy by a select group would provide focus for the watershed and ensure that the goals established in the watershed management plan would be part of a long term strategy in the watershed.

Community Planning Commissions:
Information/Education sessions need to be developed for community planning commissions to inform them of the impacts of development on the watershed. Some of the urban areas already have stormwater management planning in place, but the impacts of stormwater on the Cass River need to be emphasized. Two information sessions should be developed for community planning commissions. The first one hour session would provide a strategy to educate and inform the community planners to show:

- How development strategies are not a hindrance to development in their community
- How lack of planning can disrupt the watershed
- How planning can bring money into downtown/urban centers and decrease impervious areas
- How proper planning can bring about strategies for shared impervious parking or development of “green” parking ideas of 30% asphalt and 70% grass pavers.

A second session would provide a one hour (or shorter) presentation for community planning commissions describing how to implement review procedures for:

- New site developments in the community
- Site re-development in the community
- Stormwater management planning for site development & redevelopment
- Stormwater system maintenance planning

Finally, in this session include information on how this planning for stormwater will have implications for communities participating in the National Flood Insurance Program by providing additional discounts on flood insurance for residents required to have this insurance. This type of planning is recognized in the Community Rating System to obtain discounts on flood insurance.

4.7 Estimated pollutant reductions from proposed actions

Decreased impervious areas
With the implementation of community planning for storm water impacts from development there will be an opportunity to begin limiting the impervious foot print of the urban commercial areas and other site developments. The planning for more opportunities for shared parking or

use of pervious parking areas would be beneficial to the watershed and should be looked at during site review process. In other words the communities should look at methods to decrease the impervious footprint of the community to decrease storm water runoff to the Cass River or its tributary drainage system.

Some of the urban areas have a potential to increase their detention volumes substantially. Cass City has the largest potential in being able to implement a regional detention area for its industrial area before discharge to the Cass River. There is a large man-made water feature that was a former gravel quarry that would make a good regional detention area for the residential and industrial area in the southern portion of the community. There are opportunities coming in 2013 and 2014 for storm water asset management and planning and implementation of those plans through PA 511 of 2013. This would provide an excellent area to store clean runoff. Care would need to be taken to assure the industrial areas utilize BMPs to clean their storm water discharge to prevent a management problem for the large regional detention area. The increased hydrology for this man-made lake would help during dry weather conditions to improve the water levels.

Other communities should look at ways to increase their storm water detention availability through new and re-development opportunities. Specifically looking at storing first flush volumes and detaining larger storm events than the 10 yr design storms (10% recurrence interval) . Communities such as Frankenmuth and Caro have more aggressive storm water management programs, with Frankenmuth the most aggressive of all. Other communities such as Bridgeport need to be more aggressive in the site planning aspect. However, in defense of these communities there has been little to no development in these communities for quite some time and may not be in the future as Michigan is still loosing population and de-urbanizing.

With increasing detention volumes and the capturing of the first flush events there is also an opportunity to capture and decreae the amount of urban pollutants making their way to the Cass River. The settling of sediment from storm water runoff will help decrease pollutant loading in the river and tributaries. All urban areas should make an effort to implement the first flush BMP on any new and re-development and look for opportunities to retrofit existing systems for this BMP.

Decreasing allowable discharge rates to the River or stormwater conveyance systems

Communities along the Cass River should look at the example set by the City of Frankenmuth in decreasing the allowable discharge rates to the Cass River. Frankenmuth did a study to determine the capacity of its existing stormwater system throughout the city and set allowable discharge rates by drainage districts. This forward thinking planning results in less flooding and prevents and development from discharging more storm water from their site than the conveyance system can handle. This ultimately decreases the uncontrolled discharge from an urban area to the Cass.

Again PA 511 of 2013 provides an opportunity for funding a asset management plan with an accompanying hydraulic model of the communities storm water conveyance system. This watershed management plan already has limited hydraulic models in EPA-SWMM (storm water management modeling) for Bridgeport, Frankenmuth, Vassar, Caro, Cass City, Millington, and Mayville. These programs are limited to the information readily available and have basic assumptions made to obtain urban runoff volumes. They are a start and could be used for part of the 10% match, potentially.

Again, the best that can be done for the watershed in general is storm water management planning by the urban areas to lessen their impact on the environment. The communities of the watershed do not have a significant impact, but they have an impact nonetheless. It is time to begin thinking of mitigating the urban impact with the development and implementation of this plan. This type of planning relative to decreasing allowable discharge rates can have benefits to the communities by lowering the risk of localized flooding within the community and by the opportunity to lower the National Flood Insurance Programs premiums for the residents that are in the Cass River floodplain.

4.8 Sustainability Strategy

All plan implementation must have a strategy for sustainability to ensure long term success of the watershed management plan. Communities that are serious about protecting the water resources of this watershed should determine what practices need to become part of their zoning and ordinance procedures for their communities. Once any planning becomes part of the ordinance structure there can be long term benefits for the community and watershed.
It is recommended that every three years an outreach session needs to be developed for all planning commissions in the Cass River Watershed to review progress on the watershed planning goals with the communities in the watershed. Funds should be sought to develop these planning sessions so they will be free to community planning commissions or planning consultants in the watershed.

4.9 Measures of Success

The biggest measure of success for the watershed would be the adoption of a watershed wide effort to assure that stormwater design guidelines are adopted throughout the watershed. These should take into consideration the watershed goals and objectives and be reviewed at least every five (5) years for necessary revisions to adopt current practices or changing watershed goals. Other measures of success would be as follows:

1. The number of information/training sessions for planning commissions or planning consultants in the watershed.
2. The number of planning commission members attending these sessions.
3. The adoption of standard site review process that must address stormwater quality and the number of reviews performed per year.
4. Obtaining grant funding to address the urban central areas of communities in the watershed to adopt BMPs to address stormwater quality and quantity.
5. Adoption of shared parking and green parking BMPs.

6. Number of communities adopting the stormwater design guidelines as an administrative policy or ordinance.
7. Number of community public works personnel attending training related to how urban practices affect stormwater quality.
8. Increase of impervious area in the downtown areas of a community over time.
9. Measurable decrease in peak discharge rates over time.