Appendix C

Bear Creek and Bear Lake Watershed Stormwater Management Plan

Produced by:
Conservation Design Forum (CDF)
February 2004

Bear Creek & Bear Lake Watershed Stormwater Management Plan

February 2004

DEQ Michigan's Nonpoint Source Program

Muskegon Conservation District

CONSERVATION DESIGN FORUM

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Prepared for

Muskegon Conservation District
101 East Wesley Avenue, Room 6
Muskegon, MI 49442

Prepared by

Conservation Design Forum
375 W. First Street
Elmhurst, IL 60126
www.cdfinc.com

acknowledgement

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Conservation Design Forum:

Chingwen Cheng, Staff Designer
Landscape Architecture and Planning

Charles McGhee Hassrick, Associate
Landscape Architecture and Planning

Ken Kortkamp, P. E., Project Manager
Water Resource Engineering

Thomas Price, P. E., Director,
Water Resources Engineering

Muskegon Conservation District:

Jeff Auch,
Executive Director

Rebecca Bieneman,
District Forester

Steve Coverly,
Project Support Specialist

Tony Jarvis,
Project Manager

Greg Mund, Conservationist
USDA Natural Resources Conservation Service

Michigan Department of Environmental Quality:

Dave Fongers,
Hydrologic Studies Unit
Geological and Land Management Division

Tim Hall,
Nonpoint Source Unit
Water Division, Grand Rapids District Office

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Water quality in the Bear Creek and Bear Lake Watershed has been reported by Michigan Department of Environmental Quality (MDEQ) to be impaired and/or threatened. One of the sources of water quality impairment is contaminated runoff from impervious surfaces associated with urban development. As the watershed grows, increases in impervious cover could result in increases in excessive stormwater runoff discharged to streams, wetlands, and lakes, further degrading water quality. To address these issues, the Muskegon Conservation District (MCD) is developing a Watershed Management Plan for the Bear Creek and Bear Lake Watershed. Proper stormwater management can play a crucial role in natural resources protection, improving water quality, and controlling increases in stormwater discharge. Thus, this Stormwater Management Plan was prepared as a component of the Watershed Management Plan.

This Bear Creek and Bear Lake Watershed Stormwater Management Plan identifies a wide range of design strategies, varying in scale and type, when combined can reduce stormwater runoff and enhance water quality. These strategies include open space preservation, new environmentally sensitive development techniques, stormwater ordinances, and retrofit of existing developments.

This section describes watershed conditions, the project purpose and process, and the watershed goals that are identified in the Bear Creek and Bear Lake Watershed Management Plan.

1.1 About the Watershed

Location

The Bear Creek and Bear Lake Watershed is centrally located in Muskegon County, Michigan near the eastern shore of Lake Michigan (see Location Map next page). The watershed encompasses approximately 30 square miiles (23,160 acres) with the majority of the watershed located northwest of Michigan Highway 120 and bisected by US Highway 31. The watershed includes at least portions of five (5) townships and one municipality. It is due north of the City of Muskegon and intersects the City of North Muskegon at the south border of Bear Lake. Dalton Township is in the central portion of the watershed and the northern-most portion of the watershed includes the Twin Lakes area. The watershed includes a small contribution from the western portion of Cedar Creek Township, flows through the northwestern corner of Muskegon Township, and drains to the mouth of Bear Lake in Laketon Township.

The headwaters of the watershed begin in the Twin Lakes area, and generally flows southwesterly toward the southern-most portion of the watershed with discharge into Muskegon Lake through Bear Lake Channel, which eventually drains to Lake Michigan.

Since watersheds often cover multiple municipalities and townships or even counties, watershed-scale stormwater management plans are regional plans that requires political consensus and understanding for successful implementation. Since the Bear Creek and Bear Lake Watershed includes unincorporated areas in five (5) townships as well as portions of the City of North Muskegon, cooperation between state government, local governments, private owners, developers, and other watershed interest groups is essential.

Watershed Environmental Conditions

The Watershed area contains mostly sandy soils and the water table is less than 10 feet below the surface in most areas. In some areas, the water table is very shallow and less than 4 feet below the surface. The shallow water table areas are generally characterized by hydric soils. The high permeability of sandy soils provides greater opportunity for infiltration and groundwater recharge compared to soils with a greater clay content. However, this high permeability also makes the groundwater more vulnerable to contamination.

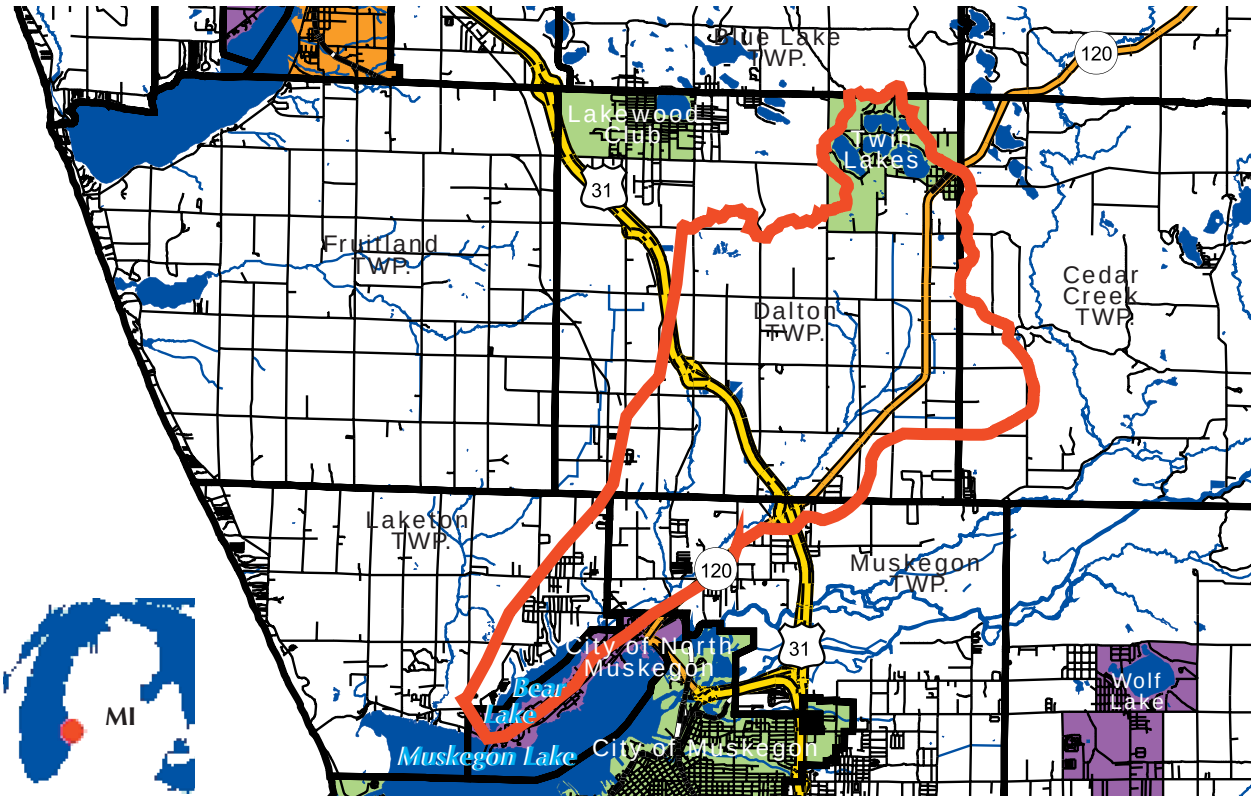
The Twin Lakes area in the upstream portion of the watershed consists of four lakes: North Lake, Middle Lake, West Lake, and Twin Lake. These lakes have no surface water connection to the downstream watershed with the exception of a historic drain and a rarely used pump station. However, the lakes are hydrologically connected through groundwater. In addition to the Twin Lakes area, there are other areas of the watershed that contribute no surface runoff due to their depressional nature and high permeability soils.

The Watershed is relatively flat, under 6% slope, with very few areas with slopes greater than 12%. The areas of steep slopes and the streambanks are sensitive to water erosion. A few other areas are sensitive to wind erosion due to loss of vegetative cover.

It is reported that water quality in the watershed area has been degrading, especially at the point where Bear Lake drains to Muskegon Lake. In addition, groundwater contamination exists at the Superfund Ott/Story/Cordova site in southwest of Dalton Township.

Several wetlands have been identified in the Watershed but no endangered or threatened species have been identified.

Since surface and groundwater hydrology are integrally linked, contamination of surface water,



Location Map

groundwater in isolated areas can potentially cause widespread pollution problems throughout the watershed, including headwaters, stream corridors, adjacent wetlands and floodplains, and Bear Lake.

Implementation of this stormwater management plan is critical to enhancing hydrologic function of the watershed while preserving and protecting natural resources, thus aiding in the maintenance and improvement of overall watershed health.

Development Patterns

During the early 1800s, before significant European settlement, the Bear Creek and Bear Lake Watershed consisted of forested riparian lands, swamps and marshes in the north central part of the watershed and along the stream corridors, and forest communities in the uplands.

Prior to the 1970s, watershed development was primarily concentrated around the lakes and also present along Route 120. Subsequent to the 1970s, the area of developed land increased from 14% to 18% and development has been much more scattered than prior to the 1970s.

New conventional development is happening in the watershed.

The current population in the Watershed is approximately 38,151 residents (MCD, 2002). Based on projected population growth rates for the townships and municipalities of the watershed (West Michigan Shoreline Regional Development Commission), the population is expected to increase by 10% to 15% by the year 2020. At the time of this report, two residential developments were being built in Dalton and Laketon Townships. One of which is adjacent to the Superfund site and another is close to Bear Lake.

Development Impacts

As a watershed experiences urban development and natural areas are converted into lawns and impervious roofs, roads and parking lots, less rainwater percolates into the ground. In addition to creating additional surface runoff, water temperatures increase and pollutants that accumulate on these surfaces are washed off and quickly conveyed to streams, wetlands and lakes. Stream and wetland ecosystems that previously received a majority of their water from groundwater flow now receive increasing amounts of surface runoff in large pulses, to which they are not naturally adapted.


Conventional stormwater management practice greatly threatens water quality.

These changes in watershed hydrology increase the magnitude and frequency of both channel forming flows and flood peaks, causing severe stream channel erosion and increased flooding downstream. In turn, physical degradation of natural stream channels occurs through scour of natural substrates in some areas and sedimentation and burial of substrates in other areas. Consequently, the alteration of stream condition reduces the diversity and suitability of aquatic habitat and causes a corresponding decrease in fish and macroinvertebrate abundance and diversity.

Changes in the hydrologic regime of wetlands and lakes results in similar degradation of physical conditions and aquatic plant and animal communities.

The Bear Creek and Bear Lake Watershed Project, of which this Stormwater Plan is a part, is intended to address water quality, aquatic habitat, and flooding in the watershed. Specifically, this Stormwater Plan is intended to identify strategies and make recommendations for reducing development-related stormwater impacts.

1.2 About the Project

Project Purpose

Water quality has been identified by MCD as one of the most important issues in the Bear Creek and Bear Lake Watershed and conventional urban development has been recognized as one of the major factors contributing to water quality impairment. The purpose of this Stormwater Plan is to outline stormwater planning and design guidance at various scales and provide recommendations to improve water quality and protect natural resources and the health of the watershed.

Project Process

This Stormwater Management Plan consists of four (4) main chapters:

- **Watershed Inventory and Assessment**
- **Stormwater Management Strategies**
- **Stormwater Management Recommendations**
- **Conclusions and the Next Steps**

1. Watershed Inventory and Assessment identifies existing watershed conditions. This chapter includes discussions on hydrology, topography, soils, and land cover/land uses.

2. Stormwater Management Strategies includes three sections:

- A ***Green Infrastructure Plan*** that identifies natural features and creates a hydrologically connected open space network. This network has been designed to protect significant natural resources and enhance greenway and open space planning.
- A ***Stormwater Best Management Practices Tool Box*** that provides illustrations and general information on the function, application, effectiveness, benefits, and design considerations of various stormwater BMPs.
- A set of site-scale ***Conservation Design Templates*** that illustrate how stormwater BMPs can be integrated into site plans, utilizing a distributed stormwater management approach. The conservation design templates are contrasted with more conventional site designs that utilize more end of the pipe stormwater management approaches. Templates include: commercial/industrial, moderate density residential, rural residential, estate residential, agricultural, stream corridor and depressional wetlands.

3. Stormwater Management Recommendations includes watershed-wide stormwater regulatory recommendations and recommendations that are specific to subunits of the watershed.

4. Conclusions and Next Steps identifies implementation steps and an institutional framework for implementing the watershed recommendations. Implementation is covered in greater detail in the Watershed Management Plan.

1.3 Watershed Goals

Watershed goals were generated from current watershed issues and concerns as outlined in the *Initial Water Quality Summary for Bear Creek/Lake 319 Watershed Management Plan* (MCD 2002). Additional watershed usage goals have been identified by communities and stakeholders through group meetings held by MCD. MCD is developing a Bear Creek and Bear Lake Watershed Management Plan based on those watershed goals. In conjunction with the watershed management plan, this Bear Creek and Bear Lake Watershed Stormwater Management Plan strives to meet these watershed goals and resolve issues related to water quality through proper stormwater management.

Current Watershed Quality

Water quality standards are defined in the quality control program as mandated in the Clean Water Act. One method of defining goals for a waterbody is to designate its uses and then establish criteria to protect those uses. In the Bear Creek and Bear Lake Watershed Management Plan, provided by MCD, the state of Michigan has defined nine designated uses of which four are impaired and two are threatened. Three of the nine potential statewide designated uses for this watershed are currently being met. Designated uses and their protection status developed by MCD are listed below:

Designated Uses	Impaired or Threatened
Cold-water fishery	Impaired
Aquatic life and wildlife	Impaired
Partial body contact recreation	Impaired
Total body contact recreation	Impaired
Warm-water fishery	Threatened (to be protected)
Navigation	Threatened (to be protected)
Agriculture	---
Industrial water supply	---
Public water supply	---

Watershed Goals

To address impaired and threatened designated uses, watershed goals were developed as described in the Bear Creek and Bear Lake Watershed Management Plan:

Goal 1: Improve surface/ground water quality to sustain cold-water fishery
Goal 2: Restore aquatic life and wildlife habitat
Goal 3: Restore both partial and total body contact designated uses
Goal 4: Maintain a balance of the needs of the fishery with navigational uses
Goal 5: Improve warm water fishery

Community Concerns

Desired Uses

In addition to the State water quality report, the MCD held community based watershed focus group meetings where the community residents identified their 'Desired Uses' for the Watershed. The community group meetings identified the following concerns and desired uses:

- Groundwater/Drinking water,
- Unique habitat,
- Open Space,
- Pollution Sites/Safety, and
- Public Access/Recreation

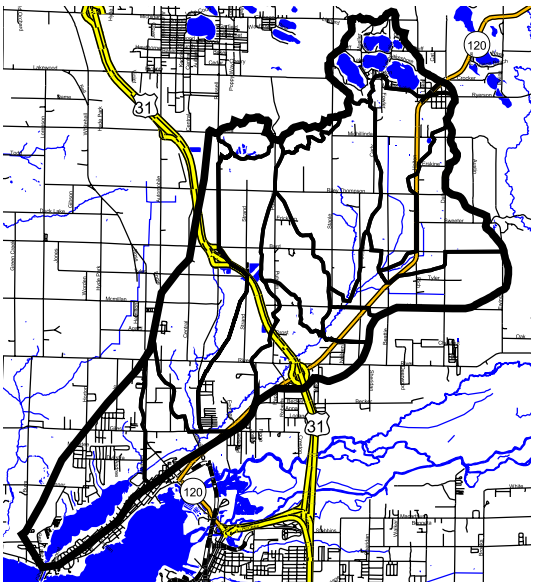
Usage Goals

In addition to the watershed goals mentioned previously, "usage goals" were identified from the community's 'Desired Uses' for the Watershed.

Usage Goal 1: Ensure water quality throughout Bear Lake/Creek Watershed
Usage Goal 2: Identify critical habitat for endangered/threatened species and ways to protect their habitat
Usage Goal 3: Establish permanent easements and nature preserves within the watershed
Usage Goal 4: Clean up polluted areas
Usage Goal 5: Establish access sites along stream and lake

This Stormwater Plan attempts to address watershed and usage goals that are related to water quality and stormwater management.

This section presents a summary of the inventory and assessment of the Bear Creek and Bear Lake Watershed, including hydrology, topography, soils, land cover, and land use/land cover. Analyses of these parameters in conjunction with local input and site observation are used to identify potential issues and concerns related to stormwater management in the watershed.



Watershed and Sub-watershed Map

2.1 Hydrology

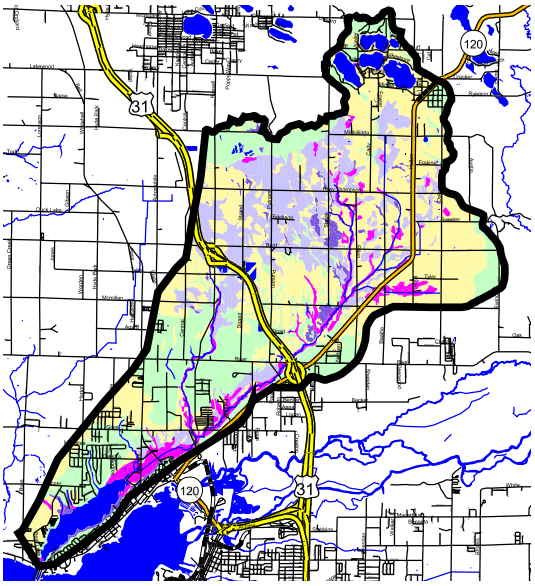
The Bear Creek and Bear Lake Watershed lies within the regional Muskegon River Watershed and discharges into Bear Lake, which itself discharges to Muskegon Lake. The Watershed was subdivided into 16 sub-watersheds by MDEQ (see Watershed and Sub-watershed Map to the right). Each sub-watershed has its own topography and connection to the watershed network. The subwatersheds were identified during preparation of the *Hydrologic Study of the Bear Creek and Bear Lake Watershed* by MDEQ.

Water Table

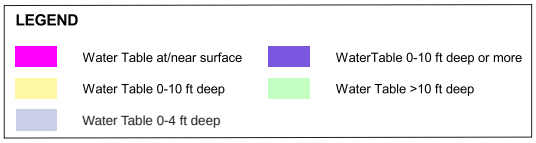
Based on the Muskegon County soil survey, the water table is within 10-feet of the surface over approximately 58% of the watershed area. The water table lies near or at ground surface over 6% of the watershed area. Shallow groundwater depth, along with the generally sandy soils of the watershed (see **Section 2.3**), suggests a relatively high potential for groundwater contamination in some area of the watershed due to improperly functioning septic systems, improper stormwater management, nutrients from lawns/agricultural livestock, and improper management of materials.

Upper Bear Creek and the lower 30% of the Watershed along Bear Creek have a deeper water table with levels more than ten (10) feet below the surface.

Water table data is derived from USDA Muskegon County Soils Survey, 1968.



Water Table Analysis Map



Wetlands

Wetlands cover only 12% of the watershed area. A total of 34 wetlands have been identified in the National Wetlands Inventory (NWI) by U.S. Fish and Wildlife Services. The NWI wetland categories within the Watershed are:

- Forested and Scrub-Shrub wetlands 6.8%
- Emergent wetlands 1.0%
- Non- NWI wetland 4.2%

Forested and scrub-shrub wetlands are dominated by woody plants such as trees and shrubs and occur mostly along stream corridors and some large wetlands near the north border of the Watershed. Emergent wetlands consist of mostly erect, rooted, herbaceous perennial vegetation and are dominant along the lower portion of Bear Creek. The remaining 4.2% of the wetlands in the watershed area are deep water habitats with less than 30% vegetation cover and covered with surface water throughout the growing seasons. These wetlands are also recognized as lakes on the map, such as: Bear Lake, North Lake, Middle Lake, West Lake, and Twin Lakes at northern headwater of the watershed.

The 1978 and NWI wetland data layers were both provided by MDEQ. However, the 1978 wetlands were interpreted by the State and the NWI wetlands were interpreted by the U.S. Fish & Wildlife Service. Because one source cannot be considered more accurate than the other, both 1978 and NWI wetlands are shown on the wetlands map on the facing page. The NWI wetland maps were produced in the middle 1980's and therefore, it is unlikely that the differences can be attributed to changes in wetland cover.

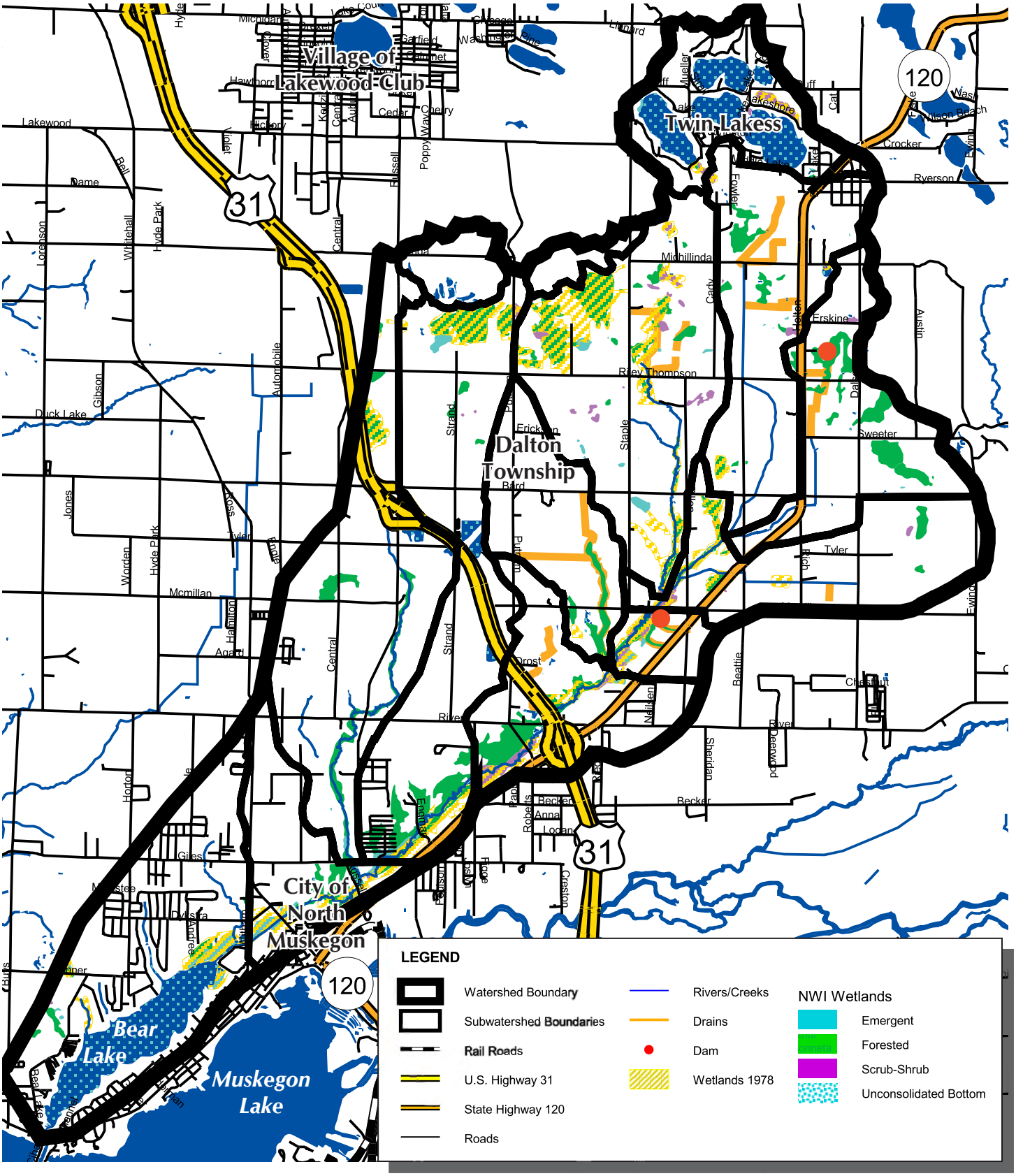
Floodplain

Floodplains are those areas that are subject to inundation during flood conditions and occur mostly adjacent to major lakes and wetlands and along stream corrdiors. The outside edge of the floodplain will flood, on average, once every 100-years and has a 1% change of flooding in any one year. Wetlands are usually associated with floodplains and provide unique wildlife habitat for species that have adapted to wet conditions and seasonal changes. In most cases floodplains are considered restricted areas for development where flood storage and conveyance must be preserved and buildings elevated to prevent flood damages.

Surrounding Bear Lake, the slopes are relatively steep and the floodplain is narrow. Upstream of Bear Lake, the terrain is generally flatter and the floodplain width varies from approximately 200 feet to 800 feet in most areas, with the width being greater in the downstream end of the watershed.

Water Quality

Bear Creek and Bear Lake, according to MCD's 2002 report *Initial Water Quality Summary for Bear Creek/Lake 319 Watershed Management Plan*, are listed as impaired or threatened for some of the designated uses as discussed earlier. Identified causes and sources of impairment and threats to maintaining a cold-water fishery include sedimentation, thermal pollution, nutrient loadings, toxic contamination, and hydrologic modification. MCD states in the *Muskegon Lake Community Action Plan* that Muskegon Lake is suffering from contaminated sediments that are derived from industrial wastes, chemicals production, and direct discharge of storm sewers.



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North

Hydrology Analysis Map

Hydrologic control structures such as dams and drainage tiles have altered the morphology and natural functioning of the watershed system.

Protection of groudwater quality, wetlands, and floodplains is critical to prevent degradation of hydrologic functions and overall health of the watershed.

2.2 Topography

The Watershed slopes gently from northeast to southwest, with an elevation range from around 730 feet to 580 feet, respectively.

Elevation is shown on the Topography Analysis Map on the next page. The greener the topographic lines, the lower the elevation and the more purple the line, the higher the elevation. The map indicates that the highest ridge line lies at the north boarder of the watershed in the Twin Lakes area. This ridge isolates the Twin Lakes area from the remainder of the watershed.

Topography Assessment

The watershed is relatively flat throughout, with flat being defined as slopes less than 6% based on the soil survey.

Areas with steep slopes, defined as slopes greater than 12% by the soil survey, are areas particularly susceptable to erosion if not protected from surface runoff and/or vegetative disturbance. Steep slopes are generally limited to the Twin Lakes area, areas along the northern watershed boundary, and the headwater areas of some of the small tributaries to Bear Creek. Typically areas with steep slopes are not suitable for development and should be protected from unnecessary disturbance.

2.3 Soils

Soil Characteristics

The Bear Creek and Bear Lake Watershed is covered by over 88% sandy soils (see Page II-7) with generally high permeability and well drained characteristics. Moderately drained Loamy soils occur mostly along the upper to middle reaches of Bear Creek with another small zone along the northwest side of Bear Lake. Loamy soils have more capacity to retain water than sandy soils and are somewhat less permeable.

Muck soils occur sporatically around the upper Bear Creek branch and a large area exists at the mouth of Bear Creek at Bear Lake. Generally speaking, muck soils are poorly drained and are associated with wetlands and floodplain riparian areas. Muck soils are high in organic content and thus are ideal wetland restoration sites. Conversely, muck soils are not suitable for development due to wetness and low strength.

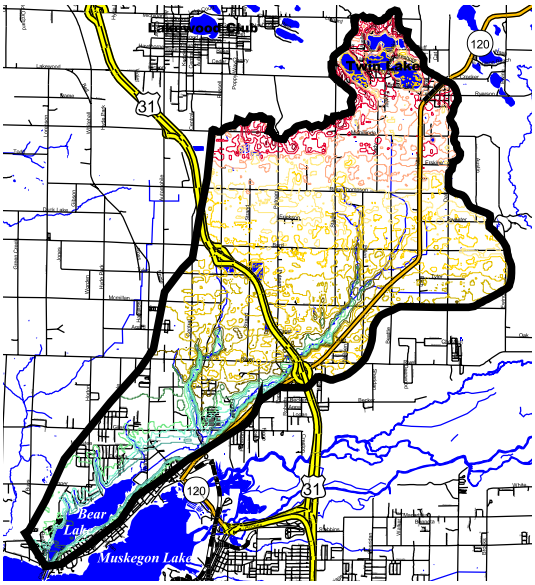
Gravel pits within the Watershed are located along interstate highway 31 and north of Riley Thompson Road. These pits are excavated below the water table and retain water throughout the year.

Erodable Soils

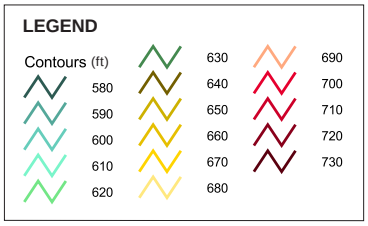
Areas of steep slope are generally more senstive to erosion than flatter slopes. Also contributing to erodability, is soil type with finer, non-clay soils being more subject to erosion than coarser soils and cohesive clay soils.

Blown-out lands are areas that were cleared and subsequently subject to wind erosion, resulting in loss of both the surface layer and subsoil, leaving loose sand at the surface. These areas are still sensitive to erosion and should be stabilized with vegetation. Areas with blown-out land characteristics in the watershed include uplands along upper and middle portion of the Bear Creek corridor.

There are several locations in the watershed that are sensitive to erosion. Wind erodable lands occur in areas of fine soils lacking in vegetative cover. A few very small areas of wind erodable lands occur on the west branch and upstream portion of Bear Creek.



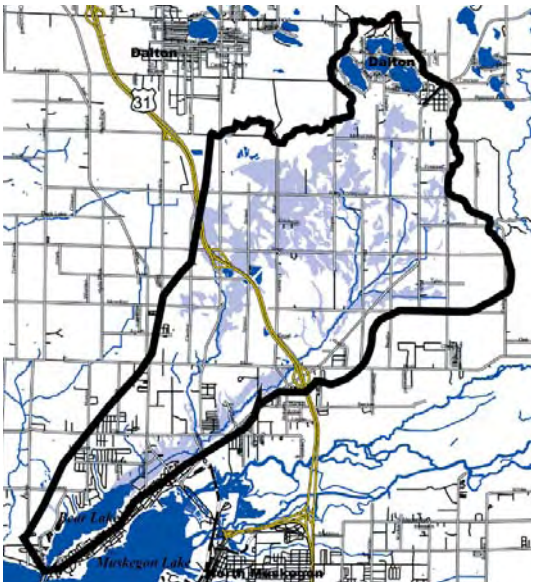
Topography Analysis Map



Hydric Soils

Hydric soils are those soils that are currently or were historically saturated with water throughout most of the year and poorly drained with persistant surface water during the growing season. Hydric soils typically occur in topographic depressions, and other areas where the water table is (or was) near the surface. Due to these characters, hydric soils are typically not suitable for intensive development and are not suitable for stormwater infiltration unless they are in a drained state (due to agrigultural drainage practices, nearby excavations or ditches, etc. that have lowered the water table). Hydric soils are historically associated with floodplain, wet praires and wetlands. They are a good indicator of potential floodplain/wetland restoration sites.

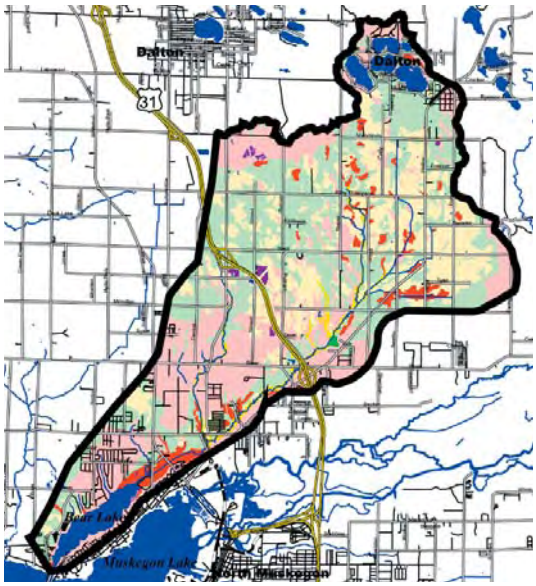
Hydric soils occur in many areas of the Bear Creek and Bear Lake Watershed, especially along most stream corridors and a large portion in the central part of the watershed, as shown on the Hydric Soils Map.



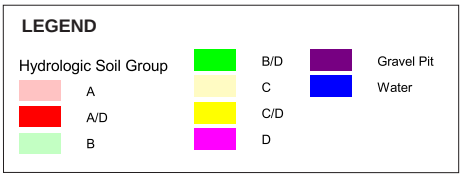
Hydric Soils Map

Hydrologic Soil Group

There are four hydrologic Soil Groups (HSG) (A, B, C, and D) used to classify runoff potential. Runoff



Hydrologic Soil Group (HSG) Analysis Map



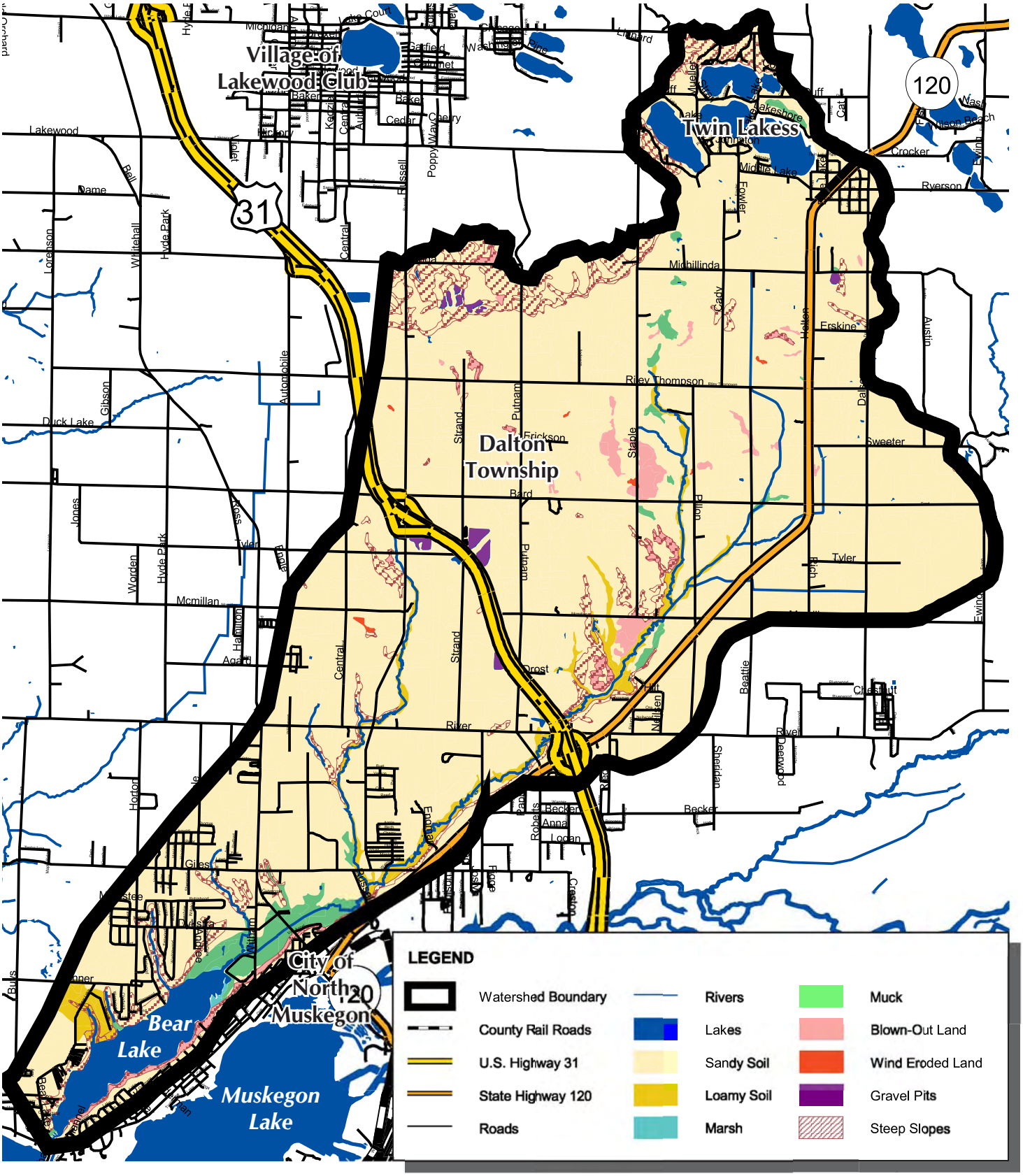
potential is a function of soil texture, permeability, and degree of drainage. These categories are utilized during stormwater management system analysis and design to estimate runoff volumes and to evaluate stormwater BMPs. In general, hydrologic soil group A has highest permeability whereas group D has the lowest or is poorly drained. Soils that are hydric are classified as A/D, B/D, and C/D, indicating their runoff potential in the drained/undrained state, respectively.

As shown on the Hydrologic Soil Group Analysis Map, HSG A soils are most common. HSG B soils are the second most common and are distributed mainly adjacent to the stream corridors and in the west central part of the watershed. HSG C is generally located within the east central portion of the watershed and scattered within generally HSG A and HSG B zones. Many of the HSG A/D soils are associated with wetlands and muck soils. Many of the stream valley areas are HSG C/D soils.

Soils Assessment

As discussed, the Watershed consists primarily of sandy, HSG A and B soils, and moderate to high groundwater tables. A significant area of the watershed has hydric soils (18% of the watershed area). Sandy soils are conducive to infiltration of stormwater and the sandy soils in the Bear Creek and Bear Lake Watershed generally have permeability rates of 10 inches/hour. However, the capacity of sandy soils to adsorb and treat pollutants such as metals, nutrients, some organic compounds, and bacteria is relatively limited. Thus, areas of sandy soils are more vulnerable to groundwater contamination than soils with greater clay and/or organic content. This is particularly true where the water table is shallow, such as in the hydric soil areas.

Due to the high permeability of the watershed soils, surface runoff is a rare occurrence in undeveloped areas. Thus, to maintain groundwater recharge, stream baseflows, and moderated high flows, it will be essential to maintain the groundwater based hydrology of the watershed. However, caution must be exercised to avoid groundwater contamination during infiltration of urban runoff. All stormwater runoff should be pre-treated prior to discharge to the sandy subsoils. For typical stormwater runoff (with little potential for contamination by stored or spilled hazardous materials), filtration through a minimum 12" layer of amended topsoil should be adequate to prevent contamination by typical stormwater pollutants. The amended topsoil should



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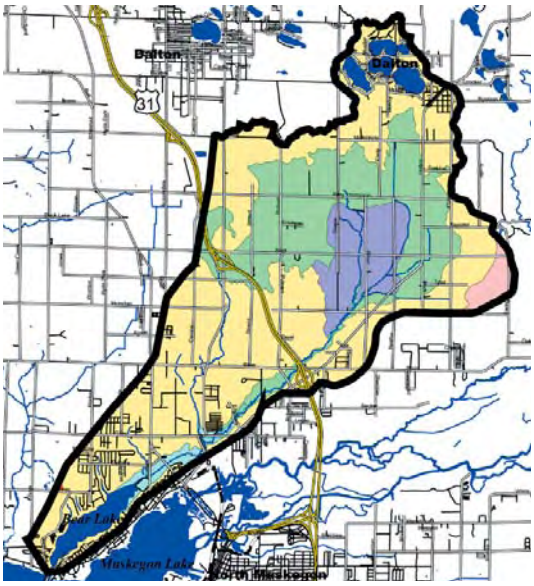
Soils Analysis Map



Land Cover Map (1800)

have a clay content of approximately 20%, an organic content of approximately 10%, and a sand content of approximately 60% to achieve adequate infiltration capacity as well as water quality filtration. Infiltration areas should be planted with native vegetation to help maintain organic content and topsoil permeability.

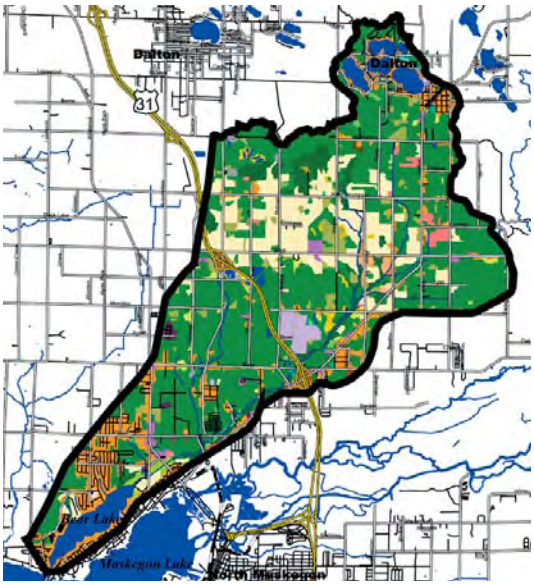
Areas of steep slopes and erodable soils are difficult to restabilize once disturbed and are much more vulnerable to surface runoff. Thus, development should avoid these areas.

2.4 Land Use/Land Cover

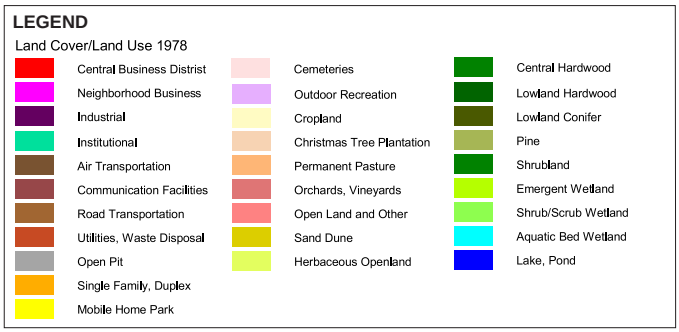
Land Cover in 1800

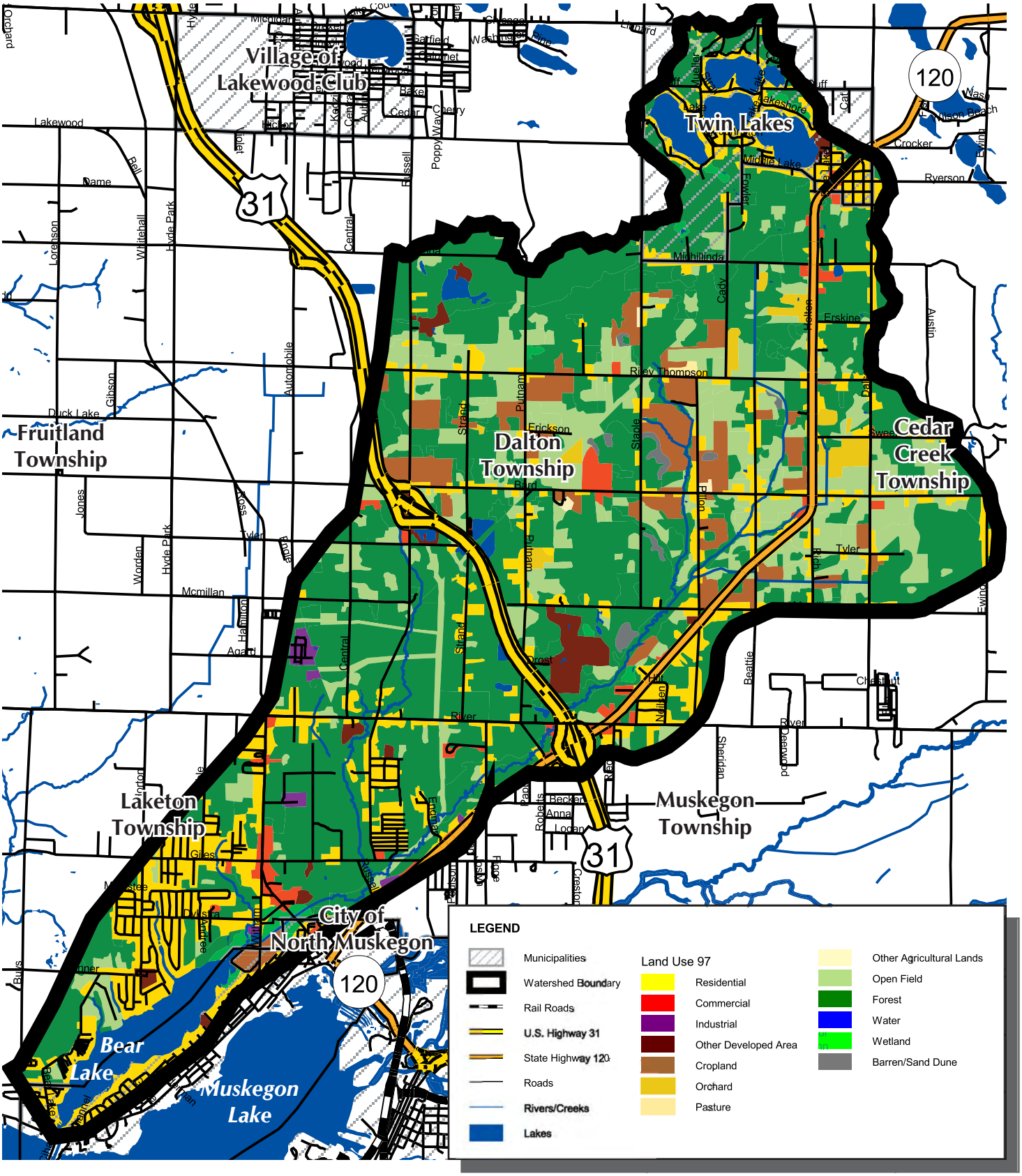
At the time of settlement, about 1800, the watershed of Bear Creek was covered prevailingly by thinly disposed mixtures of white pine and oak. These forests blended into high-water table swamps dominated mostly by conifers, paricularly in the upper reaches. (see 1800 Land Cover Map overlain by existing conditions road network and stream layers). On gentle rises within the swamps, beech and sugar maple trees grew along with Canadian hemlock. The lower reaches of Bear Creek evidently included large tracts of shrubby and emergent marshes. The ground cover over most of this watershed was dominated by grass-like members of the sedge family that produce substantial amounts of soil organic carbon when the forest floor is well lit by sun light.

The soils that prevailed in the watershed are sandy and mostly were underlain by a fairly high water table. Even during periods of scant rain, the bunch sedges had a remarkable ability to condense water from the air during the night and early morning. This surpluss moisture and the perpetual production of



Land Use/Land Cover Map (1978)





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scale:1 in = 6000 ft

North

Land Use/Land Cover Map (1997)

soil organic carbon by the bunch sedges, provided steady soil moisture even in those areas now characterized as "well-drained".

Land Use/Land Cover in 1978

Over the last two centuries, significant changes have occurred in both land cover and land use. By 1978, about one-third of the watershed was under some sort of intensive land use, mostly agricultural and residential, as shown in the Land Use/Land Cover Map (1978). Developement percentages in the watershed in 1978 included:

- Agricultural 15% (including crops, orchards, and pastures)
- Residential 14%
- Other developments 2% (commercial, industrial, and transportation)
- Open space and recreation 2%

Urban development was generally concentrated in North Muskegon, north of Bear Lake and in Twin Lakes near the lake amenities. Significant development was also present along Route 120 with good access to Interstate Highway 31. Much of the agricultural land was located in areas of more fertile and less droughty hydric soils that had been dewatered by a network of ditches.

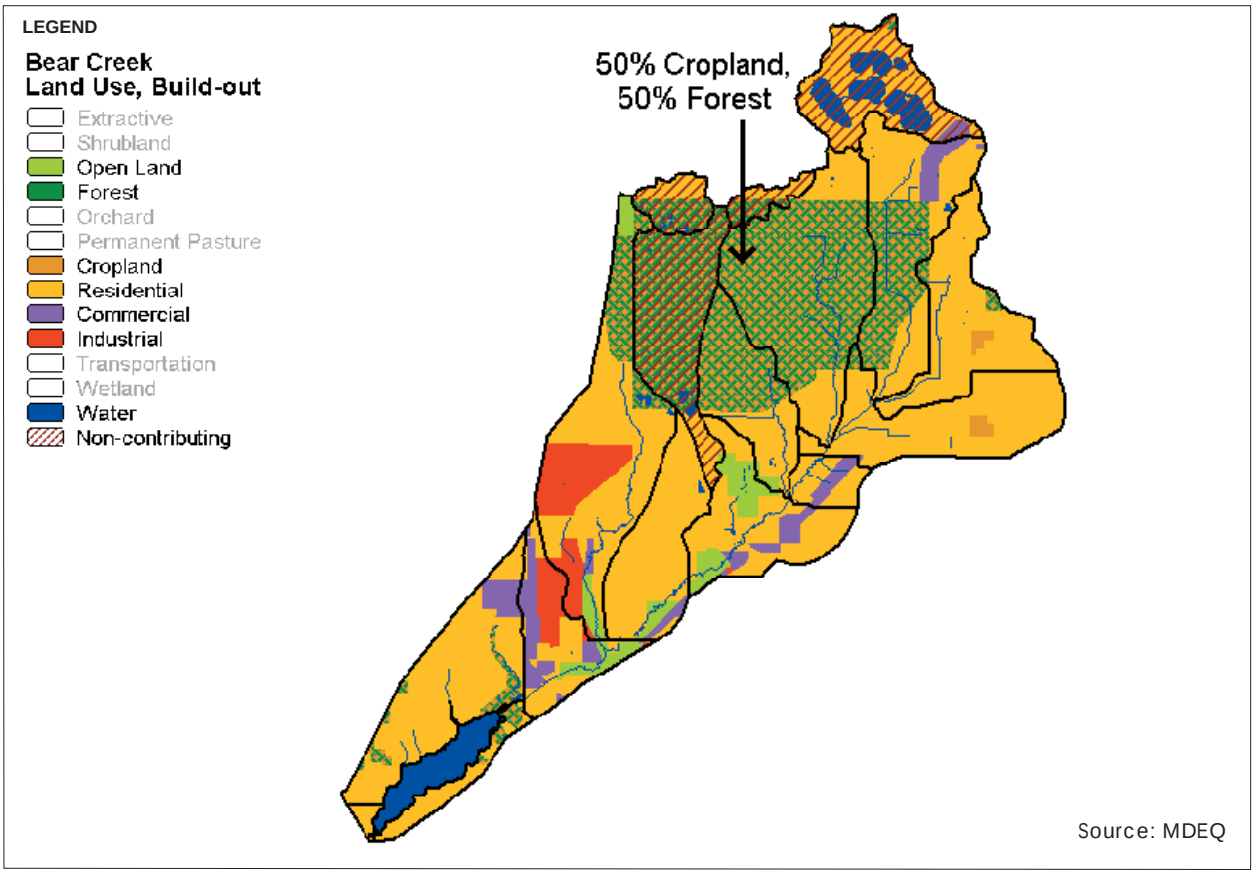
The remainder of the watershed remained in some form of its original vegetative cover. Importantly, however, fire suppression has allowed the forest's trees to become much more densely disposed, which has led to a collapse of the ground-cover of bunch sedges. This has resulted in a progressive tendency for rain water to leach nutrients through to the water table, then out through drainage ditches and streams. In general, the ability of the remnant land to sustain its biological integrity has suffered and continues to degrade. This hard-to-see impact of fire suppression nevertheless continues to degrade the quality of surface waters and corresponds to an inexorable loss of native species.

Land Use/Land Cover in 1997

Since 1978, as shown on the Land Use/Land Cover Map (1997) on the previous page, residential development has increased nearly 30%, from 14% to 18%. Commercial development expanded about 1% and land area in agriculture has remained about the same. Development since 1978 has been much more scattered than development prior to 1978.

Build-Out Analysis

Based on land use zoning plans prepared by Langworthy Strader Leblanc & Associates, Inc. and the build-out analysis conducted by MDEQ as part of their *Hydrologic Study of the Bear Creek and Bear Lake Watershed (2003),* land uses were assumed to be developed to the maximum allowable under zoning regulations. The map on the facing page shows that residential land use is the predominate land use, that commercial development is planned to occur along state highway 120 and Whitehall Roads, and that industrial development is planned to occur primarily along Central and Russell Roads. There are a few planned open lands scattered along the Bear Creek corridor and a large patch of conservation/open space zoning district in the north center of the watershed. This large patch is indicated to be half cropland and half forest. Based on the natural resources inventory discussed in earlier sections of this chapter, this conservation area contains a significant amount of hydric soils and wetlands. The Build-Out Analysis Map is based on current zoning and was used by MDEQ to estimate the hydrologic condition of the watershed under final expected land use conditions.



Build-Out Analysis Map

Land Use/Land Cover Assessment

Although the build-out condition map shows a significant area that would remain as cropland and forest as well as some open land, much of the watershed is shown to be developed. Also, the individual open land areas are generally discontinuous.

Considering that the 2020 population is expected to be only 10% to 15% greater than the current population, the watershed is not likely to reach build-out for quite some time. In the interim, current trends suggest that scattered development will continue to occur. This leads to a generally greater "footprint" on the landscape as utilities are extended, roads are widened, and wastewater systems created to serve the dispersed population. This dispersal can result in reduced area and greater fragmentation of natural lands, long before build-out occurs.

The decrease in native plant cover and increase in impervious cover related to urban development is a significant threat to water quality and aquatic habitat. To minimize these impacts, it is important to establish conservation-based land use plans and stormwater management techniques.

In addition to urban impacts, general degradation of the remaining remnant landscapes is a continuing trend due to fire suppression, drainage of the land for agricultural and urban purposes, and increasing fragmentation.

2.5 Watershed Hydrologic Modeling

A Hydrologic Study of the Bear Creek and Bear Lake Watershed was prepared in 2003. This study was initiated in support of the Muskegon River Watershed project, funded by a U.S. EPA 319 grant, and conducted by MDEQ. The Hydrologic Study Goals were to:

- better understand the Watershed hydrology and impacts of land use changes on hydrology,
- facilitate selection and design of suitable BMPs, and
- provide information for use of local government to develop or improve stormwater ordinances

The study divided the Watershed into 16 sub-basins (see Subbasin Identification Map on next page) and modeled runoff volumes and flow rates for the 1800, 1978, 1997, and Built-out conditions. Results of the study show which areas can expect the most runoff increase based on the proposed zoning and which areas would exceed recommended flow rates.

The study found that three (3) subbasins will exceed the 0.13 cfs/acre allowable release rate for the 25-year event being proposed in neighboring townships based on a model stormwater ordinance for Kent County. Most other sub-basins, including the three in exceedance, also show a significant increase in runoff from current to build-out conditions, particularly for the 2-year event. Two of the three subbasins that exceed the Kent County rate include the mainstem of Bear Creek that is influenced by large areas of the watershed. Thus, measures to prevent exceeding the proposed ordinance release rates in those reaches must consider nearly the entire watershed.

Sub-basins that currently exceed the Kent County proposed discharge rate of 0.13 cfs/acre are:

- Fuhrman Drain
- Bear Creek below McMillan Road, Which is affected by subbasins 4, 5, 6, & 7 above it.
- Bear Creek to Whitham Road, which is affected by nearly the entire watershed.

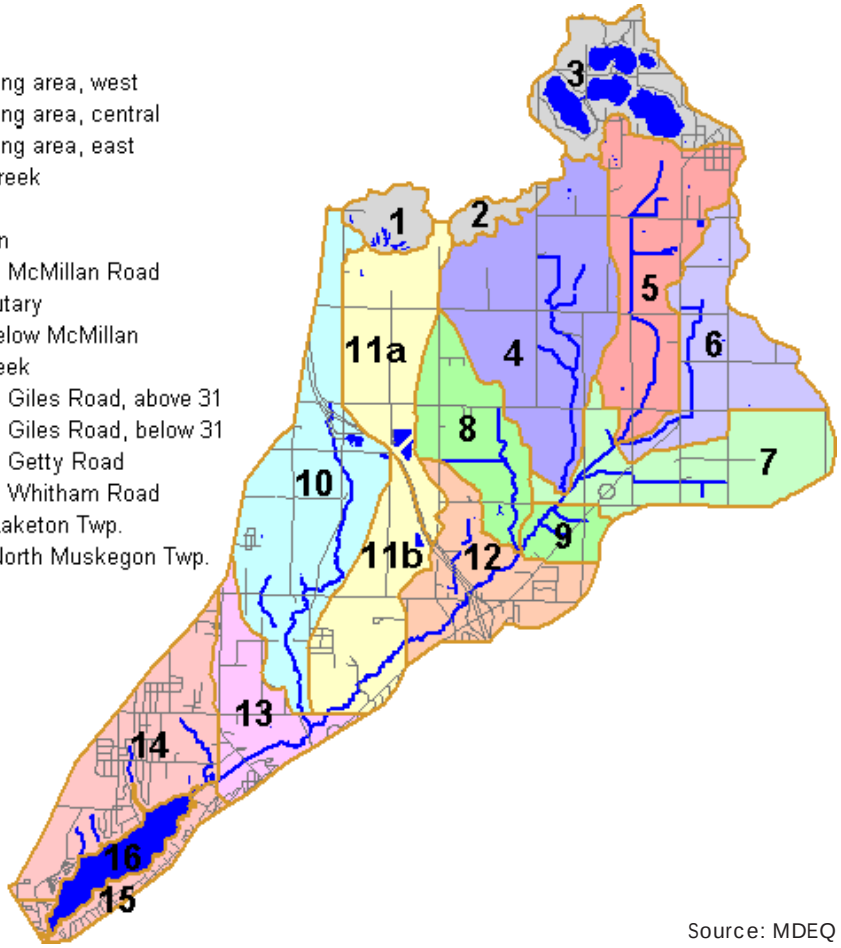
The modeling assumes conventional stormwater management practices with no detention or other stormwater BMPs. Thus, the results of the modeling could be considered a “trends” scenario of what can be expected if actions are not taken to prevent problems. If the BMPs of Section 3.2 are implemented, much of the projected increase in discharge rates and runoff volumes could be avoided.

It should be noted that the Kent County release rate is significantly greater than existing discharge rates in most areas of the watershed and therefore the proposed release rate is unlikely to be sufficient to prevent increases in 25-year flood flows.

Although it is noted that many factors are important, the report cites a study that found a strong relationship be tween the 2-year flow rate and the presence of trout in the stream. The threshold between a trout fishery and an impaired fishery was estimated to be approximately 0.008 cfs/acre. The threshold between an impaired fishery and no trout was found to be approximately 0.011 cfs/acre. Currently, discharge rates for Little Bear Creek and the mainstem below McMillan Road are at or below the trout fishery target discharge rate of 0.008 cfs/acre for the 2-year event. However, the discharge rate is expected to well exceed this rate under build-out conditions.

LEGEND

Subbasin	Area (sq. mi.)	Description
1	0.49	Non-contributing area, west
2	0.28	Non-contributing area, central
3	1.77	Non-contributing area, east
4	3.76	Upper Bear Creek
5	2.69	Ribe Drain
6	2.07	Fuhrman Drain
7	2.21	Bear Creek to McMillan Road
8	1.57	unnamed tributary
9	0.47	Bear Creek below McMillan
10	3.69	Little Bear Creek
11a	1.80	Bear Creek to Giles Road, above 31
11b	1.97	Bear Creek to Giles Road, below 31
12	1.87	Bear Creek to Getty Road
13	1.39	Bear Creek to Whitham Road
14	2.58	Bear Creek, Laketon Twp.
15	0.55	Bear Creek, North Muskegon Twp.
16	0.62	Bear Lake



Source: MDEQ

Subbasin Identification Map