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Wet Weather Pollution in Michigan

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Executive Summary

Today, the major surface water quality issues in Michigan can generally be attributed to discharges associated with wet weather pollution. Our goal with this report is to advance the knowledge of, and methods for, addressing these issues.

To accomplish this objective, five work groups were formed in October 2008 to improve our understanding of issues related to wet weather pollution and develop a strategy to more effectively protect water quality from such pollution. The five work groups were: Wastes to Land, Earth Change, Urban Living, Monitoring, and Water Quality Based Effluent Limits and Standards Applicability. The charge to the Wet Weather Pollution Work Groups was to determine how to appropriately define and handle wet weather pollution discharges to surface waters to meet Michigan's Water Quality Standards.

The work groups completed their reports in March 2010. Each work group report is included separately in this report as a chapter, those being Chapters 2 through 6.
The Wet Weather Benchmarking Report was submitted in December 2009 and has been included as Chapter 7 of this report.

Based on a review of the work group reports, there are several broad conclusions and recommendations that may be made:

1. Presently, the detrimental effects of increased *E. coli* concentrations are the most documented effects from wet weather pollution discharges. These effects are found in both urban and rural surface waters.

2. Urban streams are heavily impacted by flow modifications from wet weather pollution discharges, due to unnaturally high runoff volumes. Increases in impervious surface area, stream channelization, loss of wetland acreage, deforestation, and agricultural field tiling all have led to more rapid and higher volume runoff from storm events or snowmelt. Such unnaturally high runoff volumes can have detrimental physical impacts, causing channel erosion, flooding, and damage to in-stream habitat for aquatic organisms.

3. A large amount of subjectivity exists in many of the wet weather pollution programs. This subjectivity creates problems and makes it difficult to consistently address the effects from wet weather pollution discharges.

4. A lack of consistent terminology exists across programs that deal with wet weather pollution. For example, the term "agronomic rate" has a different meaning in at least three programs (biosolids, septage, and National Pollutant Discharge Elimination System [NPDES] concentrated animal feeding operation [CAFO] permits). Inconsistent terminology serves to hinder the ability to address the wet weather pollution issues.

5. Measuring the impacts of wet weather pollution is problematic, primarily due to sampling difficulty, a lack of methods to monitor pollutants, and established means to evaluate the impacts of wet weather pollution discharges. There is a need to develop training for wet weather pollution discharge sampling and ambient water quality monitoring.

6. Based on available records, animal wastes are the largest, by volume, wastes that are applied to land in Michigan.

7. Good regulatory mechanisms exist for biosolids, septage, CAFO permits, combined sewer overflow (CSO), storm sewer overflow (SSO), Industrial Storm Water, Municipal Storm Water (those under permit), Construction Storm Water and soil erosion and sedimentation control (SESC).

8. Urban infrastructure in Michigan is currently in need of a clearly defined adequate maintenance program. Consideration should be given to developing a Capacity, Management, Operations and Maintenance (CMOM) permit program to address this need.

9. Effective best management practices (BMP) need to be identified and BMP standards established.

10. It is difficult to understand and address total maximum daily load (TMDL) obligations for wet weather pollution discharges. This challenge makes it difficult to restore impaired waters.

Based on these broad conclusions and recommendations, the Department of Natural Resources and Environment (DNRE) recommends the following next steps be taken to address wet weather pollution:

1. A pilot project should be developed and implemented to address a specific water quality parameter. *E. coli* should be strongly considered for this pilot, as the detrimental effects are in both urban and rural areas. In addition there are established sampling methods, analytical techniques, and a numerical Water Quality Standard for *E. coli*.

2. A pilot project should be developed and implemented to address the flow quantity issue that impacts most urban streams. As a part of this project, incentives should be developed to aid in the implementation of activities that would help stream restoration.

3. Assess BMP effectiveness. This is currently being done to some extent by the United States Environmental Protection Agency (USEPA). This assessment by the USEPA should be made a priority.

4. Consideration should be given to establishing monitoring requirements for wet weather discharges that are under NPDES permit. This would assist in determining what impacts are likely from such discharges. However, such requirements need to be concisely directed with appropriate guidance developed to assist those sampling the discharges.

5. A voluntary CMOM permit program should be developed, with incentives to encourage participation in the program.

Chapter 1
Introduction

Early efforts to implement the Federal Clean Water Act of 1972 focused primarily on regulating discharges from traditional point source facilities, such as municipal sewage treatment and industrial plants. Because of those efforts, point source pollution has been greatly reduced. Until the late 1980s, little attention was paid to storm water runoff from urban areas, construction sites, farms, and other wet weather pollution discharges. Since that time, work to address wet weather pollution has increased significantly, but these types of discharges continue to be at the root of many existing surface water quality problems.

Today, the major surface water quality issues in Michigan can generally be attributed to discharges associated with wet weather pollution. Such discharges include sewer overflows, storm water, animal feeding operations, biosolids, septage, soil erosion, and farming operations. Addressing discharges from different types of land use has been very difficult. Our approach has been largely reactive rather than proactive. It is our desire to better understand these issues in order to become more proactive and put appropriate mechanisms in place to protect water quality. We recognize that this effort and report will not provide the final answers in how to address the multitude of wet weather pollution questions. With this realization, our goal is to advance the knowledge of, and methods for, addressing these issues.

To accomplish this objective, five work groups were formed in October 2008 to improve our understanding of issues related to wet weather pollution and develop a strategy to more effectively protect water quality from such pollution. The five work groups were: Wastes to Land, Earth Change, Urban Living, Monitoring, and Water Quality Based Effluent Limits and Standards Applicability. The charge to the Wet Weather Pollution Work Groups was to determine how to appropriately define and handle wet weather pollution discharges to surface waters to meet Michigan's Water Quality Standards. Each work group was to address their specific area of this overall goal, with a focus on the specific objectives identified for each work group. Attachment A contains the memo establishing the work groups, their specific charge, objectives, programs covered, and the members of each work group.

The work groups completed their reports in March 2010. Each work group report is included separately in this report as a chapter, those being Chapters 2 through 6.

To complement the detailed efforts of the work groups, benchmarking of other states and the USEPA was conducted by the University of Michigan, Center for Sustainable Systems. A research team from the University submitted a work plan designed to solicit information from the Internet to document the states' and USEPA's current wet weather pollution practices. In addition to Internet-based research, the proposal included the creation and implementation of surveys to obtain information not readily available on the Internet concerning current wet weather pollution practices from other states and the USEPA. The Water Bureau approved this proposal and the research team commenced in early May 2009. The Wet Weather Benchmarking Report was submitted in December 2009 and has been included as Chapter 7 of this report.

The final chapter (Chapter 8) summarizes our broad conclusions and recommendations, our discussion on what the DNRE is going to do next, and suggestions for what the USEPA and others should consider addressing and implementing regarding wet weather pollution.

Chapter 2
Urban Living

Urban wet-weather discharges come primarily from pipes and ditches. A similarity of urban wet-weather discharges is that most are regulated (i.e., combined sewer overflows [CSO], industrial, and Municipal Separate Storm Sewer Systems [MS4]) or prohibited (i.e., sanitary sewer overflows [SSO] and illicit non-storm water discharges). The exceptions are non-regulated MS4 discharges outside of U.S. Bureau of Census designated urbanized areas and non-regulated commercial and industrial activities without “storm water discharges associated with industrial activities.” These non-regulated discharges include all cities north of a line from Muskegon to Bay City, and small isolated population centers south of that line (e.g., Albion, Lapeer, and Ionia) for the MS4 program, and auto repair facilities for commercial/industrial activities. State and federal rules authorize the Department of Natural Resources and Environment (DNRE) to regulate the excluded discharges by designating them as significant contributors, but none have been designated as significant contributors in Michigan.

Given that all of the urban wet weather pollution discharges are highly variable in their pollutant content, they are more similar than different. For example, *E. coli* which is a concern in untreated CSOs and SSOs can also reach high concentrations in some MS4 and even industrial discharges. Metals, pesticides, and other toxins that are concerns in MS4 and industrial storm water discharges can also be present in CSOs and SSOs depending on what is going into the sanitary system and the condition of the storm water fraction of these discharges.

Eliminating or reducing storm water discharges is a control strategy that can relieve wet weather pollution impacts caused by SSOs, CSOs, industrial storm water, and MS4s.

Urban landscapes discharge a greater volume of storm water runoff per acre to lakes and streams than do undeveloped lands. Stream bank erosion occurs as a result of this increased runoff volume. Reducing volume to the stream will reduce in-stream scour and erosion. Reducing volume to collection systems will reduce the total volume of CSOs and the potential for SSOs. Keeping storm water on the land where it falls is a key control factor for all wet weather pollution issues in the urban environment.

This chapter is divided into five sections: Initial understanding (where we are now in each program), good aspects (positives) of the programs, problems and difficulties of the programs, proposed program improvements, and action items. Each of the programs is discussed separately in the first four sections and the numbered items are listed in priority order. The fifth section provides a list of actions that may be feasibly addressed in the short term.

Initial Understanding of Programs

CSO Initial Understanding:
At the onset of the CSO control initiative in the state of Michigan, which began over 20 years ago, there were approximately 600 untreated CSO outfalls identified. Since then, approximately 400 (or 67 percent) of those outfalls have been eliminated. Of the 198 that remain, approximately 20 percent of them are treated to meet water quality standards (these treated discharges are generally from retention and treatment basins [RTB], and for the purposes of this report they will be referred to as RTB discharges). Programs are in place to control the remaining untreated CSO outfalls through either treatment or elimination of the discharge through sewer separation. RTB discharges are regularly sampled by the permittees and the

sampling data is reported to the DNRE (untreated CSOs are not regularly sampled). This makes RTB discharges the best understood of the urban wet weather pollution discharges in terms of their characteristics (specifically dissolved oxygen, bacteria, and conventional pollutants), impacts, frequency of occurrence, and their locations. RTBs are also the only urban wet weather pollution discharges which routinely receive disinfection. National Pollutant Discharge Elimination System (NPDES) permits require monitoring for total residual chlorine but some questions remain regarding the need for dechlorination at some facilities. Studies and optimization of operations are currently being conducted at a number of facilities to evaluate the need for dechlorination.

SSO Initial Understanding:
Wet weather pollution related SSOs occur when the capacity of separate sanitary sewers and any associated pumping or storage facilities, or the capacity of a wastewater treatment plant (WWTP), are exceeded due to excess storm water and/or groundwater inputs to the system. SSOs may include discharges of raw sewage directly from a collection system or discharges resulting from bypasses of unit processes at a WWTP. SSOs may occur in random locations and times resulting from blockages, breaks, or capacity issues. They can contain a vast range of pollutants along with raw or partially treated sanitary wastes, and clear water from groundwater infiltration or inflow. With the exception of one permitted facility in the state, all SSOs are prohibited (note that the permitted facility is subject to secondary effluent limits and has a sufficient treatment system to meet the imposed limits). The primary focus of Michigan's SSO control efforts have been for those systems having chronic wet weather capacity issues resulting in SSOs. These SSOs are being addressed by a variety of corrective actions such as collection system infiltration/inflow reduction, and the construction of additional system storage and/or treatment facilities. Many of these corrective programs are based on enforcement cases which often contain schedules of compliance. The DNRE has established the use of "enforcement discretion" for capacity-related SSOs from sewer systems designed to handle flows up to the 25-year/24-hour storm, under growth conditions and normal soil moisture (remedial design standard).

Industrial Storm Water Initial Understanding:
There are over 3,200 permitted facilities. Industrial storm water permits require, at a minimum, a storm water pollution prevention plan (SWPPP) for source identification, structural controls and nonstructural controls, which include inspections and good housekeeping practices. Permittees must identify their point source discharges to surface waters of the state. If there are no direct discharges to surface waters of the state then an NPDES permit is not required. Under the permits, the sampling requirement is for storm water collected in required secondary containment that is discharged to surface waters of the state, from lands on the state-listed areas of environmental contamination and from other activities which may contribute pollutants to the storm water for which the DNRE determines monitoring is needed. The purpose of this monitoring is to ensure there are no violations of water quality standards as a result of the discharges.

MS4 Initial Understanding:
There are over 300 permitted MS4s. MS4 permits include a broad set of controls (six minimum measures) to meet the federal standard of controlling storm water pollution to the Maximum Extent Practicable (MEP). In practice, permittees implement a variety of non-structural or managerial BMPs under the minimum measures. Structural BMPs are also implemented, but to a lesser extent because of high costs.

Within the urban wet weather programs discussed, MS4 permits, through the post construction requirement, provide the only regulation of flow volume during wet weather. New developments and redeveloped properties must not cause runoff volume or flow rate to increase for storms up to the 2-year, 24-hour storm event. The restriction does not apply to flows from established developments unless they are redeveloped during the permit term.

Direct dumping, spills, and illicit connections contribute various pollutants to the MS4. The size and complexity of MS4s make it difficult to completely eliminate these sources of pollutants. The permit requires a program to find and effectively prohibit illicit discharges into the system. Routine sampling of MS4s is required for flows occurring during dry weather for illicit discharge detection. Additionally, one-time wet weather sampling of selected major pipes is required, to identify discharges contributing *E. coli* or phosphorus within total maximum daily load (TMDL) watersheds identified specifically for these pollutants.

Good Aspects of Programs

Good Aspects of the CSO Program

1. We have a good regulatory mechanism for addressing CSOs through the NPDES permitting program. When they occur, the facility is required to report the discharge to the DNRE and the public via the press. CSOs from retention treatment basins are treated in accordance with permit requirements. Effluent limits and design standards are established in the permit so that compliant discharges will ensure that Water Quality Standards are met in the receiving waters.

2. There is a state loan program that gives priority to funding the correction of CSOs.

3. CSOs have a high profile and, therefore, the public demands that they be controlled.

4. There is a defined goal for CSO control either through retention and treatment or elimination of the discharge through sewer separation.

Good Aspects of the SSO Program

1. We have a good regulatory mechanism for addressing SSOs after they have occurred, based on the DNRE SSO Policy and Clarification Statement.

2. When an SSO occurs the facility is legally required to report the discharge to the DNRE and the public via the press.

3. There is a state loan program that gives priority to SSO correction under enforcement action.

4. SSOs have a high profile and, therefore, the public demands that they be eliminated.

5. There is a defined goal for SSOs through elimination of the discharge or control up to the remedial design standard.

Good Aspects of the Industrial Storm Water Program

1. Regulated facilities appear to be cleaner with less exposure of significant materials.

2. The permits require a storm water certified operator who is required to have supervision over storm water treatment and control measures.

3. The DNRE has improved training for certified operators, provided resources for employee training, and made permittees aware of what to expect during a DNRE inspection.

4. Increased awareness of storm water regulations by the public.

5. Increased awareness of facilities required to have permit coverage and with the potential to contaminate storm water.

6. Increased awareness of permit requirements by employees at regulated facilities.

7. The no exposure certification process provides an incentive for regulated facilities to eliminate exposure of significant materials to storm water runoff which reduces the potential to contaminate storm water.

8. The program focuses on nonstructural and structural storm water controls instead of monitoring storm water discharges. This has been a better use of resources for some permittees who have been properly implementing a Storm Water Pollution Prevention Plan.

9. Increased removal of illicit connections, specifically floor drains connected to the storm sewer system.

Good Aspects of the MS4 Program

1. The public and regulated communities are more aware of water quality problems.

2. Permits are flexible; allowing permittees options.

3. The watershed approach allows permittees to collaborate on storm water management issues on the watershed level rather than by jurisdictional boundaries.

4. Permittees are revising their ordinances and enforcement mechanisms to ensure policies are in place to address storm water runoff for the long term.

5. Increased awareness of illicit discharges and connections. Through dry-weather screening of point source discharges, permittees have been able to better understand their system and eliminate illicit discharges.

6. The post-construction runoff control requirements in the permit focus on water quantity reductions.

7. Permittees are supporting and implementing low impact development.

8. Planning agencies and special interest groups are participating in the watershed groups, especially with public education.

Problems and Difficulties of the Programs

Problems with the CSO Program

1. Public does not always recognize the difference between treated CSOs and untreated CSOs. The lack of public understanding is causing the perception that efforts and money being spent are resulting in little progress.

2. Corrective actions are very expensive and there is insufficient funding for communities to address the problems (construction of retention basins for treatment, maintenance of collection systems, separation of systems, and reduction of storm water volume to collection systems).

3. When studies are needed to determine water quality impacts from CSOs, there may be difficulty performing meaningful studies during wet weather pollution events, including predicting when a discharge may occur during wet weather and access for sampling during wet weather.

Problems with the SSO Program

1. We are only able to address facilities where an SSO has been identified. There are likely a number of SSOs that have not yet been identified due to lack of knowledge/reporting by public and operators.

2. There is a need to be more proactive by identifying collection systems that are vulnerable to a potential SSO due to capacity issues. Some collection system issues are identified when Part 41 applications are reviewed or when capacity studies are completed by system owners. However, capacity issues are not always identified by applicants.

3. Collection systems are deteriorating. The DNRE currently lacks the staff and resources to inspect collection systems to identify the potential for an SSO. Additionally, for many communities, funds are insufficient to maintain and evaluate their collection systems.

Problems with the Industrial Storm Water Program

1. Industrial storm water compliance inspections are not conducted frequently enough to assess compliance with the industrial storm water permit. When inspections are conducted, the majority of facilities are in noncompliance and require a violation notice. This is primarily due to a lack of funding to hire staff to administer the program.

2. The review of the SWPPP is not proactive. Since the SWPPP is not reviewed before the Certificate of Coverage (COC) is issued, the SWPPP may not have adequate controls (BMPs) in place to properly manage storm water at the facility. The first review of the SWPPP is completed during an inspection which could take place up to five years from when the COC is issued.

3. There is no formal standard to measure the effectiveness of the BMPs.

4. Recertification of industrial storm water certified operators does not require any additional training or assessment of the knowledge of the industrial storm water certified operator.

5. Due to a lack of staff and adequate outreach, there are a significant number of unpermitted facilities.

6. The industrial storm water regulations based on SICs do not adequately consider the risks posed by unregulated industrial and commercial facilities to negatively impact water quality.

7. Even though the materials are available, there is a lack of employee training at some industrial facilities. Many employees do not understand how their actions or lack of action affect the control measures in place at the facility.

8. There is very little monitoring of storm water runoff at industrial facilities so we do not know the quality of the storm water runoff.

9. Industrial storm water general permits are not sector specific, therefore, controls tailored toward the industry are not specifically identified.

10. The industrial storm water program does not require reductions in the amount of storm water runoff. Reducing the volume of runoff will result in a decrease in the pollutant load to surface waters.

11. There is a general lack of understanding as to why it is important to reduce the pollutants getting into storm water runoff. This contributes to the degradation of storm water runoff from regulated and nonregulated industrial facilities.

Problems with the MS4 Program

1. The MS4 permits are very complicated. This may be due in part to an attempt to provide flexibility for regulated communities.

2. Regulated municipalities lack a dedicated source of funding for the activities they are required to implement in the MS4 permit.

3. The home rule form of government in Michigan causes many gaps and uncertain overlaps in authority (i.e. Drain Commissions, Road Commissions and Townships).

4. The program is not designed to fix existing water quantity problems.

5. Determining compliance with the MS4 permits is difficult for DNRE staff and permittees. This may be due to the ambiguous definition of Maximum Extent Practicable that the permits require.

6. There are no wet weather performance standards except post-construction standards. This also makes it difficult to determine compliance. Without standards there is little need to monitor discharges or ambient wet-weather conditions. As a consequence, the water quality impacts are not well understood.

7. There is no coordinated state-wide education campaign. The educational materials are not designed to reach a broad enough spectrum of the general public. There is still a lack of understanding among the general public about how their activities affect the quality and quantity of storm water runoff. Education programs are missing large sectors of the public.

8. Communities that do not meet the definition of urbanized areas are not regulated. Many water bodies are being impacted by separate storm sewer discharges from these non-regulated communities.

9. National environmental groups in Michigan have chosen not to be as involved in issues with urban storm water runoff as they have in other areas such as confined animal feeding operations. They don't seem to perceive storm water runoff from urbanized areas as being a priority water quality and political issue.

Proposed Program Improvements

Proposed CSO Program Improvements

During 2008 there were 39.8 billion gallons of CSO discharge of which 20.6 billion were treated. It is important to note that the numbers may be highly variable from one year to the next due to annual rainfall differences and many other factors. An archive of published CSO/SSO annual reports are available on the DNRE Web site and contain more detailed information regarding annual CSO discharge volume totals, a comparison to recent annual discharge volume totals, discharge locations, annual rainfall totals, and other relevant information. Following is a list of recommended program improvements for the CSO program:

1. Funding must be increased to construct and maintain CSO collection and treatment systems.

2. The public needs to be educated concerning the differences between RTB discharges and untreated CSO discharges, and the potential impact on human health and aquatic life.

3. The volume of runoff going into the combined sewer systems could be reduced through green solutions. BMPs aimed at infiltrating, storing, and treating storm water runoff could result in less taxing of combined sewer collection and treatment systems during wet weather pollution events. However, it would be necessary to determine the significance these types of solutions may have on a system-wide CSO control program prior to their approval. Promoting and encouraging such evaluations (technical as well as cost-effective analyses), could lead to identification of cost-effective green infrastructure options for CSO control programs. The department can prepare guidance on the funding options available for these types of evaluations and for eventual implementation of BMPs. Funding guidance can be used to educate municipalities about these CSO control funding options.

4. CSO drainage areas that are a high priority for urban revitalization projects should be identified. Revitalization projects provide the maximum opportunity to broadly implement green solutions (low-impact development [LID] practices) throughout the CSO drainage area and have an impact on water quantity and water quality. The CSO drainage basins would need to be modeled to determine which LID practices would provide the optimal

effects. Provide grant funding for implementation of LID-CSO reduction projects as part of an overall urban revitalization project.

Proposed SSO program improvements

During 2008 there were 251.24 million gallons of untreated SSO discharged. It is important to note that the numbers may be highly variable from one year to the next due to annual rainfall differences and many other factors. An archive of published CSO/SSO annual reports are available on the DNRE Web site and contain more detailed information regarding annual SSO discharge volume totals, a comparison to recent annual discharge volume totals, discharge locations, annual rainfall totals, and other relevant information. Following is a list of recommended program improvements for the SSO program:

1. Funding must be increased to adequately construct and maintain collection and treatment systems.

2. Public collection system owners need to have adequate knowledge of their systems so that they are able to identify capacity issues and adequately address them proactively, with the goal of addressing issues before they result in SSOs.

3. All collection systems should be regulated through some sort of permitting program even if they don't operate a publicly owned treatment work or have a permitted discharge. A permit program would allow collection system owners and the DNRE to better proactively address capacity issues by enabling them to identify and address issues prior to occurrence of violations. (Example: Wisconsin Capacity Management, Operations and Maintenance [CMOM] Program).

4. Wastewater treatment plant and collection system operators need to be educated so that they are better able to recognize and report SSOs when they occur, since they are legally responsible to do so.

Proposed industrial storm water program improvements

Following is a list of recommended program improvements for the industrial storm water program:

1. Methods are needed to improve compliance rates. The following would help improve compliance at industrial storm water permitted facilities:
    a. Recertification of industrial storm water certified operators to include attending a training session and taking an exam
    b. Increased inspection frequencies
        i. Need more staff
        ii. Increase efficiency of staff performing inspections (Provide staff with the ability to enter data into NMS at the time of inspection instead of in office at a later date)
    c. Identify compliance incentives for permittees
    d. Identify TMDLs in Certificate of Coverages
    e. Identify clearer standards for TMDL waters.

2. There is a need to find and permit regulated industries. Specific needs include:
    a. General public education to increase awareness of the public and regulated community.
    b. Funding support for additional field staff.
    c. Communication with new industries so that they apply before starting up.
    d. Provide incentive for unpermitted, regulated facilities to apply for permit coverage.

3. Source monitoring for specific industrial sectors is identified as a need:
    a. To identify the effectiveness of the permitting approach
    b. To allow permittees to select structural controls as they determine to be appropriate which will effectively reduce pollutant loadings rather than those structural controls required in a sector specific permit.

4. Where existing BMPs have not been proven to be effective, Water Quality Based Effluent Limitations specific to particular industrial sectors may be necessary, together with sampling requirements to identify compliance with these limitations.

5. Develop a program to encourage or require reduction in runoff volume from industrial facilities.

Proposed MS4 program improvements

1. The permittees need sustainable funding such as utility fees. Funding is especially needed to address TMDLs and impaired waters.

2. Develop a program to encourage or require reduction in runoff volume from regulated MS4s.

3. MS4 compliance could be improved through:

    a. The development of compliance assistance documents. The department established an implementation team and has developed compliance documents which are being presented at municipal training workshops.
    b. Improved staff training which will enable staff to adequately and confidently assist the permittees. This recommendation is being met by involving staff in the development of the compliance assistance documents and the presentation of the materials at municipal training workshops. After the training workshops it will be determined if additional staff training is needed.
    c. Provide training to program managers at municipally operated facilities so that they can develop and implement SWPPPs for their facilities. The compliance assistance documents, the municipal training workshops, and special industrial storm water certified operator classes tailored to municipalities are addressing this need.
    d. Addressing issues where authority to comply is weak or lacking (e.g., drain commissioners that lack land use or compliance authority). Recommend supporting the revamping of the drain code so that drain commissioners can address water quality issues in county drains.
    e. Nonpoint Source engineers providing training to MS4 staff so they can review post construction alternatives and ordinances.

4. The DNRE needs a focus and strategy for regulating discharges from MS4s that are not automatically regulated under Phase I and Phase II. A large percentage of the urban wet weather pollution discharges to Michigan's surface waters are non-regulated.

5. The Workgroup identified a need to develop wet weather technical and performance standards and move beyond inadequate BMP standards. Permittees could then implement BMPs in accordance with the standards to achieve a presumed level of storm water control.

6. There is a need to develop a process for understanding the pollutant loading from MS4s, including a process for source and ambient monitoring specific to MS4 discharges. Permittees could then implement a monitoring program to demonstrate a specified outcome. Monitoring should only be conducted to determine if BMPs are adequate or to determine the BMPs that are needed to control storm water pollution to the maximum extent practicable.

Overall Proposed Program Improvements:

Education of the public-at-large is paramount. Such education should focus on encouraging proper stewardship of aquatic resources, building support for funding of wet weather pollution environmental programs, and training people to be watchdogs for the reporting of illicit behavior and unpermitted dischargers.

The Workgroup identified a common need for education of municipal elected officials and legislators about each program. We believe that educational materials could be produced and used to introduce these officials to wet weather pollution concerns and regulatory programs. Turnover in these positions is high, and few incoming officials have a working knowledge of these programs or an understanding of why they are necessary. The multiple wet weather pollutant sources and the complexity of the control strategies make education necessary for elected officials. For most of these officials it is likely that one day they will be called upon to make decisions concerning wet weather pollution issues.

Educating the public and elected officials about wet weather environmental issues may also lead to more and better funding mechanisms. Funding is obviously a key component to addressing any environmental issue. While some grant and loan programs exist, the lack of sufficient funding often remains an obstacle for adequately addressing wet weather pollution related environmental issues.

The Workgroup recognized that the impacts of all wet weather pollution discharges (except for perhaps SSOs) may be lessened by reducing the <u>amount</u> of storm water runoff to surface waters. Conventional storm water BMPs are not generally designed to reduce the volume of storm water runoff, especially in clay soils. The recent advent of low impact development and "green" storm water BMPs offers ways to reduce runoff volume routinely and in all soil types. Reducing runoff volume helps protect stream channels from erosion and pollutant resuspension, but it also reduces pollutant loading to receiving waters. This is true for industrial and municipal storm water, and also has promise for CSOs. Both regulatory and educational methods can be used by the DNRE to increase the use of storm water volume controls. EPA is also seeking regulatory controls to prevent runoff volume increases in new development.

Preventative programs need to be implemented to proactively address SSO and CSO related problems. These may include programs adopted by system owners that track system capacity and compare it to current and future flow needs; and permitting programs that require all collection system owners, whether they own and operate the downstream WWTP or not, to address operation and maintenance needs through a state regulatory program. Innovative green solutions aimed at reducing flow inputs to combined systems as part of future CSO control programs should be evaluated.

The relationship between the permit requirements and water quality outcomes needs additional study for MS4s and industrial activities. To better link the controls to the desired outcomes, there is a need for the permits to be more specific to the type of discharger. For example, metal scrap yards need different controls than food processors, and school districts need different controls than county drain commissioners. Typically, these discharges are permitted through limited general permit options for both industries and municipalities.

Action Items

The following is a list of actions the Urban Living Workgroup believes could feasibly be addressed in the short term. The lists of actions are prioritized for implementing program improvements to cover all of the programs related to urban discharges. The action items are listed in three groups according to the impact on water quality and the perceived feasibility of the action item. (Tier 1 being of high priority and Tier 3 being of lower priority). The action items preceded by the ** symbol indicate the action item is already in process.

Tier 1 Improvements

1. Develop and implement an educational program for public and elected officials about wet weather pollution environmental issues.

2. Develop a permit program for collection systems that do not operate a WWTP or have a permitted discharge (i.e. contributing municipalities) to more effectively and proactively address SSOs. Investigate other states that currently have CMOM type programs to determine how they were created and how they currently implement their programs (Wisconsin and Ohio) to aid in program development. CMOM type programs would be encouraged (possibly required in the future) for all collection system owners.

3. **Educate the public concerning the differences between RTB discharges that meet permit limits and untreated CSO discharges, and the potential impact of each on human health and aquatic life. Include such information in the annual CSO/SSO report.

4. Recertification of industrial storm water certified operators to include attending a training session and taking an exam. The training has already been developed.

5. **A percentage of scheduled inspections for the year should be at unpermitted regulated facilities. This would include those facilities that have submitted No Exposure Certifications.

6. **Develop sector specific permits for certain industrial sectors. This would include first flush storm water monitoring or installing required structural controls in lieu of monitoring. More research needs to be conducted to determine how other states and the USEPA have developed and are implementing their sector specific permits.

7. Develop a program to require reduction in runoff volume from regulated MS4s to address existing issues.

8. Work in conjunction with other DNRE agencies (e.g. fisheries and parks) for better education of the general public on water stewardship issues.

9. **Develop compliance assistance documents for MS4 permittees.

10. Develop and provide staff training which will enable staff to adequately and confidently assist the municipal permittees.

11. Identify TMDLs in Certificate of Coverage's.

Tier 2 Improvements

12. Identify CSO drainage areas that are high priority for urban revitalization projects. This provides the maximum opportunity to broadly implement LID practices throughout the CSO drainage area and have impact on both water quantity and quality issues.

13. Model the CSO drainage basin to determine what LID practices would provide the optimal effect on water quantity and quality issues. (Ex. Fitzhugh CSO Basin modeling effort in Saginaw).

14. Coordinate with the municipality on considering LID as part of their overall urban revitalization project.

15. Provide grant funding for implementation of LID-CSO reduction projects as part of an overall urban revitalization project. (Ex. Saginaw just received $17.4 million dollars for urban revitalization. This might be an opportunity to develop LID practices throughout the Fitzhugh CSO drainage area that would reduce the volume of storm water to the CSO basin and improve water quality).

16. Develop a program to encourage or require reduction in runoff volume from industrial facilities.

17. Develop a practical and useful storm water monitoring program for MS4s. Monitoring should only be conducted if there is a specific intended use.

18. **Provide training to program managers at municipally operated facilities so that they can develop and implement SWPPPs for their facilities.

19. Address issues where authority to comply is weak or lacking (e.g., drain operators that lack land use or compliance authority).

20. Provide trained engineers to review post construction alternatives or provide training to municipal storm water staff so that they can review plans and ordinances.

Tier 3 Improvements

21. **Continue to convey SSO legal reporting requirements to WWTP and collection system owners and operators so that SSOs are properly recognized and reported.

22. Determine if we can identify where states and the USEPA are developing waste loads for individual storm water facilities where there is a TMDL.

Chapter 3
Earth Change

The Wet Weather Earth Change (WWEC) group reviewed the nine objectives provided to the Wet Weather Groups. The objectives are numbered one through nine for discussion purposes. Specific recommendations are included for each objective and subsequently prioritized (high, medium, and low) at the end of this chapter.

The WWEC addressed the major water quality problems attributed to wet weather pollution in the three earth change programs: Construction Storm Water (CSW), Soil Erosion and Sedimentation Control (SESC), and Nonpoint Source (NPS).

The WWEC attempted to identify the reactive approaches taken in the three earth change programs in order to move towards a proactive approach to wet weather pollution issues. Those aspects of the programs that are effective are also identified.

Objective No. 1
Augment the benchmarking information as needed.

Summary Response

The WWEC crafted questions to be included in Dr. Bulkley's benchmark survey, prioritized the questions (high, medium, and low), and provided selected agencies for Dr. Bulkley's students to contact to obtain in-depth information. Although the benchmark report and survey did not capture all the specific information that the WWEC had hoped to obtain, the report does include some potentially valuable information for regulation of earth change activities in other states. The report itself acknowledges some inherent flaws with the survey, as stated here in the afterword:

> "*Another substantial and frequent limitation arose in the form of an observed discontinuity between the survey results and the information contained in agencies' permits. Possible explanation for this disparity include misunderstood questions, incorrect entry to questions (causing the respondent to be automatically directed to skip subsequent questions), as well as the respondents position or responsibility about a given wet weather regulatory issue."*

From this perspective, while the report provides some potentially useful information for the WWEC to consider, additional efforts should be made to speak directly with program staff in the states of interest, to more accurately gauge the nature and effectiveness of those states' earth change programs.

At least six states responding to the benchmark survey (Connecticut, Missouri, Ohio, Vermont, Virginia, and Washington) require specific Best Managements Practices (BMP) in their permits. States such as Florida, North Dakota, Oregon, and Texas may require BMPs but there was conflicting information in the benchmark survey regarding whether BMPs were required or recommended.

Recommendations

1-1. The WWEC needs to follow-up (phone call and review of specific regulatory language) with states that appear to have program components or regulations that may be beneficial to include into the Michigan earth change programs.
1-2. The WWEC needs to obtain more specific information from the states regarding their SESC programs. The benchmark survey focused primarily on CSW programs.

Objective No. 2
Determine how water quality is protected (i.e., performance standards, specifically required BMP, BMPs selected by permittee, etc.).

Summary response

The WWEC recognizes that water quality in Michigan is primarily protected through laws and administrative rules. Other mechanisms, such as performance standards, are not established for the CSW, SESC, or NPS programs. Although BMPs are recommended for earth changes, they are not prescribed. A primary objective for the WWEC is to investigate means to determine acceptable discharges from earth change sites to effectively protect the waters of the state and adjacent properties.

Many states responding to the benchmark survey rely on more than one method to protect water quality from construction activities. The benchmark survey reported that eight states specify design criteria; four states specify performance standards; seven states recommend BMPs that permittees can implement on a voluntary basis; six states require specific BMPs; and ten states rely on narrative standards. No states responded that they utilized numeric standards to protect water quality.

Recommendations

2-1. Determine effective methods to monitor discharges, in addition to the existing Rule 50 narrative standards that would support the visual observations currently relied upon by district staff to determine site compliance. These may include:
- Identifying specific standards and specifications for BMPs.
- Identifying monitoring methods for BMPs and discharges.

2-2. Determine the applicability and effectiveness of effluent limits for the CSW and SESC programs.

2-3. Determine the applicability and effectiveness of prescribed BMPs (individual categories or decision matrix) for the CSW, SESC, and NPS programs.

2-4. Determine acceptable rainfall frequency design criteria to address water quality requirements on earth change sites.

2-5. Provide each district with a turbidity meter and guidelines on how to use them. The United States Environmental Protection Agency (USEPA) recently promulgated a 280 NTU turbidity discharge limit for sites 10 or more acres in size.

Objective No. 3
Identify specific BMPs routinely used as control devices. Are they required by regulation or permit or are they voluntary? Do they have performance standards associated with them? Is there technical information available to document their effectiveness?

Summary Response

While BMPs are commonly used to protect water resources and adjacent properties, they are not explicitly defined in the rules, are not prescribed by permits, and do not have performance standards. Currently, Michigan does not have technical information available in one comprehensive format to document BMP effectiveness. The Water Bureau is currently revising its BMP manual, and the recently completed CSW/SESC training manual provides detailed information on 13 BMPs commonly used on construction sites.

There were no follow-up questions in the benchmark survey for those states that recommended or required BMPs to provide a list of the BMPs that are commonly used. Therefore, information regarding specific BMPs must be obtained from those states through additional follow-up by staff.

Recommendations

3-1. Consider a mechanism to include specific BMP requirements in Notice of Coverage (NOC) applications for each earth change site based on known BMP effectiveness.

3-2. Develop more stringent BMP standards that can be placed in National Pollutant Discharge Elimination System (NPDES) General Permits, especially for priority sites that the WWEC defines priority sites as outstanding state resource waters (OSRW), Total Maximum Daily Load (TMDL) water bodies, highly erodible soils, or where navigational and recreational uses are impacted.

3-3. Provide a user-friendly on-line resource consisting of BMP guidance for the CSW, SESC, and NPS programs.

3-4. Request the Monitoring Work Group to determine BMP effectiveness.

3-5. Determine what types of BMPs are necessary for storm water treatment for various types of flows and site conditions.
- Determine if an acceptable discharge can be achieved using BMPs.
- Determine whether BMP performance is predictable.

Objective No. 4
Determine whether programs related to your work group are proactive (i.e., actions are implemented before water quality problems occur) or reactive (i.e., water quality problem occurs before and action is taken).

Summary Response

The WWEC finds that the CSW, SESC, and NPS programs were originally intended through the legislation and administration to be proactive. However, compliance efforts in the earth change programs have become reactive, due to work loads, staffing needs, and designated priorities. Therefore, staff response to CSW, SESC, and NPS sites is often complaint-driven. Also, time that should be used for routine inspections is often disproportionately taken up on problem sites or enforcement cases that require repeated visits.

In addition, there is a limited connection between the earth change programs and other related programs, such as the Municipal Separate Storm Sewer System (MS4) and TMDL programs. For example, postconstruction BMPs are required in certain MS4 areas, but there is no connection to or acknowledgement of postconstruction BMPs in the CSW NOCs that are issued. This issue is partly addressed in objective 8 below.

Recommendations

4-1. Review application processes from other states for standard requirements that could improve the NOC application.

4-2. Develop a process that can be used to identify one to five acre CSW sites. Landowners are not currently required to notify the Department of Natural Resources and Environment (DNRE), even though the sites are regulated under Permit-by-Rule. If and when the DNRE can amend the Part 31 rules, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Act 451), it is recommended that a notification requirement for the one to five acre sites be included in the Permit-by-Rule requirements.

4-3. As noted in Objective 3, consider creating a general permit that contains more stringent BMPs for priority sites.

4-4. Identify easy monitoring techniques that can be used by regulators and the regulated community.

Objective No. 5
Identify how success, improvement, and weakness are recognized.

Summary Response

The WWEC assumes that this objective refers to the CSW, SESC, and NPS programs themselves versus any site-specific evaluations.

Success:

Part 91, SESC; and Part 31 of Act 451:

- Success is currently determined by meeting the stated inspection and audit frequencies outlined in the Water Bureau's strategic plan, and the number of Part 91 agencies and sites that are in compliance.
- Existing facility data can be queried in the NPDES Management System (NMS). These queries can pull inspections, permit reviews, and certified operator data for permitted construction sites. These queries may be useful to indicate success or show weakness in a program.
- Success may also be determined by reductions in complaints received, or violation letters sent per number of inspections performed for construction sites listed in the NMS, Pollution Emergency Alerting System, and NPS databases. This may help establish a qualitative measurement of success in the future.

- Success can also be determined by documenting improved conditions in the receiving waters, delisting of impacted waters, etc.

NPS:

- The DNRE provides documentation of NPS control success to the USEPA.
- Before even being considered for funding, NPS grant applicants are required to certify that they will comply with all applicable laws and rules. When a NPS grantee, their partners, or subcontractors do not comply with SESC, NPDES, or any other storm water requirements, the NPS Program may withhold payment or grant funds until all issues are resolved.

Weakness:

There is a lot of subjectivity in the execution of the earth change programs. This results in difficulties achieving consistency in compliance activities. The weaknesses for each program are:

Part 91:

- It is difficult to revoke Municipal Enforcing Agency (MEA) or Authorized Public Agency (APA) designations, or to place County Enforcing Agencies (CEA) on probation.
- It is difficult to determine the adequacy of funding and inspection frequency of Part 91 agencies (that must be evaluated during agency audits). Unlike the required CSW inspections where frequency is dictated, the Part 91 language is very subjective; i.e., "conduct adequate inspections to assure minimization of soil erosion and off-site sedimentation." In addition, the statute or rules provide no basis to determine the adequacy of funding, other than if a Part 91 agency is approvable, it must be adequately funded. However, the opposite is not always true; an agency can be adequately funded but not approvable.
- It is difficult to determine the effectiveness of past compliance and enforcement efforts conducted by Part 91 agencies (which must be evaluated during agency audits). This is primarily due to poor documentation and follow-up inspections by the agencies and given that over time vegetation will re-establish with or without the agencies' compliance and enforcement efforts. When sites are inspected a year or two after project completion, staff has no way of determining whether the site is stabilized as a result of the agencies' compliance and enforcement efforts.
- There are no misdemeanor provisions in the statute; county prosecutors are often hesitant to prosecute civil offenses regarding earth change activities.
- Currently, a new permit is not required when a person buys a parcel within a larger permitted site; the permit obligations and conditions are merely transferred, not the permit itself.
- Shortage of staff to conduct inspections, audits, and assist Part 91 agencies.

Part 31:

- Permittees often submit inadequate or incorrect SESC plans with NOC applications.
- The Rule 50 narrative standards in Rule 50 are difficult to enforce without numerical limits on turbidity, total suspended solids, color, etc.
- Section 3103(4) of Part 91 prevents the DNRE from amending the Part 31 rules.
- Staff shortages reduce inspection frequencies and necessary compliance and enforcement actions.

Improvement:

Program committees and DNRE management have taken some actions intended to improve the function of the CSW and SESC programs. These include:

- Adding the District Administrative Consent Order as an enforcement tool.
- Combining the SESC and CSW programs to streamline compliance efforts.
- Conducting periodic meetings with the CEAs, MEAs, and APAs.
- Revising the NOC to include several of the Permit-by-Rule requirements on the form.

Recommendations

5-1. Request assistance from the Monitoring and Water Quality-Based Effluent Limit (WQBEL) Work Groups in developing a strategy to determine compliance with Parts 31 and 91.

5-2. Place higher priority on pursuing compliance and enforcement activities at the district and upper management levels including more staff presence in the field and increased emphasis on enforcement when compliance actions are unsuccessful.

5-3. Conduct regularly scheduled information meetings, trainings, and conferences to help eliminate the "dirt don't hurt" attitudes in the regulated community. It should be noted that some communities already have SESC issue meetings in which they invite the DNRE to participate.

5-4. Assess those areas of the NPS, agriculture, and forestry programs that could be regulated in a similar fashion as the CSW and SESC programs.

5-5. Establish qualitative measurements of success for the CSW and SESC programs.

Objective No. 6
Determine the best and worst parts of programs to deal with wet weather pollution related to your work group's topic.

Summary Response

Best

- We have talented employees who are passionate about the CSW, SESC, NPS, and other earth change-related programs.
- Permit-by-Rule (Part 31) requires the prevention (and monitoring) of **all** pollutants, versus Part 91, which only requires monitoring of erosion and sediment.
- NPS is in the process of updating/revising the BMP manual.
- Water Bureau staff conducts audits that indicate that the approved CEAs, MEAs, and APAs are successfully implementing their SESC programs.

Worst

- There is inconsistency in the administration and enforcement of Part 91 by the SESC agencies.
- No minimum requirements for BMP or sediment discharge limits in the CSW program.
- Vaguely worded decrees make enforcement difficult. For example, MCL 324.3109 states, "A person shall not discharge a substance which is or may become injurious," or R 323.2190, "shall properly operate and maintain SESC measures."
- The regulated community needs more guidance on minimum expectations for compliance. SESC enforcing agencies would also benefit from more prescriptive and clearer guidance on what to enforce through municipal citations.

- The DNRE has no sampling protocols established to monitor pollutants discharged from earth change sites, or to evaluate the impacts of those discharges.
- There is a lack of consistency across Water Bureau programs concerning sediment discharge limits for earth change during and after construction.
- Almost all CSW violations are determined by visual observations of sediment in water bodies, or “paper violations” when the permittee does not comply with recordkeeping requirements.

Objective No. 7
Identify any information and education requirements for regulatory programs.

Summary Response

There are two training options offered by the Water Bureau for SESC and CSW programs: Inspector Training and Comprehensive SESC Training. The Inspector Training is designed for SESC and CSW inspectors. The Comprehensive SESC Training is designed for individuals responsible for administering and enforcing SESC programs. Currently, the NPS grantees are not required to attend any specific training.

Only two of the states (Virginia and Washington) responded that they require the contractors, BMP installers, or someone else to obtain training or some type of certification. These states did not indicate who was required to take the training. Most states indicated that they rely on staff or permittee inspections to ensure that BMPs are installed correctly and are effective. There was no mention, however, whether the staff or permittees have to be trained.

Recommendations

7-1. Develop refresher courses so people are not taking the same CSW and SESC training every five years.

7-2. Consider allowing courses or certifications from outside agencies or groups to substitute for refresher courses required under Part 91.

Objective No. 8
Describe the discharges/situations that WQBELS may be needed most.

Summary Response

WQBELs could help district staff to determine when a discharge is out of compliance with water quality standards. It could also help Water Bureau programs target work in priority areas. While the idea of establishing WQBELs for certain earth change situations appears appropriate, more information is needed to determine the feasibility and effectiveness of such an approach. The USEPA has established a 280 NTU effluent limit for construction sites greater than 10 acres, to which Michigan will have to comply.

Recommendations

8-1. Establish a functional connection between the CSW, SESC, and NPS programs, and priority sites (TMDL water bodies, OSRWs, areas of highly erodible soils, etc.).

8-2. Evaluate the feasibility of establishing WQBELs for construction sites discharges.

Objective No. 9
Identify information and implementation gaps and provide recommendations to fill them.

Summary Response

The WWEC identified information gaps and recommendations within objectives 1-8.

Priority of Recommendations:

The WWEC provided recommendations for each of the individual objectives, and identified weaknesses of the CSW and SESC programs. The recommendations have been prioritized (high, medium, or low) based on the greatest potential for improving program effectiveness resulting in greater water quality protection or improvement. Although some of the recommendations will take considerable staff time, they are necessary for program improvement. The recommendations were not prioritized beyond the high, medium, or low classifications.

High Priority:

1-1. The WWEC needs to follow-up (phone call and review of specific regulatory language) with states that appear to have program components or regulations that may be beneficial to include into the Michigan earth change programs.
1-2. The WWEC needs to obtain more specific information from the states regarding their SESC programs. The benchmark survey focused primarily on CSW programs.
2-2. Determine the applicability and effectiveness of effluent limits for the CSW and SESC programs.
2-3. Determine the applicability and effectiveness of prescribed BMPs (individual categories or decision matrix) for the CSW, SESC, and NPS programs.
2.5. Provide each district with a turbidity meter and guidelines on how to use them. The USEPA recently promulgated a 200 NTU turbidity discharge limit for sites 10 or more acres in size.
3-4. Request the Monitoring Work Group to determine BMP effectiveness.
4-2. Develop a process that can be used to identify one to five acre CSW sites. Landowners are not currently required to notify the DNRE, even though the sites are regulated under Permit-by Rule. If and when the DNRE can amend the Part 31 rules, it is recommended that a notification requirement for the one to five acre sites be included in the Permit-by-Rule requirements.
4-3. As noted in Objective 3, consider creating a general permit that contains more stringent BMPs for priority sites.
4-4. Identify easy monitoring techniques that can be used by regulators and the regulated community.
5-1. Request assistance from the Monitoring and WQBEL Work Groups in developing a strategy to determine compliance with Parts 31 and 91.
5-2. Place a higher priority on pursuing compliance and enforcement activities at the district and upper management levels including more staff presence in the field and increased emphasis on enforcement when compliance actions are unsuccessful.
5-5. Establish qualitative measurements of success for the CSW, SESC, and NPS programs.

Correct Part 91 weaknesses identified in Objective 5.

- Must develop an expeditious process to revoke the status of MEAs and APAs and place CEAs on probation.
- Must have minimum inspection frequency requirements.
- Must develop process to determine effectiveness of agency's compliance and enforcement efforts.

Correct Part 31 weaknesses identified in Objective 5

- Work with legislators to repeal Section 3103(4) of Part 31 so as to enable the DNRE to amend the Part 31 rules.
- Develop guidelines or rules to assist in enforcing Rule 50 narrative standards.

Medium Priority:

2-1. Determine the effective methods to monitor discharges, in addition to the existing Rule 50 narrative standards that would support the visual observations currently relied upon by district staff to determine site compliance. These may include:
   - Indentifying specific standards and specifications for BMPs.
   - Identifying monitoring methods for BMPs and discharges.

2-4. Determine acceptable rainfall frequency design criteria to address water quality requirements on earth change sites.

3-3. Provide a user-friendly on-line source consisting of BMP guidance for the CSW, SESC, and NPS programs.

4-1. Review application processes from other states for standard requirements that could improve the NOC application.

5-3. Conduct regularly scheduled information meetings, trainings, and conferences to help eliminate the "dirt don't hurt" attitudes in the regulated community. It should be noted that some communities already have SESC issue meetings in which they invite the DNRE to participate.

7-1. Develop refresher courses so people are not taking the same CSW and SESC training every five years.

7-2. Consider allowing courses or certifications from outside agencies or groups to substitute for refresher courses required under Part 91.

8-2. Evaluate the feasibility of establishing WQBELS for discharges from earth change sites.

Low Priority:

3-1. Consider a mechanism to include specific BMP requirements in NOC applications for each earth change site based on known BMP effectiveness:

3-2. Develop more stringent BMP standards that can be placed in NPDES General Permits, especially for priority sites that the WWEC defines priority sites as OSRWs, TMDL water bodies, highly erodible soils, or where navigational and recreational uses are impacted.

3-5. Determine what types of BMPs are necessary for storm water treatment for various types of flows and site conditions.
   - Determine if an acceptable discharge can be achieved using BMPs.
   - Determine whether BMP performance is predictable.

5-4. Assess those areas of the NPS, agriculture, and forestry programs that could be regulated in a similar fashion as the CSW and SESC programs.

8-1. Establish a functional connection between the CSW, SESC, and NPS programs, and priority sites (TMDL watersheds, OSRWs, areas of highly erodible soils, etc.).

Chapter 4
Waste to Land

Introduction:

On December 5, 2008, the Michigan Department Environmental Quality (DEQ), Water Bureau (WB) convened the Wet Weather Committee, and one of the five subgroups was the Waste to Land Group (WTL). The charge to the WTL was to define and evaluate wet weather pollution discharges to surface waters of the state. For the WTL specifically, a wet weather pollution discharge is defined as a discharge of water due to a precipitation event (which may include, but not limited to, events such as rain or snow melt runoff). This discharged water will have been in contact with the land applied wastes and will convey components of that waste to the receiving surface waters.

In order to address and properly determine the scope and impact of wet weather pollution discharges from land areas receiving wastes, a number of issues and topics needed to be addressed by the WTL. Major points include, (in no priority order):
-The amount of waste applied to land in particular program areas,
-The characterization of the land applied materials,
-The impacts-real and potential of discharged materials,
-The terminology used in land applied waste programs,
-The current monitoring (sampling and analysis) of receiving waters,
-The management of land applied wastes, including WB staffing levels.

Waste Application:

An attempt was made to quantify and compare the amount of land applied waste. The WTL determined that direct waste comparisons were not appropriate due to differences in the physical and chemical makeup (i.e. the “strength”) of the wastes from different sources and methods of reporting (i.e. dry weight versus tonnage). Baseline assessments were made using available data from biosolids, septage, groundwater wastewater treatment facilities, and agricultural programs. Recognizing the waste comparison issues described above, the greatest volume of waste, by several orders of magnitude, appears to originate from animals and animal industry programs. For WTL purposes, the focus is on animal manures and other associated farm animal wastes. The volume of farm waste will not necessarily include (but also does not exclude) milk house wastes, animal washing, antibiotic treatment, yard runoff, silage waste, etc. The second largest volume of land applied waste comes from discharges associated with groundwater permitted waste water treatment facilities, followed by biosolids, and lastly septage.

Characterization:

A review of current regulatory requirements in land applied waste programs noted a lack of uniformity for waste characterization related to wet weather pollution. Ideally, all wastes applied to land would be analyzed for nutrients (e. g. nitrogen, phosphorus), pathogens, metals, and pollutants of concern (depending on the operation or industrial activities involved). In addition, WTL also identified the potential presence of pharmaceuticals, such as antibiotics, or hormones in certain land applied waste materials as a source of environmental concern.

Discharge Impacts/Current Monitoring:

Measuring the impact of a land applied waste is problematic due to sampling difficulty. Current regulatory land application programs do not allow for a surface water discharge of the land applied waste. However, under certain precipitation conditions, applied waste enters surface water via sheet flow, groundwater venting, and tile discharges. Local weather conditions may prevent staff from mobilizing quickly enough for sample collection. In addition, there are no uniform requirements to monitor the potentially impacted 'receiving' surface water body. Provisions or funding to provide baseline sampling or monitoring data for the potential receiving surface water at a land application site is also lacking. If monitoring has occurred, results must be compared to the applicable Water Quality Standards (WQS) to determine if the discharge has violated WQS or adversely impacted the surface water.

Terminology:

There are a number of terms which are common amongst the various departmental programs responsible for regulating land application of waste materials. For example, agronomic rate, incorporation, isolation distance, and public notice are all terms commonly utilized within land application programs. However, the specific definitions of those terms and how they are applied can vary between programs. The lack of common terminology of such terms and/or an understanding of how these terms are used amongst the different programs within the WB may be an obstacle to addressing wet weather pollution discharges from land applied wastes in a consistent and effective manner. In addition, some of these terms are defined by statute or permit and may be contrary to common or popular usage. For example, land appliers are routinely instructed to apply at agronomic rates but that may vary from program to program. It is suggested that WB come to some consensus on the use and/or definitions of these terms or at least familiarize decision and policy-makers with the subtle differences in how the terms are applied in the programs.

Management of Land Applied Wastes:

Upon review of current waste to land practices, a number of issues have been identified in WTL programs. For example, the land application of waste on frozen ground during the winter months is recognized as a risky practice because of the high potential for the waste to runoff to surface waters. In addition, soil disturbance is necessary to incorporate the applied wastes: however, model results indicate increases of runoff volume and soil erosion as cover crops or crop residuals are tilled in. Furthermore, tillage that is important for land application of wastes conflicts with cropping practices designed to control runoff and soil erosion. In tiled fields, pollutant loads from the wastes may actually increase as wastes are pushed into the soil and closer to the drainage system.

Another issue is the level of field staff resources devoted to regulating and addressing wet weather pollution discharge complaints and concerns. Looking at field staff resources and availability for the fiscal year 2009 year, the concentrated animal feeding operation (CAFO) program had about 5 full-time equivalent staff (FTE's), groundwater compliance about 8 FTE's, biosolids about 4 FTE's, and septage about 3.0 FTE's. If one looks at the ratio of staffing to quantity of waste land applied, the CAFO program has the least number of FTE's followed by groundwater, then biosolids, and finally septage. Program staff did not believe they have enough staffing to adequately meet all the requirements of their respective program. It was also noted that non-regulated agricultural farming operations apply more waste to land than all the regulated waste to land programs combined, yet no FTE's are dedicated solely to this area.

The issue of program inconsistency has been recognized in the past. In March 2006, Director Steven Chester asked the Environmental Advisory Council (EAC) to provide recommendations to programs and policies governing the application of materials to the ground to protect public health and the environment in light of cost and benefits (to all parties) and the need for consistency among programs. The primary focus of the EAC's effort was on wastes from industrial by-products and compost, and use of Part 201 criteria. However, the WTL agrees with the EAC recommendations that there is not enough information on sites where waste derived material is land applied, that there needs to be a bona fide benefit deriving from the land application of waste, and that larger scale applications that could affect large populations or sensitive populations or ecosystems should be subject to a more thorough evaluation than other applications.

Wet Weather Benchmarking Report WTL Noteworthy Findings:

Biosolids

The biosolids section of the report did not contain any noteworthy findings. Of all of the programs that apply waste to land, biosolids is the most regulated and states are adhering closely to Part 503 requirements without much deviation.

Septage

Of the states that responded, many reported that they use federal Part 503 to regulate septage handling and disposal and they do not have any additional state regulations that apply specifically to septage waste. However, a few states mentioned that they had recently revised or had adopted new state requirements for septage handling and disposal; or that they were in the process of doing so.

Most of the states that responded have very few staff dedicated to compliance oversight of septage handling and disposal; many of those stated that they had one FTE equivalent or less dedicated to septage. Several states including Colorado, Maryland and Kansas reported no state government FTEs. Several states have delegated oversight to the local county health departments. Of the states that responded, it appears that Florida has the largest number of FTEs dedicated to oversight of septage handling and disposal.

Nearly all of the states that responded stated that they consider fats, oils and grease to be a significant problem issue. Some states have proactive collection programs for these, some do not.

Disposal requirements and methods of disposal vary by state. A couple of states (Hawaii and Massachusetts) reported that 100 percent of the septage generated went to a treatment works treating domestic sewage (TWTDS). The state reporting the largest percentage of septage disposed of by land application was Iowa at 85 percent and they reported using Part 503 to regulate septage. Interestingly, another plains state, North Dakota, has additional state requirements for septage beyond Part 503 and also has a high percentage of septage land applied at 80 percent. Alternately, Wyoming has no additional state requirements beyond Part 503 and most of their septage is hauled to a TWTDS. Connecticut reported that none of their septage was land applied; the septage either went to a TWTDS or was incinerated. This is likely because there is not enough land available in Connecticut for land application of septage. Some states allow the septage to be disposed of and treated in a lagoon; other states prohibit the use of lagoons for septage. Texas reported that 70 percent of its septage was land filled and 30 percent land applied. A couple of states, including Florida, require lime stabilization of the septage before it is land applied. Obviously, even though some states only regulate septage hauling and disposal under Part 503, the methods of disposal can vary, even among states with similar topography, land use and population.

Agricultural Production Waste

According to the report, Florida's survey indicated a requirement for monitoring of pathogens in land-applied CAFO waste. No other state that responded to the survey indicated that they require pathogen monitoring. None of the states reported monitoring requirements for pharmaceuticals.

States requirements for manure application before and during precipitation events vary quite a bit, from nearly unrestricted to complete prohibition. Some state's requirements are general and lack specific guidelines so it would be difficult to determine permit compliance or take enforcement action. Some examples: Massachusetts and Nebraska have no explicit weather specific prohibitions. New Hampshire directs operators to avoid irrigation with liquid manure when excessive rainfall causes ponding or runoff, which could be very difficult to predict. Kansas prohibits application of concentrated animal waste during a precipitation event, unless approved in advance by the department. Texas prohibits land application of manure during a rainfall event unless there is danger of imminent overflow from a retention control structure or as approved by the commission. Florida restricts manure application within three days of likely rainfall.

Similar to application of manure during precipitation events, the states that responded to the survey vary in their requirements for application to snow covered or frozen ground. Several states have prohibited the practice or severely restricted it. Recent amendments to Iowa's code restrict application on snow covered or frozen ground, except in emergencies, and require the CAFO to plug intakes (drain tiles) down gradient of the application when the manure is applied up until at least two weeks after the application. Kansas and Ohio prohibit it except when approved by the department. Texas only allows it when there is danger of imminent overflow from a retention control structure or as approved by the commission. North Carolina and Missouri prohibit any application to frozen, snow covered or saturated soils. Among the remaining states that responded, restrictions are placed on slope, requirement for setbacks, or land that has a high phosphorus risk. Understandably because of their mild climates, most of the southern states have no restrictions for application of manure to frozen or snow covered ground.

Florida responded that the state does not allow application of waste to fields that are tiled. Oregon reported that many tile systems are fitted with valves or recycle systems to prevent discharge. The report does not contain any additional information such as the percentage of total agricultural use land that must be drained in Florida or Oregon to make a determination whether or not the requirement is stricter than Michigan.

On the subject of agronomic rates, most of the states use methodology similar to Michigan whereby the agronomic rate is determined from manure tests, soil tests and the crop to be grown. Most states rely on guidance for agronomic rates from an in-state university with an agricultural extension program, the Natural Resources Conservation Service, or their state agricultural department.

Of the states that responded to the survey, Georgia, Minnesota and Iowa require land applicators of manure to be certified.

North Carolina requires monitoring of copper and zinc in land applied CAFO and animal feeding operation (AFO) waste. If the soil index reaches a certain level the application must stop. Applicants must measure the background levels of heavy metals at a proposed application site prior to the first application and monitoring frequency is determined by the amount of manure applied to the site. Applications must cease when the Mehlich 3 Soil Test Index for copper is greater than 3,000 (108 pounds per acre) or zinc greater than 3,000 (213 pounds per acre).

Florida requires groundwater monitoring for total nitrogen, nitrate nitrogen, total phosphorus and orthophosphates near storage ponds and land application areas and background monitoring of the groundwater from wells up-gradient of the storage ponds and land application sites at CAFOs. The locations and depths of the monitoring wells are specified in the permit. Monitoring is typically conducted quarterly, but it can be reduced to semi-annual if more than six consecutive samples show no increase in the concentration of a given parameter. Florida has the ability to also require this at AFOs and it is done on a case-by-case basis. Florida is currently developing permit rules for AFOs that discharge to groundwater.

Georgia requires that one down gradient water monitoring well be installed for each waste storage lagoon or series of lagoons. The wells must be monitored at a minimum semiannually for TKN and nitrate-N. It was not clear from the report, but Georgia may require this for both CAFOs and AFOs.

Washington requires CAFOs to collect samples of land application areas annually in the fall for analysis for nitrate-N concentrations. The samples must be collected prior to heavy rainfall and at least 30 days after manure applications. The depth of the soil samples is region specific. Operators may choose groundwater monitoring in lieu of the soil monitoring.

Many of the states that responded regulate AFOs in addition to CAFOs in several areas, much more than what Michigan requires. Some examples: Georgia requires AFOs to contain all process wastewater from the AFO operation plus all runoff from a 25-year, 24-hour rainfall event. Florida reported that they can require pathogen monitoring at AFOs. Iowa's certification requirement for applied manure waste from a confined feeding operation applies to livestock operations with 500 or more animal units, thus Iowa has certification requirements for the large AFO operations. North Carolina requires zinc and copper monitoring in AFO as well as CAFO waste. Georgia requires AFOs to monitor total nitrogen in their waste once a year; and requires AFOs that have 300 or more animal units with liquid manure systems to apply for a Land Application System Permit. The majority of states that responded to the survey--Iowa, Georgia, Kansas, Minnesota, Nebraska, North Carolina, North Dakota, Ohio, and Oregon—all have a requirement for AFOs to either measure background levels of nutrients prior to the first application of waste and/or monitor their waste periodically (frequency varies between the states) for nutrient content.

<u>Michigan's Status as Compared to the States Surveyed</u>

For the biosolids program, Michigan's program is consistent with the other states that responded to the survey, likely due to Part 503 and the amount of time the program has existed as compared to the programs that address septage and agricultural wastes. From review of the information reported, it appears that Michigan's septage program (and regulation) is one of the most environmentally protective in the country.

Michigan appears to fall into the mid range among the state respondents for CAFO regulations and permitting requirements. Several states have more stringent groundwater, pathogen and heavy metals monitoring, bans on application of manure on frozen or snow covered ground, and certification requirements for land application of manure. Most strikingly, many of the responding states have permitting programs and stronger regulations for AFOs, especially the larger sized AFOs; whereas in Michigan, the universe of AFOs and their locations is not even known or tracked.

Summary:

The ability to address and regulate wet weather pollution discharges to surface waters that occur from the land application of wastes are essentially hampered and unable to be adequately resolved due to the following issues:

- Agricultural wastes, both CAFO related and non-CAFO related, are relatively unknown with regard to the volume, character, and impact;
- Staff and capital resources are not distributed based on the source type that applies the largest volume of waste to land or potentially can have a large impact to surface waters. Program staff are assigned based on available program funding, not on surface water impacts;
- There is a lack of consistent terminology across the programs;
- There is a lack of complete and consistent characterization of land applied wastes across the programs;
- There is a lack of complete and consistent characterization of the soils receiving the land applied wastes;
- There is insufficient information to determine the frequency of wet weather pollution discharges;
- There is a lack of information on the effectiveness of various statutory or voluntary Best Management Practices;
- There are no established sampling protocols for surface water quality monitoring, either before or after application of wastes.

High Priority Recommendations

1. The Wet Weather Benchmarking Report contained useful information, especially regarding the differences among states in regulating agricultural waste. However, there were gaps in the information provided and it was hard to *really* understand the other states regulations and programs from the few written paragraphs. Program staff in the states that have regulations or programs of interest to Michigan should be contacted directly by CAFO program staff, preferably by phone, to learn more.

2. The waste to land programs use similar terms such as “agronomic rate” but the definition of these terms like “agronomic rate” varies between the programs. This makes it difficult to apply rules and regulations in a consistent and effective manner. More work should be done in this area to establish one common definition for these terms that is used consistently in all the regulations and programs that depend on those terms to evaluate compliance.

3. Comparisons of the different land applied wastes--agricultural, process, septage and biosolids is difficult because the way they are measured is different (dry weight, percent

solids, volume, etc.); they receive differing levels of processing, from virtually none at all (agriculture waste), to some (biosolids); and they vary in their percentage of solids, even just among the different animal manures. A common denominator or equalizing factor must be established so that accurate assessments can be made as to which waste stream is most significant, is of the most concern to surface waters, etc. The WTL attempted to do this, but this is a huge task that was beyond the scope of the workgroup to complete. Additional research should be conducted to learn if this has been done in another state or country; or perhaps a project should be initiated to find a method to "normalize" the wastes so that accurate comparisons can be made.

4. Michigan is behind several other states in regulating the AFOs, especially the larger sized AFOs. Among all the waste to land programs, the largest percentage of waste applied to land in Michigan originates from farming operations that are not CAFOs. Michigan will not be successful in restoring nutrient or pathogen impaired rural surface waters until these sources can be better controlled. Michigan lawmakers should be made aware that that the greatest volumes of land applied waste (LAW) are generated by the programs with the least regulation. A good start toward more control could be achieved by requiring all AFO's to register with the Department of Natural Resources and Environment and include baseline information such as animal species and livestock numbers.

<u>Other Recommendations</u>

1. The problems encountered with manifesting of waste from CAFOs needs to be resolved. The manure applicators that apply manifested CAFO waste are not registered or certified and they are not regulated until after staff find a discharge. The program needs to be proactive and protective rather than reactive. A certification program or other means to more effectively control application of agricultural wastes by third parties needs to be established.

2. The groundwater discharge requirements for CAFOs and AFOs need to be strengthened. Other states are requiring monitoring wells to observe if the CAFO or AFO is affecting groundwater quality. If anything, consideration should be given to reducing the threshold number of animal units that trigger the requirement for a groundwater discharge permit (a number less than 5000 animal units).

3. DEQ WB staff do not know what chemicals, antibiotics or hormones are present in manure, animal or barn wash water, milk house waste, or silage waste. Recent studies have indicated that dairy waste can have high levels of copper, and possibly zinc and formaldehyde. Selenium has been added to livestock feed, there may be other chemicals of concern unknown to us that also have been added as a supplement to feed. Monitoring work for a suite of potential contaminants should be conducted in these waste streams to determine if there are concentrations of concern present in agricultural waste and if there are, further controls on land application of these wastes may be warranted.

4. Pathogens and pharmaceuticals in land applied waste (LAW) have become a national concern. Michigan should be involved with national efforts to characterize pharmaceuticals found in LAW and identify potential impacts to the receiving waters.

5. To perform adequate assessments and effective monitoring of the wet weather pollution impacts of wastes applied to land, all pathways of runoff and the relative contribution of each pathway should be evaluated. Is tiled field runoff the most significant and detrimental to

surface waters? Or is it sheet flow runoff? A better understanding of all pathways to the surface water is needed to improve over all control of runoff, or to work toward possible establishment of effluent limits.

6. Uniform protocols for monitoring potentially impacted surface waters need to be developed so consistent sampling occurs and the sampling results are comparable. These would include sampling protocols for the pre-application of LAW and the post-application of LAW. Baseline characteristics (of the constituents of concern analyzed in LAW) of surface waters near a land application site need to be determined.

7. More evaluation is needed to determine whether or not for some waste to land programs, effluent limits should be established rather than reliance on Best Management Practices (BMPs) to control runoff. The BMPs commonly used to control runoff from land application sites should be evaluated for effectiveness, and research to find newer, more effective BMPs should continually be done. For unregulated entities, perhaps a means to voluntarily promote increased use of BMPs should be established, such as a type of incentive program.

8. More evaluation work is needed to determine if Michigan should adopt stricter regulations for land application of waste on frozen or snow covered ground. Some states have banned it and WB staff have found discharges from these sites.

Chapter 5
Wet Weather Monitoring

Introduction

The Wet Weather Monitoring Work Group's (WWMWG) final report consists of five Sections and one Appendix:

- Section 1. Discharge Types and Pollutant Character of Wet Weather Events
- Section 2. Environmental Effects of Wet Weather Discharges
- Section 3. Guidance for Assessing the Instream Impacts of Wet Weather Discharges
- Section 4. Guidance for Monitoring Wet Weather Discharges Other Than Those Covered by the MS4 Watershed and Jurisdictional General Permits
- Section 5. Recommendations of the Wet Weather Monitoring Work Group
- Appendix A. Storm Water Sampling Guidance for Total Phosphorus and *E. coli*

  Much of the sampling advice information presented in the Appendix is also applicable to wet weather discharge types and pollutants, other than those covered by the MS4 jurisdictional and watershed general permits.

Section 1. Discharge Types and Pollutant Character of Wet Weather Events

The Waste to Land, Earth Change, and Urban Living Work Groups, with participation from members of the WWMWG and Water Quality-Based Effluent Limits/Standards Work Group, were asked to consider two questions:

What types of discharges result from the activities associated with your work group and what is their relative importance?

What are the expected chemical, microbiological, and aquatic toxicological characteristics of the discharges?

Subsequent work group deliberation and discussion to answer these questions revealed a clear picture: Michigan's surface waters are subjected to many different types of wet weather pollution discharges and, when considered as a group, these wet weather pollution discharges contribute many types of pollutants to the surface water in significant concentrations and amounts. It is important to remember the attributes of any wet weather pollution discharge are dependent upon previous meteorological conditions, land use type and pattern, storm intensity and duration, and other watershed characteristics.

In an effort to augment information produced from the above evaluation, available literature on wet weather pollution discharge types and their associated pollutant character was reviewed by the WWMWG. The WWMWG also obtained some pollutant character data for certain wet weather pollution discharge types from the National Pollutant Discharge Elimination System (NPDES) Management System (NMS) and the National Storm Water Quality Database (NSWQD). The results of this work culminated in the development of Tables 1 and 2.

Information and data presented in Table 1 are organized according to work group, discharge type, pollutants involved, concentration, and reference. Some of the discharge types provided by the other wet weather work groups were eliminated (culvert replacement) or combined with other discharge types (farming, Concentrated Animal Feeding Operations [CAFOs], and Animal Feeding Operations [AFOs]), due to a lack of clarity or similarity among types. Broad discharge type categories (i.e., industrial and farming) were not broken down into specific types of industries or farming systems, based on how the information was provided by the other work groups and how the information is represented in the literature. Concentrations of pollutants highlighted in Table 1 represent those that are either above their respective Rule 57 allowable level, other relevant Michigan Water Quality Standards (WQS), or relevant federal water quality criteria. Pollutants labeled with an asterisk are those that should first and foremost be considered for inclusion in a sampling regime.

Table 1. Pollutants and concentrations found in certain types of wet weather pollution discharges.

Work Group	Discharge Type	Pollutants Involved	Concentrations	Reference
Earth Change	Construction	Oil*		
		TSS*	29000 mg/l	Cal. Dept. of Trans., 2000
		TDS	11700 mg/l	Cal. Dept. of Trans., 2000
		nutrients (P, N)*		
		temperature		
		turbidity*		
		BOD, CBOD5		
		Flow*		
		DO		
		arsenic	2300 µg/l	Cal. Dept. of Trans., 2000
		diazinon	2.4 µg/l	Cal. Dept. of Trans., 2000
		benzidine	500 µg/l	Cal. Dept. of Trans., 2000
		BTEX		
		PAHs		
	Forestry, Logging	TSS* TDS turbidity* DO nutrients (P, N)* flow*		
	Drain Maintenance	TSS* turbidity* TDS DO nutrients (P, N)*		

Work Group	Discharge Type	Pollutants Involved	Concentrations	Reference
		flow*		
	Landscapers	TSS* nutrients (P, N)* flow* turbidity* DO pesticides herbicides		
	Mining, Gravel Pits	TSS* TDS* DO turbidity* nutrients (P, N) selenium		
		calcium	27 mg/l	Gammons, et al., 2005
		copper	0.12 mg/l	Gammons, et al., 2005
		potassium	3.5 mg/l	Gammons, et al., 2005
		magnesium	3.8 mg/l	Gammons, et al., 2005
		manganese	0.47 mg/l	Gammons, et al., 2005
		sodium	9.9 mg/l	Gammons, et al., 2005
		phosphorous	0.094 mg/l	Gammons, et al., 2005
		sulfate	53 mg/l	Gammons, et al., 2005
		silicon	2.6 mg/l	Gammons, et al., 2005
		zinc	0.2 mg/l	Gammons, et al., 2005
		flow* Oil metals		
Urban Living	CSOs	TSS*	13-2796 mg/l	Sweat and Wolf, 1996; NMS Data; Lee and Bang, 2000
		TDS	42-911 mg/l	Sweat and Wolf, 1996
		phosphorous*	0.1-138 mg/l	Sweat and Wolf, 1996; NMS Data; Lee and Bang, 2000
		nitrogen (TKE)	1.1-23.7 mg/l	Sweat and Wolf, 1996
		nitrogen	0.07-4.31 mg/l	NMS Data; Lee and Bang, 2000
		*E. coli**	6x10n6 cts/100 ml	Sweat and Wolf, 1996
		Fecal Coliform*	10-4x10n7 cts/100 ml	Sweat and Wolf, 1996; NMS Data

Work Group	Discharge Type	Pollutants Involved	Concentrations	Reference
		Fecal Streptococci	508,000 cts/100 ml	Geldreich et al., 1968
		DO		
		turbidity*		
		Oil		
		pharmaceuticals*		
		flow*	0.616-14.5 MG	NMS Data
		antimony	0.18 µg/l	Sweat and Wolf, 1996
		arsenic	46.3 µg/l	Sweat and Wolf, 1996
		beryllium	4.2 µg/l	Sweat and Wolf, 1996
		cadmium	30 µg/l	Sweat and Wolf, 1996
		chromium	1071 µg/l	Sweat and Wolf, 1996
		cobalt	2-71 µg/l	Sweat and Wolf, 1996
		copper	10-330 µg/l	Sweat and Wolf, 1996
		cyanide	0.024 µg/l	Sweat and Wolf, 1996
		iron	100-54300 µg/l	Sweat and Wolf, 1996; Lee and Bang, 2000
		Lead	2-1013 µg/l	Sweat and Wolf, 1996; Lee and Bang, 2000
		manganese	0.08-1.67 µg/l	Sweat and Wolf, 1996
		mercury	0.8 µg/l	Sweat and Wolf, 1996
		nickel	150 µg/l	Sweat and Wolf, 1996
		silver	48 µg/l	Sweat and Wolf, 1996
		thallium	6 µg/l	Sweat and Wolf, 1996
		zinc	10-2040 µg/l	Sweat and Wolf, 1996
		chloride	287 mg/l	Sweat and Wolf, 1996
		TRC*	0.7-1.8 mg/l	NMS Data
		ammonia	5.3 mg/l	Sweat and Wolf, 1996
		Aroclor 1016	0.2 µg/l	Sweat and Wolf, 1996
		Aroclor 1242	12 µg/l	Sweat and Wolf, 1996
		Aroclor 1254	0.7 µg/l	Sweat and Wolf, 1996
		Aroclor 1260	0.4 µg/l	Sweat and Wolf, 1996

Work Group	Discharge Type	Pollutants Involved	Concentrations	Reference
		lindane	0.03 ug/l	Sweat and Wolf, 1996
		n-hexane	2.0-1965 mg/l	Lee and Bang, 2000
		methylene chloride	12 µg/l	Sweat and Wolf, 1996
		chrysene	21 µg/l	Sweat and Wolf, 1996
		chlordane	0.2 µg/l	Sweat and Wolf, 1996
		bis(2-Ethyl-Hexyl) Phthalate	36 µg/l	Sweat and Wolf, 1996
		fluoranthene	48 µg/l	Sweat and Wolf, 1996
		phenanthrene	32 µg/l	Sweat and Wolf, 1996
		pyrene	47 µg/l	Sweat and Wolf, 1996
		styrene	42 µg/l	Sweat and Wolf, 1996
		phenol	110 µg/l	Sweat and Wolf, 1996
		CBOD*	8-308 mg/l	Sweat and Wolf, 1996; NMS Data
		COD	22-1455 mg/l	Sweat and Wolf, 1996; Lee and Bang, 2000
		BOD	12-254 mg/l	Lee and Bang, 2000
		chlorine		
	MS4s, Municipal Storm Water	flow*	0.56-265 cfs	Wolff and Wong, 2008
		TSS*	4-129,000 mg/l	Brodie, 2007; Cave et al., 1994; Wolff and Wong, 2008; Bannerman et al., 1993
		TDS	16-800 mg/l	Cave et al., 1994; NSWQD; Wolff and Wong, 2008
		turbidity*		
		nitrogen (TKE)	1.39-4.9 mg/l	Cave et al., 1994; NSWQD; Taylor et al., 2005
		total dissolved nitrogen	1.63 mg/l	Taylor et al., 2005
		total nitrogen	2.13 mg/l	Taylor et al., 2005
		organic nitrogen	1.10 mg/l	Taylor et al., 2005
		ammonia*	0.29 mg/l	Taylor et al., 2005
		total phosphorous*	0.13-1.23 mg/l	Cave et al., 1994; NSWQD; Wolff and Wong, 2008; Bannerman et al., 1993
		*E. coli**	700-1050 cfu/100 ml	NSWQD

Work Group	Discharge Type	Pollutants Involved	Concentrations	Reference
		Fecal Streptococci	150,000 cts/100 ml	Geldreich et al., 1968
		Fecal Coliform*	294-175,106 cfu/100 ml	Reeves et al., 2004; NSWQD; Bannerman et al., 1993
		Enterococci	5600 cfu/100 ml	Reeves et al., 2004
		chlorine		
		temperature	16.4-20.3 C	NSWQD; Wolff and Wong, 2008
		pesticides		
		conductivity		
		CBOD*		
		DO		
		pharmaceuticals		
		herbicides		
		arsenic	3 µg/l	NSWQD
		barium	0.08-0.12 mg/l	Characklis and Wiesner, 1997
		beryllium	0.3 µg/l	NSWQD
		lead	0.43-190 µg/l	Cave et al., 1994; NSWQD; Wolff and Wong, 2008; Bannerman et al., 1993
		mercury	0.2 µg/l	NSWQD
		nickel	5.4 µg/l	NSWQD
		iron	1.37-3.02 mg/l	Characklis and Wiesner, 1997
		copper	4.6-97 µg/l	Cave et al., 1994; NSWQD Wolff and Wong, 2008; Bannerman et al., 1993
		zinc	6-580 µg/l	Cave et al., 1994; NSWQD Wolff and Wong, 2008; Bannerman et al., 1993
		cadmium	0.4-8 µg/l	Cave et al., 1994; NSWQD Wolff and Wong, 2008; Bannerman et al., 1993
		strongtium	0.07-0.23 mg/l	Characklis and Wiesner, 1997
		chromium	2-12 µg/l	NSWQD; Bannerman et al., 1993
		hormones		
		COD	10-316 mg/l	Cave et al., 1994; NSWQD; Wolff and Wong, 2008
		BOD	7-125 mg/l	Cave et al., 1994; NSWQD
		oil & grease*	3.9-5 mg/l	NSWQD
		BTEX		

Work Group	Discharge Type	Pollutants Involved	Concentrations	Reference
		naphthalene	17.7-59 ng/l	Hwang and Foster, 2006
		acenaphthylene	2.09-25.2 ng/l	Hwang and Foster, 2006
		fluorene	8.79-152 ng/l	Hwang and Foster, 2006
		phenanthrene	26.1-338 ng/l	Hwang and Foster, 2006
		fluoranthene	86.5-380 ng/l	Hwang and Foster, 2006
		pyrene	65.6-774 ng/l	Hwang and Foster, 2006
		chrysene	48.6-519 ng/l	Hwang and Foster, 2006
		total PAHs	1510-12500 ng/l	Hwang and Foster, 2006
	Industrial Storm Water	flow*	1-51 cubic meters	Bannerman et al., 1993
		turbidity*		
		TSS*	78-20778.8 mg/l	Cave et al., 1994; NSWQD; deHoop et al., 1997; Bannerman et al., 1993
		TDS	92-403 mg/l	Cave et al., 1994; NSWQD
		DO		
		phosphorous	0.11-1.5 mg/l	Cave et al., 1994; Bannerman et al., 1993
		pH*	6.7-8.1 S.U.	deHoop et al., 1997
		nitrogen (TKE)	1.4-.6 mg/l	Cave et al., 1994; NSWQD
		BOD, CBOD5*	9-14723.8 mg/l	Cave et al., 1994; NSWQD; deHoop et al., 1997
		COD	60-150 mg/l	Cave et al., 1994; NSWQD
		mercury	0.2 µg/l	NSWQD
		lead*	3.7-130 µg/l	Cave et al., 1994; NSWQD; Bannerman et al., 1993
		cadmium	1-3.3 µg/l	NSWQD; Bannerman et al., 1993
		chromium	3.5-23 µg/l	NSWQD; deHoop et al., 1997; Bannerman et al., 1993
		thallium	8 µg/l	deHoop et al., 1997
		copper*	10-172 µg/l	Cave et al., 1994; NSWQD; Bannerman et al., 1993
		nickel	16 µg/l	NSWQD
		arsenic	0.4 µg/l	NSWQD

Work Group	Discharge Type	Pollutants Involved	Concentrations	Reference
		zinc methylene chloride cadmium *E. coli** *Enterococci* Fecal Coliform oil & grease* temperature* conductivity BTEX PAHs	23-1230 µg/l 15.4 µg/l 8 µg/l 3000 cfu/100ml 11100 cfu/100ml 144-8338 cfu/100 ml 5 mg/l 17.9 C	Cave et al., 1994; NSWQD; deHoop et al., 1997; Bannerman et al., 1993 deHoop et al., 1997 Cave et al., 1994 Reeves et al., 2004 Reeves et al., 2004 NSWQD; Bannerman et al., 1993 NSWQD NSWQD
	Airports	TSS* turbidity* BTEX* nutrients (P, N) DO BOD, CBOD5 temperature* flow* deicer* oil*		
Waste to Land	Septage	TSS* turbidity* TDS DO BOD, CBOD5* pathogens* nutrients (P, N)* pharmaceuticals hormones metals		
	Septic Systems	TSS pathogens (*E. coli*, Entercocci)* turbidity* DO temperature conductivity nutrients (P, N)* hormones BOD, CBOD5* pharmaceuticals		
	Tile Drains	TSS* flow* turbidity* DO		

Work Group	Discharge Type	Pollutants Involved	Concentrations	Reference
		pH	7.3-8.4 S.U.	Haack and Duris, 2008
		Fecal Coliform*	1-35000 cfu/100 ml	Haack and Duris, 2008
		*E. coli**	1-7000 cfu/100 ml	Haack and Duris, 2008
		BOD, CBOD5*		
		phosphorous*	0.06-3.53 mg/l	Haack and Duris, 2008
		nitrate + nitrate nitrogen	38-55.3 mg/l	Haack and Duris, 2008
		ammonia	0.03-0.62 mg/l	Haack and Duris, 2008
		organic + ammonia nitrogen	0.53-9.8 mg/l	Haack and Duris, 2008
		tylosin	0.2 μg/l	Haack and Duris, 2008
		pathogens pesticides herbicides		
	Biosolids	TSS* Flow* turbidity* BOD, CBOD5* DO pathogens* metals hormones pharmaceuticals nutrients (P, N)*		
	Slaughterhouses	TSS* DO turbidity* pathogens pharmaceuticals hormones nutrients (P, N)* BOD, CBOD5*		
Earth Change Waste to Land	Agriculture (CAFOs, Farmland, etc.)	Flow* DO* turbidity* temperature		
		COD	119 mg/l	Cave et al., 1994
		TDS		
		TSS	307 mg/l	Cave et al., 1994
		BOD, CBOD5*		
		total dissolved nitrogen	2.52 mg/l	Edwards et al., 2008
		Dissolved organic carbon	16.6 mg/l	Edwards et al., 2008
		Fecal Streptococci	12683 cts/100 ml	Edwards et al., 2008
		Fecal Coliform	1975 cts/100 ml	Edwards et al., 2008

Work Group	Discharge Type	Pollutants Involved	Concentrations	Reference
		total phosphorous*	0.23-12.54 mg/l	Graves et al., 2004; Edwards et al., 2008; Cave et al., 1994
		total nitrogen*	1.09-38.9 mg/l	Graves et al., 2004
		Nitrogen (TKE)	3.93 mg/l	Cave et al., 1994
		organic nitrogen	9.98 mg/l	Graves et al., 2004
		Ammonia nitrogen*	0.09-28.5 mg/l	Graves et al., 2004
		potassium	18.6 mg/l	Edwards et al., 2008
		Zinc	0.218 mg/l	Edwards et al., 2008
		Cadmium	2.8 µg/l	He et al., 2004
		Copper	1475 µg/l	He et al., 2004
		Cobalt	18.5 µg/l	He et al., 2004
		chromium	14.1 µg/l	He et al., 2004
		Lead	30.4 µg/l	He et al., 2004
		Iron	9227 µg/l	He et al., 2004
		Nickel	39.3 µg/l	He et al., 2004
		Zinc	1401 µg/l	He et al., 2004
		Manganese	2118 µg/l	He et al., 2004
		Molybdenum	15.0 µg/l	He et al., 2004
		*E. coli**	750 cfu/100ml	Reeves et al., 2004
		Enterococci	1600 cfu/100 ml	Reeves et al., 2004
		Fecal Coliform		
		hormones		
		pharmaceuticals		
		copper sulfate		

Makepeace *et al*. (1995) conducted an extensive literature review to identify and quantify contaminant data in urban storm water. This paper also compared the contaminant data to pertinent guidelines, regulations, and concentration levels that have been reported to not cause adverse water quality impacts. A summary of the possible contaminants in urban storm water as reported by Makepeace is presented in Table 2.

Table 2. General storm water pollutant concentrations from Makepeace *et al.*, 1995.

Pollutants Involved	Concentrations	Reference
Total Solids	76-36,200 mg/l	Makepeace, D.K. (1995)
TSS	1-36,200 mg/l	
TDS	75.9-2792 mg/l	
Temperature	10-30.5 C	
Aluminum	0.1-16 mg/l	
Antimony	0.0035-0.023 mg/l	
Arsenic	0.001-0.21 mg/l	
Asbestos	NA	
Barium	0.066-0.087 mg/l	
Beryllium	0.001-0.049 mg/l	
Cadmium	0.00005-13.73 mg/l	
Calcium	0.04-2113.8 mg/l	
Chloride	0.30-25000 mg/l	

Pollutants Involved	Concentrations	Reference
Chromium	0.001-2.30 mg/l	
Cobalt	0.0013-0.0054 mg/l	
Copper	0.00006-1.41 mg/l	
Cyanide	0.002-0.033 mg/l	
Fluoride	0.1-0.2 mg/l	
Hydrogen sulfide	NA	
Iron	0.08-440 mg/l	
Lead	0.00057-26 mg/l	
Magnesium	0.02-304.2 mg/l	
Manganese	0.007-3.80 mg/l	
Mercury	0.00005-0.067 mg/l	
Nickel	0.001-49 mg/l	
Total nitrogen	0.32-16 mg/l	
Inorganic nitrogen	0.09-5.44 mg/l	
Organic nitrogen	0.32-16 mg/l	
Nitrate	0.01-12 mg/l	
Nitrite	0.02-1.49 mg/l	
Ammonia	0.01-4.3 mg/l	
TKN	0.32-16 mg/l	
Potassium	0.01-34 mg/l	
Selenium	0.0005-0.077 mg/l	
Silver	0.0002-0.014	
Sodium	0.18-660 mg/l	
Sulfate	0.06-1252 mg/l	
Thallium	0.001-0.014 mg/l	
Vanadium	0.0072-0.0085 mg/l	
Zinc	0.0007-22 mg/l	
Alkalinity	8-1273 mg/l as CACO3	
BOD	1-7700 mg/l	
COD	7-2200 mg/l	
DO	0-14 mg/l	
Hardness	12-1100 mg/l as CACO3	
pH	4.5-8.7 SU	
PCB	0.0000269-0.00112 mg/l	
Anthracene	0.000009-0.01 mg/l	
Benzo(a)anthracene	0.0000003-0.01 mg/l	
Benzo(b)fluoranthene	0.0000034-0.0019 mg/l	
Benzo(k)fluoranthene	0.0000012-0.01 mg/l	
Benzo(g,h,i)perylene	0.0000024-0.0015 mg/l	
Benzo(a)pyrene	0.0000025-0.01 mg/l	
Benzo(e)pyrene	0.0004-0.000609 mg/l	
Chrysene	0.0000038-0.01 mg/l	
Dibenzo(a,h)anthracene	0.0000006-0.0009 mg/l	
Fluoranthene	0.00003-0.056 mg/l	
Fluorene	0.000096-0.001 mg/l	
Indeno(1,2,3-c,d)pyrene	0.00031-0.0005 mg/l	
Methyphenanthrenes	0.0029-0.0034 mg/l	
2-Methylanthracene	0.00001-0.0016 mg/l	
9,10-Dimethylanthracene	0.001-0.0014 mg/l	
Naphthalene	0.000036-0.0023 mg/l	

Pollutants Involved	Concentrations	Reference
Perylene	0.00005-0.00005	
Phenanthrene	0.000045-0.01 mg/l	
Pyrene	0.000045-0.01 mg/l	
Total PAH	0.00024-0.013 mg/l	
Dichloromethane	0.05-0.0145 mg/l	
Tetrachloromethane	0.001-0.002 mg/l	
Trichloromethane	0.0002-0.012 mg/l	
1,2-Dichloroethane	0.004 mg/l	
1,1,1-Triochloroethane	0.0016-0.01 mg/l	
1,1,2-Trichloroethane	0.002-0.003 mg/l	
1,1,2,2-Tetrachloroethane	0.002-0.003 mg/l	
1,1-Dichloroethylene	0.0015-0.004 mg/l	
1,2-Trans-dichloroethylene	0.001-0.003 mg/l	
1,1,1-Trichloroethylene	0.0003-0.01 mg/l	
Tetrachloroethylene	0.0045-0.043 mg/l	
1,2-Dichloropropane	0.003 mg/l	
1,3-Dichloropropene	0.001-0.002 mg/l	
Benzene	0.0035-0.013 mg/l	
Chlorobenzene	0.001-0.01 mg/l	
Ethylbenzene	0.001-0.002 mg/l	
Toluene	0.009-0.012 mg/l	
Phenol	0.003-0.010 mg/l	
2-Chlorophenol	0.002 mg/l	
Pentachlorophenol	0.001-0.115 mg/l	
4-Nitrophenol	0.001-0.019 mg/l	
2,4-Dimethylphenol	0.010 mg/l	
P-Chloro-m-cresol	0.0015 mg/l	
Diethyl phthalate	0.002-0.010 mg/l	
Di-n-butyl phthalate	0.0005-0.011 mg/l	
Di-n-octyl phthalate	0.0004-0.001 mg/l	
Bis(20ethylhexyl) phthalate	0.007-0.039 mg/l	
Butylbenzyl phthalate	0.010 mg/l	
Aldrin	0.0001 mg/l	
Hexachlorocyclohexane	0.0000027-0.0001 mg/l	
Lindane	0.000052-0.011 mg/l	
Chlordane	0.00001-0.010 mg/l	
DDD	0.000008 mg/l	
DDT	0.0001 mg/l	
DDE	0.000015 mg/l	
Endosulfan	0.0001-0.0002 mg/l	
Heptachlor	0.0001 mg/l	
Isophorone	0.010 mg/l	
Methoxychlor	0.00002 mg/l	
Oil and Grease	0.001-110 mg/l	
Chlorinated organics	0.0066 mg/l	
Chlorinated hydrocarbons	0.000038 mg/l	
Alkyl lead compounds	0.0000025-0.000117 mg/l	
Total coliforms	7-1.8x10n7 cfu/100ml	
Fecal coliforms	0.2-1.9x10n6 cfu/100ml	
Fecal streptococci	3-1.4x10n6 cfu/100ml	

Pollutants Involved	Concentrations	Reference
E. coli	1.2x10n1-4.7x10n3 cfu/100 ml	
Salmonella	4.5x10n3 cfu/100ml	
Shigella	NA	
Klebsiella	4.0x10n3-1.9x10n5 cfu/100ml	
Staphylococcus aureus	1-1.2x10n2 mpn/100 ml	
Fungi	6.0x10n2-1.2x10n7 org/100 ml	

A brief review of Table 1 reveals that the WWMWG was unable to obtain pollutant concentrations for several wet weather pollution discharge types. A more extensive review of the available literature or the NMS/NSWQD databases may have yielded additional pollutant data, but the WWMWG did not have sufficient time or resources to take those steps. Most publications with information on the pollutant character of wet weather pollution discharges evaluated large catchment areas containing several generic land use types or broadly compared urban and agricultural wet weather pollution discharges. Rarely did the literature focus on the pollutant character of a specific wet weather pollution discharge type. The NSWQD is extensive, but the data are not organized in a way to easily yield pollutant characteristics for specific wet weather pollution discharge types.

Considerable wet weather pollution discharge data has been collected for a variety of wet weather pollution discharge types by Department staff or permittees. These data are unfortunately not easy to retrieve and most of it is likely housed in individual facility files at the Department's district offices. Even though it will prove to be a monumental task, the WWMWG recommends a Geographic Information System (GIS)-based, interactive wet weather pollution discharge database be designed and populated with data that have been (or will be) collected by the Department (or its contractors). This database should include relevant metadata (e.g., weather conditions, catchment area type, estimated or measured discharge flow, degree of BMP implementation in the catchment area, etc.) to better describe and help users interpret the sample results. Before wet weather pollution discharge data are entered into this database, the data must be capable of passing a validity check administered by a Department database manager. Consideration could also be given to expanding this wet weather pollution discharge database to include data collected by permittees, watershed groups, and other parties as long as those data are also quality assured. Finally, after such a wet weather pollution discharge database is constructed and populated by the Department, it would be beneficial for the Department to begin contributing wet weather pollution discharge data to the NSWQD through periodic data transfers.

The WWMWG was asked to develop recommendations for filling information gaps regarding the character of wet weather pollution discharges. The sheer number of different wet weather pollution discharges entering Michigan's surface waters, their wide variety of associated pollutants, and the scarcity/cost of monitoring resources, prohibit the Department from bearing the burden of characterizing these wet weather pollution discharges alone. The WWMWG recommends that wet weather pollution dischargers be required, through the inclusion of appropriate monitoring requirements in NPDES permits or other control documents, to quantify the effluent concentrations of those pollutants determined by the Department to have the potential to be present in their effluents at levels of concern. Currently, the Department's CAFO General Permit (MIG019000) requires the permittee to only report the total daily volume and visually monitor the physical characteristics of their storage structure overflows and surface water discharges. Other control documents currently being used by the Department to regulate different types of wet weather pollution discharges usually do not include wastewater characterization requirements. The recent inclusion of *E. coli*/total phosphorus monitoring requirements in the

MS4 NPDES permits is a step in the right direction, but even more comprehensive wastewater characterization requirements should be considered for inclusion in those control documents, as well as others.

Section 2. Environmental Effects of Wet Weather Discharges

Unlike regularly discharging point sources, wet weather pollution discharges are not constant, do not reoccur in a consistent pattern, often occur over a diffuse area, and originate from watersheds whose characteristics and pollutant loadings vary through time. Wet weather pollution disturbances can be characterized by their size, intensity and frequency. Wet weather pollution discharges are episodic and capable of causing three types of disturbances, in terms of duration and intensity, in surface waters. Lake (2000) uses the terms "pulse," "press," and "ramp" to describe the three types of disturbance (Figure 1). The elevation and decline of a toxic chemical's concentration in a river's water column during and after storm events is an example of a "pulse" disturbance; while the buildup of a heavy metal in interstitial sediment to a certain threshold concentration after available bonding sites have been exhausted is a "press" disturbance. Wet weather pollution event-induced channel erosion can continue indefinitely and is considered a "ramp" disturbance. Human generated pulse disturbances include such events as spills of rapidly degradable or dilutable chemicals, rapid thermal pollution, rapid changes in flow, and short-term substrate movements. Human induced press disturbances include channelization, dredging, persistent nonpoint pollution, and increased sedimentation and nutrient inputs due to catchment alterations. Ramp disturbances resulting from human activities can be processes of land clearing, tillage, and settlement; processes of urbanization; and increasing imposition of barriers (Lake, 2000).

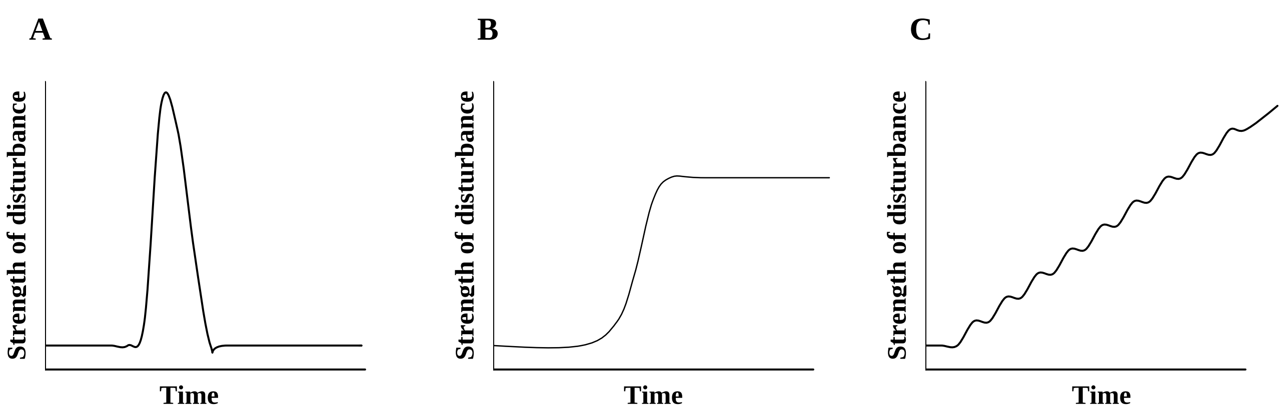

Figure 1. Three types of disturbance: (A) pulse – short-term events with a sharp peak in intensity; (B) press – long-term events that are constant in strength; and (C) ramp – long-term events that with time change in intensity. (Adapted from Lake [2000]).

As established in Section 1, wet weather pollution discharges come in many different types and contain multiple stressors that can act in antagonistic, additive, or synergistic ways to disrupt aquatic systems. The heterogeneous nature of wet weather pollution discharges and their associated qualities make it difficult to predict their environmental effects. Different land development or land use practices may create substantially different runoff flows. Different rain patterns cause different particulate washout, transport, and dilution conditions. Based on the different types of land development, flows, and rain patterns, it is not surprising that wet weather pollution discharge effects are quite variable and site-specific. These aspects of wet weather pollution discharges make it imperative that Department monitoring studies be carefully designed to ensure appropriate sampling regimes and methods are employed.

Although environmental effects of wet weather pollution discharges are difficult to predict and isolate from other water pollutant sources, **when improperly managed** wet weather pollution discharges have the potential to cause serious problems in surface waters that interfere with designated uses, including:

- Increase the magnitude and frequency of flooding, particularly in urban areas.
- Widen stream cross sections, which leads to significant channel erosion, unstable conditions, and associated habitat problems.
- Smother coarse sediments needed by spawning fish and other aquatic life.
- Reduce aesthetic value.
- Increase water column bacteria concentrations to levels that can impair total and partial body contact recreation.
- Stimulate nuisance algal and macrophyte growth conditions.
- Shift in-stream biological communities from diverse to much less diverse assemblages that are dominated by species more able to tolerate perturbed conditions.
- Increase the loading of certain toxic chemicals, which can bioaccumulate to levels in fish tissues that necessitate the establishment of fish consumption advisories.
- Increase the difficulty and cost of public drinking water treatment.

The most serious environmental effects of wet weather pollution discharges are usually not caused by short-term pollutant exposures from specific rain events. Instead, they are more often linked to the inability of aquatic systems to withstand repeated exposure to high pollutant concentrations or high flow events. Environmental effects of wet weather pollution discharges are usually more apparent and evident in small streams compared to larger rivers due to the inherent dilution provided by the latter systems.

Although wet weather pollution discharges definitely limit the ability of many Michigan surface waters to reach their fullest water quality potential, the degree of water quality impairment (when *E. coli*-based WQS are ignored) rarely qualifies these water bodies for placement on Michigan's Section 303(d) nonattainment list.

Pulse exposures of aquatic life to wet weather pollution discharges contaminated with heavy metals, certain organic chemicals (i.e., pesticides), and total dissolved solids can produce chronic toxicity responses in exposed fish and benthic macroinvertebrates. This chronic toxicity (usually associated with contaminated sediment or suspended solids) can reduce the reproductive potential and growth rates of sensitive species, resulting in their eventual replacement by more tolerant organisms. The degree of impact on an exposed organism is dependent on numerous factors, such as the organism's sensitivity, life stage, feeding habits, frequency of exposure, and magnitude and duration of exposure to wet weather-related stressors. The Department is currently dealing with at least two aquatic chronic toxicity problems that are attributable to heavy metals in wet weather pollution discharges: (1) elevated copper concentrations in the water column of several Upper Peninsula streams and rivers that receive runoff from historic copper stamp sands; and (2) elevated selenium concentrations in the water columns of Warner Creek, Goose Lake inlet/outlet, and Goose Lake. Each of these water bodies receive runoff from the waste rock piles at the Empire and Tilden Iron Mining Companies.

Fish kills are usually not attributable to individual wet weather pollution discharges, unless the discharge is severe and inappropriate (similar to the wet weather pollution discharge from manure-laden agricultural land that caused major fish kills in Seymour Creek, Black Creek, and the Black River, Sanilac and St. Clair Counties in August 2009).

Polychlorinated biphenyls (PCBs), mercury, chlorinated dioxins/furans, and chlordane are introduced to Michigan surface waters to some extent by wet weather pollution discharges. These pollutants can bioaccumulate in fish tissue to levels that require the establishment of fish consumption advisories by the Michigan Department of Community Health. The causes of fish consumption advisories impairing certain Michigan surface waters vary, but wet weather pollution runoff should not be overlooked as a potential contributor.

In this part of the United States, phosphorus is the critical nutrient limiting the growth of aquatic plants (algae and macrophytes) in streams, rivers, and lakes. Runoff from agricultural land or urban areas can contribute substantial phosphorus loads to surface waters. When phosphorus concentrations in the water and sediment matrices of these water bodies (particularly, inland lakes) exceed certain thresholds, nuisance aquatic algae and/or plant growth conditions can occur. Blue green algae species often become more dominant in nutrient enriched systems and, in some cases, algae blooms and die offs occur causing odors and unsightly conditions. Several Michigan inland lakes and impoundments are included on the Section 303(d) list of nonattaining water bodies due to nuisance algae or plant growth conditions partly attributable to wet weather pollution discharges.

Disruption of stream channel stability by high flow conditions during wet weather pollution discharge events is responsible for processes that eventually reduce biological habitat and aesthetic value. Floodplains increase in size, stream banks are undercut, riparian vegetation is lost, and water temperature can rise. When the magnitude and frequency of high flow events in a lotic system increase, it is quite common for the steam/river to widen its banks as much as two to four times. The increased sedimentation moves through the system as bedload, covers sand/gravel/cobble substrates, eliminates refuge areas, and destroys habitat. The effects of habitat loss, plus the chronic toxicity associated with wet weather pollution discharges, cause in-stream biological communities to shift. Aquatic systems that are wet weather stressed typically become less diverse and less stable. These trends occur at all levels of biological organization including fish, insects, zooplankton, phytoplankton, benthic macroinvertebrates, protozoa, bacteria, and macrophytes. Channel cross-sectional changes and associated biological degradation were found to occur when watershed impervious cover exceeded ten percent (MacRae, 1997).

Wet weather pollution discharges (particularly those from CAFOs, AFOs, and some urban catchment areas) contribute *E. coli* (and other bacteria) to some Michigan surface waters in amounts that cause these water bodies to not support their total body and, even in some cases, their partial body contact recreation designated use. According to Michigan's Draft 2010 Integrated Report,, approximately 3,077 river miles (includes, inland rivers and Great Lake Connecting Channels) and several Great Lakes and inland lake beaches are listed as not attaining the total body contact recreation designated use. Much of this nonattainment is due, in part, to wet weather pollution contributions of *E. coli* (MDNRE, 2010).

Section 3. Guidance for Assessing the Instream Impacts of Wet Weather Discharges

Early efforts to implement the federal Clean Water Act focused primarily on regulating discharges from traditional point source facilities, such as municipal sewage and industrial plants. Because of those efforts, point source pollution has been greatly reduced. Until the late 1980s, little attention was paid to runoff from streets, construction sites, farms, and other wet weather pollution discharges. Since that time, work to address wet weather pollution discharges has increased significantly, but these discharges continue to be at the root of many current surface water quality problems.

Increases in impervious surface area, stream channelization, loss of wetland acreage, deforestation, and agricultural field tiling all have led to more rapid and higher volume runoff from storm events or snowmelt. Such unnaturally high runoff volumes can have physical impacts, causing channel erosion, flooding, and damage to in-stream habitat for aquatic organisms.

Rapid runoff also affects water chemistry by washing nutrients, metals, oils, pathogens, salt, and sediment into receiving waters to the extent that they sometimes exceed human health-based or ecological health-based WQS. Wet weather pollution discharge events can reduce the dissolved oxygen concentration and increase the temperature of receiving waters. In addition, wet weather pollution events can mobilize deposits of contaminated sediments, periodically increasing concentrations of toxic materials in the water and creating deposits in previously clean areas.

This Section of the WWMWG's final report is intended to provide guidance to the Department staff for assessing wet weather pollution discharge impacts on ambient water/sediment chemistry, aquatic biological communities, and channel form and stability. It assumes a high level of knowledge of environmental chemistry, aquatic biology, and channel morphology terms and concepts. It also assumes – even requires – extensive communication between staff in the SWAS and district field offices; while the SWAS staff will usually execute the sampling and analyze/interpret/report the data, the district staff's knowledge of local land uses and landowners will be crucial in successfully designing and executing the sampling program.

3.1 Types of Wet Weather Ambient Water Monitoring Studies

There are two basic types of wet weather pollution ambient water monitoring studies: (1) those carried out in response to short-term, acute wet weather pollution discharge events; and (2) those carried out to assess the chemical, biological, and/or physical impacts on aquatic systems from wet weather pollution discharge events that occur episodically over a long or chronic period of time. Each type has inherent study design demands that require careful consideration by the Department's lead investigator. Decision trees for selecting monitoring study design options for assessing acute and chronic wet weather impairments are shown in Figures 2 and 3, respectively.

To effectively assess impacts due to acute wet weather pollution discharge events it is critical that sampling occurs in the receiving water(s) when (or shortly after) the event occurs. Chemical and biological sampling is best conducted concurrently to provide the greatest chance of documenting a cause/effect relationship. Physical monitoring is not as time critical and should only be done if physical impacts are obvious and documentation is necessary. Qualitative biological sampling methods may be sufficient to demonstrate dramatic effects, while quantitative methods may be warranted if a more defensible result is needed.

Fortunately, lead investigators have more time to carefully plan monitoring studies that are meant to assess chronic impairments caused by episodic wet weather pollution discharge events. Qualitative or semi-quantitative methods should be used to initially screen the receiving water for physical impacts. Quantitative physical monitoring should be implemented later, if warranted, based on review of the initial screening results and relevance to the study objective(s). Biological monitoring often needs to be accomplished using quantitative techniques due to the fact that chronic impairments may be quite subtle and difficult to measure. Chemical monitoring can usually be delayed until a decision is made by the lead investigator that water/sediment chemistry is potentially responsible for observed biotic impairment.

3.2 Monitoring Study Plans

A detailed and well thought out study plan, which may equate to a formal Quality Assurance Project Plan (QAPP), needs to be developed for any wet weather ambient water monitoring study conducted by the Department or its contractors/grantees. The monitoring study plan must connect all of the study design specifics (e.g., sampling station number and location, sample collection techniques, sampling frequency, data analysis procedures, etc.) to the study objective(s) and fulfill the requirements of WB Policy/Procedure #008 (Quality Assurance Planning for Environmental Data Collection). Numerous documents providing guidance on appropriate water chemistry monitoring Quality Assurance/Quality Control (QA/QC) procedures are available (e.g., Burton and Pitt, 2002; California Department of Transportation, 2000). In Section 3, the term “water chemistry” is used as a catch-all for chemistry, pathogen, and sediment sampling.

The Department should also consider developing a “boilerplate” study plan/QAPP for monitoring studies that need to be conducted by staff to assess acute impacts of individual wet weather pollution discharge events. This “boilerplate” study plan/QAPP should be oriented to sampling design and decision point issues/factors commonly encountered by lead investigators charged with the responsibility of responding quickly and effectively to unexpected, problematic wet weather pollution discharge events (i.e., fish kill investigations). Such a “boilerplate” study plan/QAPP would be most useful if it is developed to produce ambient monitoring data of sufficient quality and quantity to support enforcement actions.

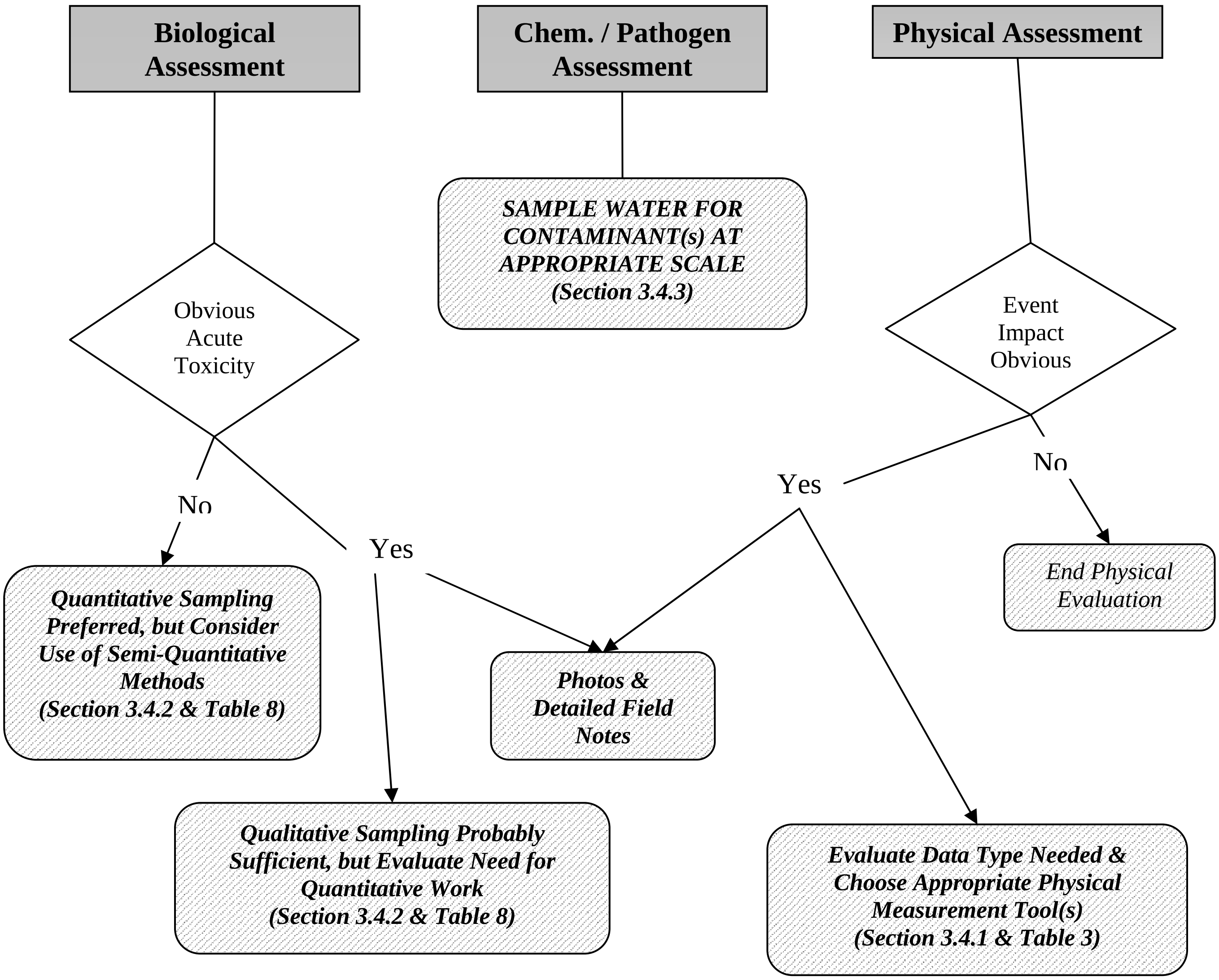

Figure 2. Decision Tree for Selecting Monitoring Options for Assessing Acute Wet Weather Impairments.

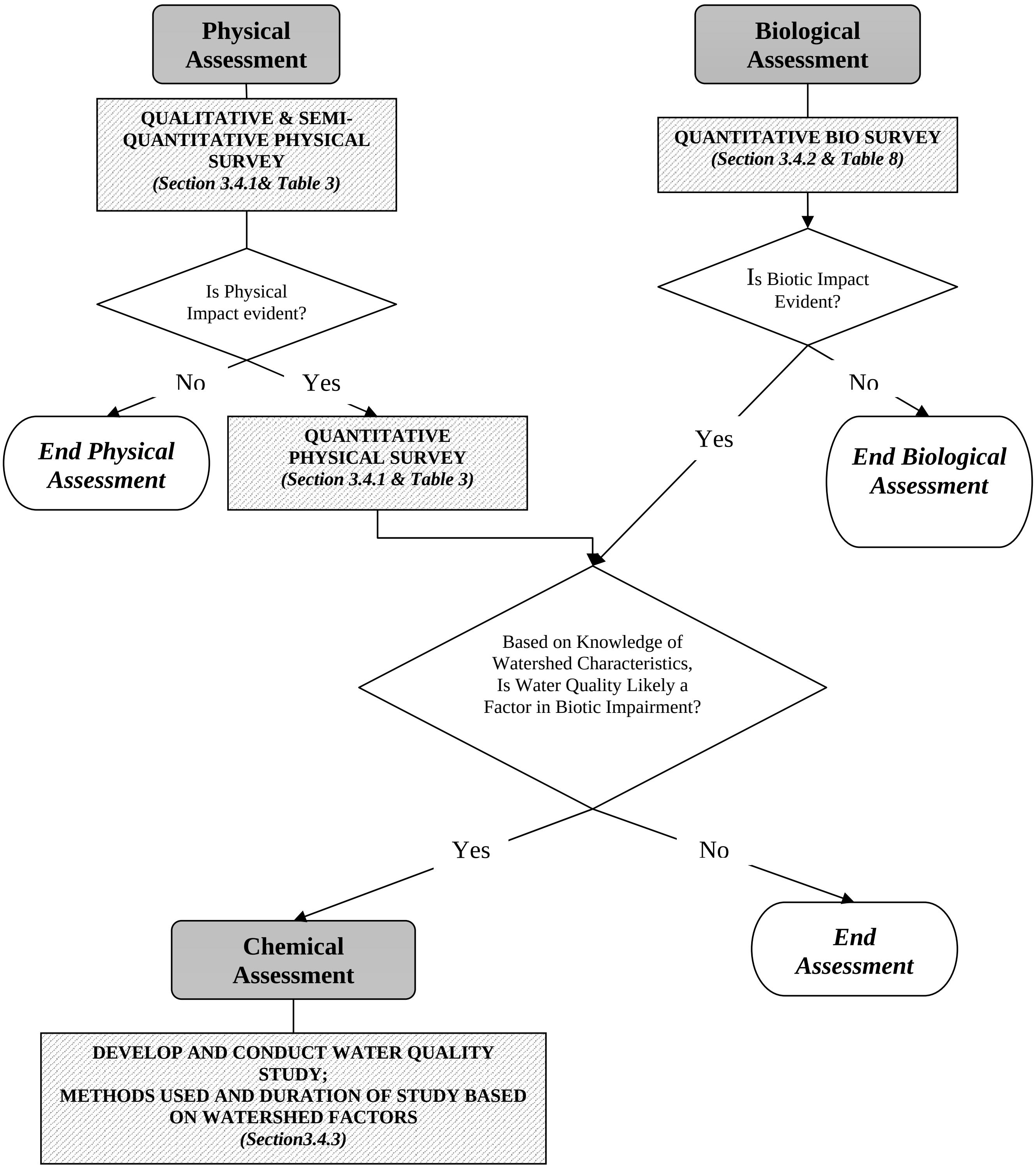

Figure 3. Decision Tree for Selecting Monitoring Options for Assessing Chronic Wet Weather Impairments.

The following QA/QC steps are necessary when conducting wet weather water chemistry and biological monitoring:

- Monitoring equipment and supplies need to be properly maintained and regularly cleaned.
- Sampling locations need to be accurately documented (ideally using Global Positioning System), so they can be easily revisited, if necessary.
- Data analysis methods and decision break points need to be identified and established before sampling occurs.
- Sampling and analytical methods need to be well understood, particularly sample holding time and preservation requirements. The six hour holding time for *E. coli* samples will affect the timing and/or duration of sampling for enforcement cases, but may not be as great a concern for general screening surveys. Certain parameters (e.g., oil and grease, *E. coli*) cannot be sampled for with automatic samplers.
- Chain-of-custody must be maintained for all samples collected and analyzed in support of potential enforcement actions.
- For water chemistry studies, sufficient field duplicate and field/laboratory blank samples need to be collected and analyzed to assess accuracy, precision, and any contamination issues associated with the data, particularly in the case of water/sediment chemistry monitoring studies. To assess data precision, five to ten percent of the collected samples need to be field duplicates. If sample collection equipment is reused at multiple locations, five to ten percent of the collected samples should be appropriate field blanks.
- For biological studies, specimen identification verification and archiving processes need to be established and routinely maintained.

QA activities for physical measurements are not as well defined as for chemical or biological measurements; there are no field duplicates or taxonomic keys. Physical measurement QA activities, pertinent to investigations of both acute and chronic wet weather problems, include:

- Confirming that the measurements address the study objective(s), and carefully following an established standard operating procedure.
- Checking laser level calibration several times a field season.
- Establishing the spatial limits of a pebble count: wetted channel vs. up to the bank full elevation; riffle only vs. reach average; etc.
- Randomly selecting sediment particles and measuring the intermediate axis during pebble counts.
- Accurately identifying bank full field indicators.
- Placing cross-channel transects at riffles if possible.
- Recording enough elevation measurements across a transect to document significant elevation changes.
- Selecting representative stream reaches for bank erosion hazard index (BEHI) scoring and qualitative stream stability observations.
- Starting and ending longitudinal profiles at riffles, if possible.

3.3 Monitoring Study Planning Concepts and Considerations

Wet weather pollution discharges can have varied and widespread effects on the chemical, physical, and biological conditions of receiving waters. Consequently, it is often necessary to collect data on chemical, biological, and physical conditions, either simultaneously or in follow-up surveys, to assess cause-effect relationships and support WRD program needs.

One complicating aspect of trying to detect environmental impacts related to specific wet weather pollution inputs at a small scale is that often much broader portions of the watershed are also impacted. In these situations, it is critical for the monitoring study to include appropriate controls and sufficient statistical robustness so spatial changes can be distinguished. Increased taxonomic resolution and quantitative methods may also be needed for biological investigations.

The first critical step in designing an effective wet weather ambient monitoring study is to produce a well-defined question. Defining the question requires assessment of the spatial and temporal scope of the wet weather pollution discharge(s) and the potentially impacted area. Spatial and temporal scale will drive the statistical rigor necessary, sampling techniques used, level of effort employed, and analysis and interpretation of the data.

Spatially, monitoring studies can be designed to assess conditions at the reach, subwatershed or watershed scale. A “reach” scale design is often used to assess the effectiveness of a BMP or to assess the environmental impacts of a specific wet weather pollution point source discharge. A “subwatershed” scale design is needed to evaluate the effectiveness of several BMPs strategically placed throughout a portion of a watershed. Finally, a “watershed” scale design is required to evaluate the environmental impacts of a catastrophic storm event, the broad application of BMPs, or broad land use changes.

Some wet weather ambient monitoring studies must be capable of assessing pre- and post-conditions, or comparing conditions at impacted and unimpacted (or less impacted) sites. This can be done either by using upstream/downstream sites or finding a representative paired site from a nearby watershed. The strongest study design is a Before-After/Control-Impact (BACI), in which conditions are assessed both before and after an impact has occurred, at both the potentially impacted site and at a control or reference site. Less rigorous, but still potentially useful, designs are either half of the BACI, a Before-After survey of the potentially impacted site, or a Control-Impact study of impacted and control sites after a potential impact. A BACI design provides the strongest data for enforcement and BMP effectiveness studies, while a Before-After design can be adequate for trend and some BMP effectiveness studies.

It cannot be stressed enough that a well-designed study will likely require input from statistics and environmental sampling design experts. Input from these professionals from the start will lead to a more valid, defensible study and more meaningful analyses and interpretation of the data.

3.3.1 Enforcement

The defensibility of study design, data collection, and data analysis and interpretation are always important, but particularly so when handling issues that are or may become part of enforcement proceedings. It is generally advisable to use quantitative methods to document environmental impacts caused by illegal wet weather pollution discharges, but qualitative methods may be sufficient to support an enforcement action in cases where the impacts are obvious and dramatic. In any case, care should be taken to document all observations and actions via detailed field notes and photographs. The use of chain-of-custody sample handling procedures are an absolute must in an enforcement scenario.

3.3.2 Trend Assessment

Wet weather ambient monitoring studies conducted to assess spatial or temporal trends in biological communities or the physical characteristics of a water body need to be designed to have adequate quantitative data confidence and statistical rigor. Power statistics should be employed to determine the required sampling level of effort needed to detect subtle changes. The long-term nature of trend studies allows for detailed planning and choice of sampling tools and analysis with an eye for demonstrating more subtle changes, if they exist. Wet weather ambient monitoring trend studies will typically rely on repeated sampling at a given set of stations, requiring some effort to adequately document sampling locations to minimize variation attributable to different areas.

3.3.3 BMP Effectiveness

The ability to study conditions before and after the installation of a BMP (and other point source-type studies) is critical to a BMP effectiveness monitoring study. Ideally, the timeline of planning a BMP installation allows for studies to be conducted at the particular site or reach prior to implementation. If, however, BMP effectiveness studies are conducted without pre- and post-monitoring at the same location, it will be important to establish a valid control station(s) against which comparisons can be made. The control station(s) is often upstream of the BMP site and should be as similar as possible to the BMP site (i.e., similar habitat, shading, channel hydrology and morphology, land-use, etc.).

3.3.4 Designated Use Attainment Status

Before designing wet weather ambient monitoring studies directed toward evaluating designated use attainment of a given water body, lead investigators should carefully review the Assessment Methodology in Michigan's Integrated Report. This step will help ensure such studies are designed to produce data of sufficient quality and quantity to make designated use attainment decisions. When investigating the impact of wet weather pollution discharge events on the biological condition of steams/rivers, with regard to attainment of the "coldwater fishery," "warm water fishery," and "other indigenous aquatic life and wildlife" designated uses, the SWAS's Procedure 51 and draft nonwadeable river survey method (or other equivalent methods) are currently accepted techniques.

Assessing designated use attainment based on chemical parameters requires comparison of their measured concentrations in water to appropriate Rule 57(2) allowable levels. The Department does not use physical parameters to assess designated use attainment status. Physical parameters that could be useful for assessing designated use attainment in the future include stream flashiness and stream power calculations.

3.4 Monitoring Methods

3.4.1 Measuring Physical Impacts

Physical impacts of wet weather pollution discharge events include an increase in stream discharge and hydrologic "flashiness." Flashiness can cause stream bank and/or bed erosion and excessive sedimentation from upland and/or stream bank erosion that can smother or bury in-stream habitat features. Useful parameters for evaluating the magnitude and extent of physical impacts include assessments of sediment particle size, stream channel geometry, stream flow variability, stream bank condition, and general channel stability (Table 3), and can be grouped along a quantitative to qualitative continuum as follows:

- Quantitative: pebble counts, cross-channel transects, bank profiles, and stream flashiness.
- Semi-quantitative: riffle embeddedness and bank erosion hazard index.
- Qualitative: qualitative stream stability indicators.

Other, more involved assessments of stream physical condition are also useful, and include scour chains to evaluate stream bed mobility (Nawa and Frissel, 1993), residual pool depth measurements to assess sedimentation in pools (Lisle, 1987), and the suite of monitoring and modeling techniques incorporated into the Watershed Assessment of River Stability and Sediment Supply (WARSSS) Protocol (Rosgen, 2006). Note that some of the physical monitoring tools described here are components of WARSSS.

Suggestions for choosing among the recommended physical monitoring tools for different study objectives are as follows:

- Enforcement studies = quantitative tools
- Trend studies = quantitative tools
- BMP effectiveness studies = semi-quantitative and/or quantitative tools
- Watershed-wide environmental condition studies (status studies) = qualitative, semi-quantitative, and/or quantitative tools

Survey design recommendations to address these four objectives are provided in Table 4. Surveys conducted for enforcement investigations or BMP performance assessments usually include an unimpacted upstream reference or control site as well as one or more sites downstream of the suspected problem or BMP. Trend assessment surveys will measure conditions at the same locations repeatedly, and the site selection criteria for the sites will vary with the study objective. Surveys conducted to assess channel condition status at the watershed-scale can "screen" large areas by sampling at the downstream end of major tributaries, plus upstream and downstream of suspected problem areas.

Table 3. Parameters for Assessing the Physical Impacts of Wet Weather Discharge Events.

Parameter	Explanation and Method Reference
Pebble counts or riffle embeddedness	Pebble count is a quantitative measurement of particle sizes on the stream bottom and can be related to stream energy and sediment transport (Wolman, 1954; Bunte and Abt, 2001). Embeddedness is a semi-quantitative assessment of the amount of fine sediment in riffles and is a useful indicator of macroinvertebrate and/or fish productivity (MDEQ, 2008; Sylte and Fischenich, 2002)
Cross-channel transect	A quantitative record of channel depth in a line (transect) across the stream channel, related to stream energy and sediment transport (Harrelson *et al.,* 1994)
Bank profile	A quantitative technique for measuring the rate of bank erosion and the mass of eroded bank soil (Rosgen, 2006)
Stream flow "flashiness"	A quantitative calculation of stream discharge variability; useful for hydrologic trend assessments; already performed for approximately 280 locations around the state (Fongers *et al.,* 2007)

Parameter	Explanation and Method Reference
BEHI	A semi-quantitative scoring procedure for stream bank erosion risk; useful for rapidly ranking erosion hazard at multiple sites (Rosgen, 2001)
Qualitative stream stability indicators	Qualitative observations of stream stability indicators, such as unvegetated mid-channel bars, exposed infrastructure like sewer pipes, head cuts, slumping banks, and failed bank stabilization projects (Rathbun, 2008)

Barring a massive wet weather pollution event, like a 100-year storm, physical effects from wet weather pollution discharges usually do not change rapidly, so annual monitoring is usually adequate. Multi-year studies are usually required to assess trends in physical conditions.

Compared to chemical or biological monitoring, the training, manpower, and equipment requirements of physical measurements are relatively low (Table 5). Nonetheless, some aspects of certain measurements do require special attention:

Pebble count: consistent random selection of particles, and measurement of the intermediate axis of each particle, are important for representative sampling.

- Cross-channel transects: careful establishment of a monumented benchmark is vital for long-term monitoring.
- BEHI: choosing a representative stream reach, and accurately judging the bank angle, are important.

Table 4. Design Recommendations for Assessing Physical Impacts for Different Study Objectives.

Study Objective	Station Locations	Sampling Frequency	Tool Selection
Enforcement	Upstream and downstream to bracket suspected problem, + reference reach(es)	• Pre event • ASAP after event • Perhaps periodically thereafter	Quantitative tools; choice determined by type and magnitude of suspected problem
Trend assessment	Repeat same stations over time	Annual at most	Quantitative tools; choice determined by desired information
BMP effectiveness	Upstream and downstream to bracket BMP, + reference reach(es)	• Pre BMP • Post BMP, after BMP is likely to have had an impact (lag time)	Semi-quantitative and/or quantitative; choice determined by BMP objective
Status assessment	Variable; one option = downstream end of major tributaries, + suspected problem areas	Annual at most	Qualitative, semi-quantitative, and/or quantitative

Table 5. Parameter Measurement Requirements for Assessing the Physical Impacts of Wet Weather Discharge Events.

Analysis	Training	Level of Effort	Equipment	Other Costs
Pebble counts or riffle embeddedness	½ day	1-2 people; 0.5 hours per site	Ruler or calipers, sand card	None
Cross-channel transect	1 day	1-2 people; 1 hour per site	Level, survey rod, 100'-300' tape measure	None
Bank profile	½ day	1-2 people; 0.5 hours per site	Survey rod, pocket rod, or ruler	None
Stream flow "flashiness"	The Department has calculated stream flashiness at ~ 280 locations around the state (Fongers *et al.,* 2007)			None
BEHI	½ to 1 day	1 person; a few minutes per site	None	None
Qualitative stream stability indicators	Minimal	1 person; a few minutes per site	None	None

Factors to consider when choosing sites for physical measurements, beyond those listed in Section 3.4.1 are summarized in Table 6.

Table 6. Site Selection for Physical Measurements.

Parameter	Factors to Consider
Pebble counts or embeddedness	Pebble counts should be performed within the wetted channel, within riffles, and/or along a stream reach that is stratified by habitat type. Embeddedness should be assessed at riffles.
Cross-channel transect	Transects should be established at riffles and through a pool.
Bank profile	Sites could either be representative reaches established after walking a length of stream, or local "hot spots" (e.g., road/stream crossings, cattle access sites) that are not representative of the larger stream reach.
BEHI	Same as bank profile.
Qualitative stream stability indicators	Same as bank profile.

3.4.2 Measuring Biological Impacts

Since biological communities incorporate different stressors over time, can be relatively inexpensive to monitor, are reflective of overall ecological integrity, and are easily relatable to the general public when conceptualizing water quality; it is often important to monitor some aspect of the biological community (Barbour *et al.*, 1999). Depending on the study objective(s), the pollutants in a wet weather pollution discharge, the time frame and longevity of the discharge, sampling logistics, and other factors, certain biological communities may be more advantageous than others to target in a wet weather ambient monitoring study. However, it is often necessary to assess multiple biological communities to satisfy some monitoring study objectives.

Each of the biological communities listed below can be sampled using qualitative or quantitative methods, lending flexibility to their use. Additionally, their varying mobility, life cycle timing, and responses to water and habitat quality provide an array of options to pair with physical and/or chemical monitoring in a full study design.

Periphyton: The composition and density of algal and diatom communities may be relatable to wet weather pollution disturbances ranging from toxics and nutrients to physical scouring. Because of their sessile nature and rapid recolonization ability, periphyton can be used to assess acute impacts as well as broader chronic impacts. While useful, other influences like shading, light penetration, and velocity may have confounding effects between samples and must be considered and controlled.

Macrophytes: Macrophytes, in terms of their density and composition, may be related to wet weather pollution disturbances like nutrient loading, scour, and suspended solids loading (decreased clarity and light penetration) and are easily identified in the field by trained biologists. Macrophytes may be most appropriate to use for longer-term discharge issues at a particular location(s), given their relatively slow response to changing water or habitat quality conditions. Similar to periphyton, other influences like shading, light penetration, and velocity may have confounding effects between samples and must be considered and controlled.

Macroinvertebrates: Macroinvertebrate communities are easily identified in the field to family by trained biologists, with laboratory identification to lower taxonomic level possible. Macroinvertebrates are able to reflect water and habitat quality changes due to their limited mobility; many of these relationships are well understood. Particularly with lower level taxonomy, density and composition monitoring in paired studies can begin to identify impacts and potentially point to causes based on species' (or suites of species') life history needs and tolerance to various environmental conditions.

Fish: Fish species are easily identified in the field by trained biologists and are able to reflect water and habitat quality changes. Density and composition monitoring in paired studies can begin to identify impacts and potentially point to causes based on species' (or suites of species') life history needs and tolerance to various environmental conditions. Fish are highly mobile and may not be suitable for small-scale studies (outside of acute impacts like fish kills) because of the ability to avoid an area and possibly return following cessation of the discharge.

The objective(s) of the monitoring study and spatial/temporal scale will govern the need for quantitative versus qualitative data and whether active or passive collection techniques can be used (Table 7). In this context, active sampling is defined as collection techniques that involve the active manipulation of the sampling device (e.g., D-frame sweep net, electrofishing) or of the substrate (e.g., Surber sampler) in the collection of the sample. Passive sampling involves devices designed to be set and left for a period of time to collect the sample (e.g., drift nets, Hester-Dendy samplers, minnow traps). In situations where time is of the essence and biological samples need to be collected quickly, active techniques are most appropriate. Passive techniques are appropriate for use in longer term studies where it is possible for the investigator to deploy and retrieve equipment in the field.

Table 7. Design Recommendations for Assessing Biological Impacts for Different Study Objectives.

Study Objective	Station Locations	Sampling Frequency	Tool Selection (Active/Passive [A/P])
Enforcement	Upstream and downstream to bracket suspected problem, + reference reach(es)	• Pre event • ASAP after event • Perhaps periodically thereafter	Quantitative or qualitative tools (A); choice determined by type and magnitude of suspected problem
Trend assessment	Repeat same stations over time	Annual at most	Quantitative tools (A/P); choice determined by desired information
BMP effectiveness	Upstream and downstream to bracket BMP, + reference reach(es)	• Pre BMP • Post BMP, after BMP is likely to have had an impact (lag time)	Semi-quantitative and/or quantitative (A/P); choice determined by BMP objective
Status assessment	Variable; one option = downstream end of major tributaries, + suspected problem areas	Annual at most	Qualitative (A/P), semi-quantitative, and/or quantitative

Specific biological sampling methods are listed in Table 8. While not exhaustive, these are meant to represent the majority of commonly used techniques to provide some guidance for options to consider when designing a monitoring plan. As stated earlier, spatial and temporal scale and the type/amount of data needed to satisfy the monitoring objective(s) are the primary factors which influence method selection.

To effectively support a wet weather pollution management program, the Department will need to conduct more biological monitoring studies that require the use of quantitative sampling and advanced statistical analytical techniques. The ability to detect dramatic, acute changes is typically realized by qualitative techniques, but detecting subtle or incremental changes are more difficult. Quantitative methods leading to predictable data quality and increased taxonomic resolution, where applicable, can result in more robust statistical analyses and a better possibility of assigning cause to effect. The data resulting from increased taxa resolution and the use of quantitative sampling could lend itself to some statistical testing and also metric development, perhaps more targeted to the types of questions that need to be tackled by a wet weather pollution monitoring program. It is envisioned that metrics could be “built” to identify sediment tolerant taxa, for example, in an effort to identify areas where more (or less) fine solids are impacting habitat and driving community changes. Metrics developed, or taken from others, would need to be tested for response to environmental variables in Michigan streams to determine their validity and usefulness to a monitoring scheme. Historically, the SWAS conducted quantitative sampling and more detailed taxonomy, but that aspect of the monitoring program shifted to broader qualitative assessments using Procedure 51. As monitoring questions are increasingly geared toward demonstrating changes at a localized scale, it becomes important to once again develop quantitative measurement capability.

Table 8. Details of Selected Macroinvertebrate Sampling Methods.

MACROINVERTEBRATES							
Method	**Source**	**Active/ Passive (A/P)**	**Quantitative (Qt)/ Qualitative (Ql)**	**Level of Effort (Field)**	**Staff Req.**	**Training**	**Other Costs**
Drift Nets	1, 5	P	Qt (with flow meter and time)	3h (to 24h to get full range of diel variability)	1	Low Level Taxonomy (if Dept. Staff to process)	Nets/Samplers, Sample processing to taxonomic level (contract or staff time)
Kick Net	3, 4, 5	A	Ql, Semi-Qt	Depends on # samples needed per site, each sample, core, grab, or sweep takes << 1h	2		
Dip Net (D or other)	2, 4, 5	A	Ql, Semi-Qt		1		
Surber Sampler	1, 2, 5	A	Qt		1		
Hess Sampler	1, 5	A	Qt		1		
Corer (stovepipe, standpipe, etc.)	1	A	Qt		2		
Grab Sampler (Ekman, Ponar, Petersen)	1, 2	A	Qt		2		
Artificial Substrate (Hester Dendy, leaf packs, rock basket)	1	P	Qt	½ d for set and retrieval (1 d total) – in-stream set of up to 6-8 weeks	2		
FISH							
Seine Net	1, 2, 3, 5, 6	A	Ql, Semi-Qt	< ½ d per site	2		
Minnow trap	1, 6	P	Ql	Overnight	1		
Electrofishing (boat, barge, backpack, seine)	1, 2, 3, 4, 5, 6	A	Ql, Qt (with block netting and depletion sampling)	½ d per site	2 – 4		
Ichthyocide (rotenone)	1, 6	A	Qt	Depends on reach size 1-2d for most small reaches	4 +		Chemicals

Table 8 (cont.). Details of Selected Macroinvertebrate Sampling Methods.

PERIPHYTON							
Method (by substrate type)	**Source**	**Active/ Passive (A/P)**	**Quantitative (Qt) / Qualitative (Ql)**	**Level of Effort**	**Staff Req.**	**Training**	**Other Costs**
Hard nonremovable: scrape & plankton net	5	A	Qt/Ql	Depends on # samples needed per site, each sample, core, grab, or sweep takes << 1h	1	Sampling Techniques, Taxonomy (if Dept. Staff to process)	Sample processing (contract or staff time)
Hard nonremovable: PVC and pipette	4	A	Qt		1		
Hard removable: SG-92 syringe and brush	2	A	Qt		1		
Hard removable: top-rock scrape, brush, etc.	1, 2, 3, 4, 5	A	Qt/Ql		1		
Hard removable: gravel sampler	2	A	Qt		1		
Hard removable: cylinder scrape	2	A	Qt		1		
Soft plants: square frame	2	A	Qt		1		
Soft plants: agitation	4, 5	A	Ql		1		
Sand or silt: inverted Petri-dish	2, 4	A	Qt		1		
Sand: agitation	5	A	Qt/Ql		1		
Silt: turkey baster, pipette, syringe	3, 5	A	Qt/Ql		1		
Chlorophyll *a*, ash-free dry mass, particulate organic matter, acid/alkaline phosphatase activity	1, 2, 3, 4	A	Qt		1		Laboratory analysis
Rapid Periphyton Survey	4	A	Semi-Qt	1-2 h	2	Techniques, coarse-level taxonomy	

Equipment/supply demands, while important, are minimal compared to the investment in personnel needed to design and conduct quantitative biological monitoring studies and analyze the resultant data. Quantitative periphyton and algal monitoring (beyond rapid bioassessment-type protocols; for example Barbour *et al*., 1999) not only require a potentially extensive (and expensive) working laboratory, but the expertise in sampling and identification would, in large part, need to be built into the Department's current monitoring program through training or hiring or through contracts with outside entities. Similarly, taxonomic resolution is currently taken to family in most cases for macroinvertebrates. Increased taxonomic resolution, while generally achievable with existing SWAS staff, would require the dedication of staff time, training, and some potential equipment and laboratory costs. An alternative would be to establish a contract with an outside entity to identify macroinvertebrate samples to the species level. Fish monitoring is the only area that would not likely need additional personnel or training resources because fish are currently being identified to species and SWAS biologists already have the expertise to conduct quantitative fish community assessments.

The involvement of a professional statistician familiar with environmental monitoring study design and data analysis is critical to the development of viable biological monitoring studies. The Department should consider taking appropriate steps to retain a statistician with this type of expertise.

3.4.3 Measuring Changes in Water Chemistry

Wet weather pollution discharges will often increase the concentrations of toxicants, nutrients, and pathogens in the receiving water. Water temperature, conductivity/salinity, dissolved oxygen, and other physical/chemical characteristics of the receiving water can also be affected. These factors, individually or in combination, can negatively impact the quality of surface waters, disrupting stream ecology and potentially causing human health risks.

A wet weather water chemistry monitoring project must meet the challenges presented by the random nature of rainfall-runoff events, and may need to address several different temporal and spatial scales. Five points to consider when developing a water chemistry monitoring plan are:

1. What to monitor.
2. Where to monitor.
3. What type of monitoring is needed.
4. How frequently to monitor.
5. How long to monitor.

These points are discussed below.

1. What to monitor

The constituents to be monitored may not be clear in every case. Evaluation of the target watershed and any past sampling of the stream may help to limit the scope of chemical sampling necessary. Baseline monitoring of a broad spectrum of constituents may be needed to establish the general conditions in the stream.

It may also be possible to use constituents that can be reliably monitored with continuous probes as surrogates to predict concentrations of other constituents. For example, measurements of specific conductance can be used to estimate chloride and sulfate concentrations, and turbidity measurements can be used to estimate *E. coli* and total phosphorus concentrations (Christensen *et al*., 2000). A significant amount of research relating real-time measurements of surrogates to other constituents of interest has been conducted. One set of publications of note, produced by the USGS in Kansas, can be found at: http://ks.water.usgs.gov/studies/qw/. The following abstract is linked to that page and summarizes some uses of the method:

An innovative approach currently is underway in Kansas to estimate and monitor constituent concentrations in streams. Continuous in-stream water-quality monitors are installed at selected U.S. Geological Survey stream-gaging stations to provide real-time measurement of *specific conductance, pH, water temperature, dissolved oxygen, turbidity, and total chlorophyll. In addition, periodic water samples are collected manually and analyzed for nutrients, bacteria, and other constituents of concern. Regression equations then are developed from measurements made by the water-quality monitors and analytical results of manually collected samples. These regression equations are used to estimate nutrient, bacteria, and other constituent concentrations. Concentrations then are available to calculate loads and yields to further assess water quality in watersheds. The continuous and real-time nature of the data may be important when considering recreational use of a water body; developing and monitoring total maximum daily loads; adjusting water-treatment strategies; and determining high constituent concentrations in time to prevent adverse effects on fish or other aquatic life.*

The following items should be considered when selecting the list of analytical constituents to monitor at a given location (adapted from California Department of Transportation, 2000):

Project Objectives and Resources – The list of constituents selected for a monitoring program will ultimately depend upon the program objectives and available resources (personnel, funds, time).

Regulatory and Legal Requirements – Constituents specified for analysis by regulatory requirements (including NPDES permit provisions) or legal (court-ordered) requirements should be included within the list of analytical constituents.

Pollutant Sources in the Catchment Area – An assessment of land uses and known dischargers in the watershed may be necessary for defining potential pollutants to be monitored. For example, certain pesticides or herbicides are often associated with specific crops, and certain toxic compounds may be associated with particular industries (see Table 1).

Existing Monitoring Data – Appropriate databases should be searched to determine if previous water chemistry samples have been taken in the watershed. Staff familiar with the watershed should be consulted.

Constituents to Be Used for Data Interpretation – The usefulness of data generated through runoff monitoring can be enhanced by collection of additional supporting data. For example, hardness should be determined in order to effectively analyze the impact of several metals (e.g., cadmium, chromium, copper, lead, nickel, silver, and zinc), which have hardness-dependent toxicity levels and regulatory levels of concern. Additionally, the analysis of both total and dissolved metals will enable effective comparisons to water quality criteria. Temperature and pH values are needed to help assess ammonia speciation and toxicity.

Typically Monitored Constituents – If a significant number of potential problem constituents are identified or if inclusion of certain constituents is questionable, a two-phased approach may be considered. During the first phase, conduct an initial screening by analyzing samples collected from the first one or two storms (preferably storms occurring after extended dry periods) for a broad range of parameters of potential concern. Parameters not detected, or measured at levels well below concern, can be dropped from subsequent monitoring efforts (second phase).

2. Where to monitor

The size of the drainage area to be monitored, the number of tributaries in the watershed area of interest, and critical areas or sources will influence the number and location of sampling sites within the watershed. For a given sampling location, vertical and horizontal sampling position along the stream cross section must be considered.

In addition to water column sampling, measuring contaminant concentrations in stream sediments should be considered. Many toxic contaminants have an affinity for soil and other particulate matter, and stream sediments will act as a sink for those materials. Monitoring stream sediments can provide important clues to the cause and sources of water quality impairment.

In designing the monitoring study, probabilistic methods should be considered. In most cases, a well designed study will select sampling sites so that results can be extrapolated beyond the specific chosen sampling sites. There are many references available that fully discuss the pros and cons of various sample designs (Gilbert, 1987; Burton and Pitt, 2002).

3. What type of monitoring is needed

Water chemistry monitoring can be conducted using a variety of ways: manual methods, automated equipment, or continuously recording/transmitting equipment. The type of sampling used depends on the constituents to be measured as well as the expected variability in constituent concentrations with flow and depth at a given site. An ideal wet weather pollution monitoring program would use all three types of sampling to most completely characterize water chemistry. However, one or two types of sampling may be sufficient depending on the scope and objectives of a monitoring effort.

A variety of methods are available for sampling stream bottom material, and they generally can be classified as either core sampling or grab sampling. Advantages and disadvantages of the various methods are discussed in Burton and Pitt (2002). Sediment sampling design and methods are also discussed in United States Geological Survey (USGS), 2008.

Manual water sampling is often used in determining baseline conditions and is generally used for compliance and assessment monitoring. The USGS water sampling handbook (USGS, 2008) covers in detail methods for manually collecting depth and width integrated samples from streams to obtain a composite, discharge-weighted sample that is proportional to total stream flow.

Several methods are available for in-field determination of concentrations of certain constituents. Depending on project objectives and the parameter of interest, these methods can be used to reduce the overall monitoring costs.

Automated samplers are most often used for monitoring storm runoff when changes in stream discharge occur rapidly, making manual sampling too difficult, time-consuming, or dangerous. Flow varies greatly within a given storm event as well as between different events at the same site. In addition, the concentrations of various constituents behave differently; for example, Total Suspended Solids (TSS) and total phosphorus concentrations tend to track the rise and fall of the hydrograph, while PO_4-P and nitrate/nitrite-N concentrations tend to increase on the falling portion of the hydrograph. Seasonal effects, storm intensity, and the length of preceding dry periods all affect the variability of different analytes in different ways. Because of this variability, it may be necessary to monitor several events and to sample at several points in time within each event to properly characterize storm water contributions of a set of constituents. Electronic automated samplers allow samples to be collected at prescribed time or flow intervals and are generally more reliable than manual collection when specific sample intervals are required.

Mechanical samplers can be practical alternatives to electronic automated samplers. Several such samplers are cited and briefly described by Harmel *et al*. (2006). According to Harmel, these samplers have the ability to collect flow-weighted samples and estimate flow volume, thus allowing simple calculation of event mean concentrations and mass loads.

A comparison of potential advantages and disadvantages of manual and automatic sampling is presented in Table 9. Major advantages of automated samplers include the ability to use a consistent sampling procedure at multiple sites and to take multiple samples throughout the entire duration of storm runoff. Automated samplers are also able to sample within the quick hydrologic response time of small watersheds. Automated samplers do, however, require considerable maintenance and repair effort, and some manual sampling should be conducted in conjunction with the automated effort to provide for data quality assurance.

Table 9. Potential advantages and disadvantages of automated and manual wet weather sampling. (Adapted from Harmel *et al*. 2006)

Automated Sampling		Manual Sampling	
Advantages	Disadvantages	Advantages	Disadvantages
Reduced on-call travel	Large investment in equipment	Low equipment costs	Frequent on-call travel often in adverse or dangerous conditions
Multiple samples collected automatically	Samples taken at one point in flow	Vertical & horizontal integration of samples	Sample collection at numerous sites difficult to manage
Minimizes work in dangerous conditions	Difficult to secure intake in centroid of flow		Difficult to obtain samples throughout hydrograph
Numerous sites feasible			Large investment in personnel

In contrast, manual storm sampling requires trained personnel available to travel to each sampling site and collect samples, generally in less than ideal conditions. Manual sampling has the advantage of providing depth-integrated and flow-proportional samples across the stream cross-section. This produces more accurate concentration measurements than automated sampling. USGS (2008) provides guidance on manual sampling techniques.

A variety of instruments are available that allow real-time, continuous monitoring (e.g., YSI sondes). Stable and sensitive probes are available for a growing list of constituents, including water temperature, specific conductance, dissolved oxygen, chlorophyll-α, turbidity, and pH. Probes are also available for ammonium, nitrate, and soluble phosphorus, although the sensitivity of these probes should be considered before using them. For example, the chemical sensitivity of probes for ammonium may be appropriate for monitoring potentially enriched systems, such as below wastewater or CAFO facilities, but in many natural waters these probes may not be sensitive enough to be useful.

In addition to water column sampling, measuring contaminant concentrations in stream sediments should be considered. Many toxic contaminants have an affinity for soil and other particulate matter, and stream sediments will act as a sink for those materials. Monitoring stream sediments can provide important clues to the cause and sources of water quality impairment.

4. How frequently to monitor

Determining an appropriate frequency for sampling nonpoint source contributions can be a difficult task. The concentrations of different water constituents will vary depending on stream flow, storm intensity and duration, season, and the time since the last storm event. Statistical power analysis techniques should be used to determine the appropriate number of samples needed to achieve a desired precision. Those statistical techniques require estimates of the normal variation in concentrations of the analytes of interest; if sufficient historical data are not available, baseline monitoring may be necessary as part of the study plan development.

Data collection efforts generally represent a compromise between the precision needed and available monitoring resources.

5. How long to monitor

The duration of a water chemistry monitoring project depends on the purpose of the program. Reconnaissance monitoring or sampling in response to a suspected acute pollution event may occur in one day. Evaluating increasing or decreasing trends in water quality requires that data be collected over many years. Monitoring to measure water quality changes after a change in management practices requires the establishment of baseline conditions, followed by an extended period of sampling.

If the purpose of the monitoring project is to measure trends in water quality or to determine the effectiveness of BMP installation or other watershed management changes, statistical analysis should be conducted to determine the duration of the sampling period necessary. Several basic formulas are available for estimating the necessary duration of a monitoring project (Gilbert, 1987; Clausen and Spooner, 1993). A key component of these formulas is an estimate of the variance expected in concentrations of a given constituent without the variance due to any watershed change or underlying trend. Preliminary monitoring may be needed to obtain an estimate of this variance. The formulae provide an estimate of the time needed for sampling to statistically detect potential trends in constituent concentrations. Minimizing the time and sampling effort involved can be very important, both in minimizing costs of sampling and in determining whether or not implemented control practices are sufficient to meet target water quality goals.

Strategies used for water chemistry monitoring generally require a balancing of cost with the need for confidence in the data collected. It is necessary to have sufficient data to avoid false conclusions and to meet monitoring objectives, while avoiding wasteful sampling.

Acute Event Sampling

The effects of a specific event will lead to a need for water chemistry sampling if there is evidence of acute effects on stream biota. If a fish kill is apparent or unusual water conditions arise (e.g., odor, color) then an investigation will be necessary. The scope of water chemistry monitoring after an acute event is dependent on the suspected cause of the unusual conditions. Unfortunately, if the event coincides with storm discharge, any associated chemical release will most likely be gone before staff can arrive to take proper water samples. Nonetheless, it is important to be prepared to collect samples in a timely manner and that those samples are analyzed for any likely causative agents and any other unusual constituents that may be associated with the suspected source.

The most efficient and effective sampling plan for such events would rely on field staff to collect sufficient appropriate water samples promptly after notification. This would require that all field staff be properly trained in appropriate methods and techniques, that proper sampling equipment and supplies are available, and that laboratory support is available within holding time limits. Staff time for such sampling will, in most cases, take a maximum of one day. Training should occur on a regular basis to reinforce the concepts behind sampling in a scientific manner in order to provide defensible data.

Chronic/Long-Term Monitoring

In general, the high variability of chemical constituents in wet weather pollution discharges means that long-term intensive studies are necessary in order to detect trends or evaluate implementation of BMPs or changes in watershed management. Because such monitoring of chemical constituents can be very expensive, it is often more cost effective to track changes in physical or biological characteristics instead. As an alternative, in some cases surrogate measurements can provide reasonable estimates of particular analytes of interest.

An intensive water chemistry survey may necessitate the installation of one or more automated samplers to properly characterize storm water runoff. Automated samplers require periodic regular maintenance for cleaning and battery replacement, as well as sample retrieval during or after storm events. Installation of one or more real-time recording sensors may be necessary instead of, or in addition to, automated samplers. Recording samplers will generally require at least weekly maintenance and data retrieval (assuming data are not transmitted as generated). In addition, water samples will need to be taken manually on a regular basis to provide baseline data and for QA/QC purposes.
Law *et al*. (2008) provide cost estimates for various wet weather water quality monitoring studies. The cost for a paired watershed water chemistry monitoring study, including planning, equipment, implementation, data management, and reporting was estimated to cost a minimum of $250,000. The example study plan included the use of two ISCO automated samplers and a monitoring period of four years. A breakdown of estimated staff time (based on Law *et al*. 2008) is presented in Table 10. This provides a reasonable estimate of the time involved in planning and conducting a good long-term study.

Table 10. Estimated Level of Effort Required for Paired Watershed Study

Project Planning and Management			200 hours/yr
Implementation			
	Monitoring	2 staff x 200 hr/yr	400 hours/yr *
	Data Management/Evaluation		100 hours/yr
Reporting			250 hours

* - does not include travel costs

Section 4. Guidance for Monitoring Wet Weather Discharges other than those Covered by the MS4 Watershed and Jurisdictional General Permits

The Department needs to periodically monitor the quality and quantity of individual wet weather pollution discharges to help support the following program needs:

- Identify wet weather pollution discharges that are contributing to water quality impairment of specific Michigan surface waters; or inhibiting specific Michigan surface waters from achieving their fullest water quality potential.

- Evaluate whether wet weather pollution discharges are complying with the effluent limitations and/or monitoring requirements set forth in NPDES permits or other relevant control documents.

- Support the accurate selection of BMPs or other treatment techniques to eliminate or control water quality and water quantity problems caused (or potentially caused) by specific wet weather pollution discharges.

- Evaluate the effectiveness of specific BMPs or other treatment technologies being selected (or contemplated) for wet weather pollution discharges.

- Support wet weather pollution discharge-related enforcement actions.

To fulfill any of these program needs, it is critical that wet weather pollution discharge monitoring studies be carefully planned to ensure representative samples are efficiently collected and analyzed for relevant pollutants using appropriate methods. Data quality objectives, sampling points, sample collection procedures, analytical techniques, data interpretation, data quality and corrective action controls, reporting, and data management practices should be documented in a QAPP or other comparable document consistent with WB Policy/Procedure #008 (Quality Assurance Planning for Environmental Data Collection). The preparation and approval of this document should occur prior to actual sample collection, except in rare circumstances when immediate sampling of a wet weather pollution discharge is necessary (e.g., pollution control response).

The selection of target analytes should be based on a careful review of the activities on land that cause or have the potential to influence the quality and quantity of a wet weather pollution discharge. In a BMP effectiveness monitoring study only the pollutant(s) (or an indicator of those pollutants) expected to be affected by the implementation of a BMP(s) should be monitored. Depending on the parameter(s) of interest, wet weather pollution discharge samples can be collected by either automated or manual sampling. When possible, samples collected using programmable automated samplers are preferred. Flow stratified sampling designs allow the best determination of pollutant loading, but such sampling approaches require considerable flexibility on the part of the sampling crews. Grab samples must be used for some pollutants (i.e., *E. coli*) in wet weather pollution discharges, due to sample holding and laboratory analysis holding time requirements. Grab samples must also be used for oil/grease and volatile organics.

Wet weather pollution discharges that enter surface waters diffusely, rather than through a pipe or outfall, usually require that lead investigators devote special attention to identifying representative sampling points and developing special sample collection procedures. In some cases, weirs need to be constructed to accurately measure the flow and/or quality of a wet weather pollution discharge. For example, to effectively monitor phosphorus reductions in runoff from agricultural lands in the Conservation Enhancement Reserve Program (CREP), the lead investigator took special precautions to identify channels and furrows that were transporting wet weather pollution runoff to adjacent receiving waters (MDEQ, 2008). A special sampling device was also developed by the lead investigator to capture the “first flush” runoff from the CREP-treated agricultural lands for subsequent nutrient and solids analysis.

When necessary and possible, the timing, frequency, and duration of sample collection should support accurate calculation of the **event mean concentration** of a wet weather pollution discharge. This calculation usually requires several sample measurements taken over an entire discharge event. It is important that at least some of these samples be taken during the rising limb of the hydrograph. Especially for land runoff-type discharges, the event mean concentration is best determined when at least 10 measurements of the runoff are taken over the duration of a storm event with a depth of at least 0.25 inches within a 24-hour period. However, the WWMWG recognizes that fewer discharge samples may need to be sufficient given the Department’s budget constraints.

To fulfill the sampling demands of a viable wet weather pollution discharge monitoring study, Department sampling crews must be flexible enough to sample wet weather pollution discharges at inconvenient times and for extended periods. This requirement of wet weather pollution discharge sampling presents unique time reporting issues (e.g., overtime payment, compensation time accrual, and schedule adjustment practices) that demand the attention of Department managers and the Department of Management and Budget, Office of Human Services. It has proven to be easier and more efficient to conduct a significant part of the field work component of wet weather pollution discharge monitoring studies using private contractors. Nevertheless, Department contract administrators need to remain intimately involved with the study design, data analysis, data interpretation, data reporting, and data management components. Regardless of whether wet weather pollution discharge sampling is performed in the field by the Department or its contactors, sampling crews should consist of no less than two persons for safety considerations alone. The WWMWG recommends the Department dedicate at least 1.0 full-time equivalent (or equivalent contractor support funding) and associated analytical/equipment/supplies to wet weather pollution discharge monitoring each year. According to the UM wet weather benchmarking report, several states (including Minnesota and Washington) have found it necessary to enhance their respective monitoring budgets to better respond to wet weather pollution needs.

Whenever available, United States Environmental Protection Agency (USEPA) approved methods should be used to measure specific pollutants in wet weather pollution discharges. If multiple USEPA approved analytical methods exist for a pollutant, method selection should be based on a method’s ability to measure the target pollutant at its environmentally significant level.

Finally, the Department (and contractor) personnel with wet weather pollution discharge monitoring responsibilities must be provided adequate training to ensure discharge samples are collected, preserved, and analyzed correctly. The training program also should cover the basics of monitoring study design and review the components of QAPPs. Part of the training should take place in the field, so trainees can work side-by-side and interact with persons that have considerable expertise and experience designing and conducting wet weather pollution discharge monitoring studies. The WWMWG recommends that such training workshops be held periodically in each relevant MDNRE district office.

Section 5. Recommendations of the Wet Weather Monitoring Work Group

During its deliberations, the WWMWG identified and concurred on several aspects of the Department's current permitting, field operations, and monitoring programs that should be enhanced or improved to better protect Michigan's surface waters from wet weather pollution discharge-induced stress. The lists of recommendations are prioritized for implementing program improvements and are divided on the basis of feasibility (Tier 1 being of high priority and Tier 3 being of low priority).

Tier 1 Recommendations

1. Enhance the Water Quality Data Exchange (WQX) and the Michigan Surface Water Information Management (MiSWIM) system to allow internal and external users to easily locate, separate, and statistically analyze wet weather pollution ambient data that have been (or will be) collected by the Department, its contractors, grantees, local watershed management organizations, and even permittees. Relevant and appropriate metadata should be included in these databases to facilitate better use and statistical analysis of the wet weather pollution ambient data. (See Section 1 of this report for more information regarding this recommendation.)

2. Develop a GIS-based, interactive database to house wet weather pollution discharge data that are collected by the Department, its contractors, grantees, and permittees. This database should include relevant and appropriate metadata to complement the target analyte information. (See Section 1 of this report for more information concerning this recommendation.)

3. Enhance the Department's staff report storage and retrieval system to provide users better access to wet weather monitoring staff reports.

4. Sufficient personnel, laboratory services, and equipment/supplies should be provided to the WB, Field Operations Division and SWAS to fully support the design and implementation of viable wet weather pollution discharge and ambient water monitoring studies. (See Sections 3 and 4 of this report for more information regarding this recommendation.)

5. A comprehensive training program for all staff with wet weather pollution discharge or ambient water monitoring responsibilities should be developed. This training program should include classroom and field components to ensure participants are exposed to the basic concepts of water quality monitoring study design, QAPPs, correct sample collection/preservation and analytical procedures, data management and reporting expectations, Michigan's WQS, and Michigan's Assessment Methodology. (See Sections 3 and 4 of this report for more information concerning this recommendation.)

6. The Department staff with wet weather pollution discharge or ambient water monitoring responsibilities should be required, as part of their individual training program, to read relevant parts of the following literature: Stormwater Effects Handbook, A Toolbox for Watershed Managers, Scientists, and Engineers (Burton and Pitt, 2002); Monitoring to Demonstrate Environmental Results: Guidance to Develop Local Stormwater Monitoring Studies using Six Example Study Designs (Law *et al*., 2008); Receiving Water Impacts Associated with Urban Runoff (Pitt, 2002); Guidance Manual: Stormwater Monitoring Protocols (California Department of Transportation, 2000), and

WB Policy/Procedure #008 (Quality Assurance Planning for Environmental Data Collection).

7. Water quantity should be further recognized by the Department as a key factor that can degrade the physical habitat and biological condition of surface waters of the state. Additional tools and processes need to be developed to better address this problem. (See Sections 2 and 3 of this report for more information concerning this recommendation.)

8. Effective communication and coordination is necessary between designated staff from the Field Operations Division and SWAS in the planning and implementation phases of wet weather ambient water monitoring studies. It is imperative that ambient water monitoring activities be closely linked and adjusted, as needed, to reflect the actual land management practices and weather conditions that occur in the targeted watershed. (See Section 3 of this report for more information regarding this recommendation.)

Tier 2 Recommendations

9. Physical measurements and observations are a particular data management problem for the Department; since neither the WQX nor the NSWQD accept channel morphology data. These measurements/observations are usually recorded on field forms, and later transcribed into spreadsheets or other electronic records. In addition, channel transect and pebble count data (and longitudinal profile data if collected) may be processed and stored in the Ohio Department of Natural Resource's geomorphic data processing spreadsheet (Mecklenburg, 2006). This spreadsheet calculates particle size distributions, bank full dimensions including cross-sectional area, channel slope, and other parameters derivable from stream dimension measurements. RIVERMorph® software is another data processing and storage option for physical measurement data. A more formal database for physical parameters, specific to the Department, should be developed.

10. Improved communication between the SWAS/District Offices and the MDNRE, Environmental Laboratory, is needed to facilitate timely sample analyses. (See Section 3 of this report for more information regarding this recommendation.)

11. Expand and/or enhance the use of physical measurements in the Department's water quality monitoring program. Unnatural changes in the channel morphology of Michigan's rivers and streams should be routinely monitored to ensure the timely selection and application of appropriate BMPs. Trend monitoring for physical parameters should also be considered for inclusion in the Department's ambient water quality monitoring program (Table 11). (See Sections 2 and 3 of this report for more information concerning this recommendation.)

Table 11. Recommendations for a Long-Term Wet Weather Effects Monitoring Program.

Parameter	General Outline	Approximate Level of Effort
Cross-channel transect and pebble count	Measure at 5-10 stations per watershed, in selected watersheds according to the five-year rotating basin cycle; repeat same stations each time; place stations in: (a) rapidly developing areas; and (b) stable reference reaches	Crew of 2, 5-6 weeks a year
Stream flashiness	Update with new gage data, every five years (next update in 2012)	Performed by Land and Water Management Division staff

12. The Department should begin contributing wet weather pollution discharge data to the NSWQD. (See Section 1 of this report for more information regarding this recommendation.)

13. The Department should consider developing guidance for MS4 permitted communities to demonstrate how ambient monitoring can be used to meet MS4 major discharge point permit requirements. (See Appendix A of this report for more information concerning this recommendation.)

14. Wet weather pollution dischargers should be required to bear more of the pollutant characterization burden for their respective discharges through the inclusion of monitoring requirements in NPDES permits and other control documents issued by the Department. The Department does not have the analytical or monetary resources to bear this responsibility alone. It would be worthwhile to require the permittees to submit their wet weather pollution discharge data in an electronic format that is compatible with the wet weather pollution discharge database recommended in #1 above. (See Section 1 of this report for more information regarding this recommendation.)

Tier 3 Recommendations

15. The Department should consider establishing a working relationship with a biostatistician for future collaboration on study design and data analysis issues. (See Section 3 of this report for more information regarding this recommendation.)

16. The Department should investigate options (and associated costs) for securing low level taxonomy capability for certain biological samples. Low level taxonomy is sometimes required to effectively assess the more subtle environmental impacts of wet weather pollution discharge events and evaluate the effectiveness of BMPs. (See Section 3 of this report for more information concerning this recommendation.)

17. The Department should consider the use of dedicated staff to design and conduct wet weather monitoring projects. The dedication of certain staff to wet weather monitoring will increase efficiency and facilitate improved study designs. (See Section 3 of this report for more information concerning this recommendation.)

18. The Department should develop a generic wet weather ambient monitoring study plan and/or QAPP for acute wet weather pollution discharge events that require a rapid response. (See Section 3 of this report for more information concerning this recommendation.)

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Appendix A

Storm Water Sampling Guidance for Total Phosphorus and *E. coli*

Introduction

National Pollutant Discharge Elimination System (NPDES), Municipal Separate Storm Sewer System (MS4) permits require regulated public entities located within urbanized areas that discharge storm water from an MS4 to a water body designated with a Total Maximum Daily Load (TMDL) to demonstrate progress toward meeting Water Quality Standards (WQS). When a lake or stream does not meet WQS, the Federal Clean Water Act requires that a TMDL be developed. Studies shall be completed to determine what is impacting the water body and to develop goals so the water body can meet the standards. A TMDL describes the process used to determine how much of a pollutant a lake or stream can assimilate and sets pollutant reduction targets for that water body. If the TMDL was written for *E. coli* or Total Phosphorus (TP), the MS4 permits further require permittees to collect representative samples of storm water discharges from their regulated MS4s to those water bodies.

Specifically, the MS4 permits state:

"Within three years of COC issuance, the permittee shall take at least one representative sample of a storm water discharge from at least 50 percent of the major discharge points discharging directly to surface waters of the state within the portion of the TMDL watershed in the urbanized area. A major discharge point is a pipe or open conveyance measuring 36 inches or more at its widest cross section. At a minimum, the sample shall be analyzed for (*E. coli* or Total Phosphorus).

The permittee shall use these results and other available information, which may include results from a well-designed ambient monitoring program, to develop and prioritize actions to reduce the discharge of (*E. coli* or Total Phosphorus) to be consistent with the TMDL. These prioritized actions shall be reported to the Department in the second progress report, with implementation targeted during the five-year permit cycle that begins in 2013."

This guidance document details the essential elements of a wet weather monitoring study design which will provide an accurate representation of the storm water discharge from the MS4 to address TMDL concerns and meet permit requirements. The guidance consists of two parts detailing different strategies for conducting a wet weather monitoring program. Part One of this guidance walks MS4 permittees through a comprehensive study design that involves multiple sampling over a variety of storm events and is focused on getting the best quality data to define representative wet weather pollution discharges. Part Two provides a basic study design for sampling a single storm event as required by the MS4 permits. These recommendations should be viewed as an 'ideal', to guide the development of a high-quality monitoring plan. This guidance may present logistic and budgetary challenges if fully implemented. It is recognized that a final monitoring program will have to balance the need for accurate and representative data with available resources, and that reduced efforts may be necessary.

Because storm water discharge quality may vary widely, a monitoring plan aimed at defining a 'representative sample' needs to encompass the normal range of conditions with the expectation that those storms are generating the normal range of runoff conditions. A representative sample, as considered in this document, is a suite of samples assumed to characterize discharge quality over a range of seasons, storm size, and storm duration (see Selection of a Storm Event for Monitoring for additional discussion).

Without knowing the normal range of storm water discharge quality under a variety of conditions, permittees who opt for the single-sample monitoring plan run a significant risk of generating data that fails to capture the realistic range of variability of the parameters of concern in the discharge, and is therefore unlikely to be truly representative. The permittee will then be left with unreliable data upon which future decisions and actions will be based. Additionally, it should be recognized that if single sample monitoring is conducted (Part Two), any subsequent questions or doubt with regard to data reliability for *any* portion of the data should be viewed as doubt for *all* data collected.

A detailed study design carefully considers sample site location, sample collection numbers, collection methods, quality control procedures, and data interpretation ensuring the success of a wet weather pollution monitoring program. While more time consuming and costly up front, investing in a comprehensive monitoring plan, as described in Part One, will result in a more accurate, representative, and confident characterization of the storm water discharge, upon which future decisions can be based. The monitoring results will help permittees make sound storm water management and land use decisions and prioritize potentially expensive and intensive actions necessary to make progress towards meeting WQS in TMDL areas.

It is recognized that the Part One guidance often recommends actions that are scientifically sound, but in practicality may be difficult to achieve in some instances. It will be up to the individual communities using the Part One guidance to understand the goals of their monitoring strategy and make all practical efforts to gather the highest quality data that they reasonably can. The Department is available for input or review if there is a need to scale back monitoring from the guidance goals laid out in Part One.

Michigan has two NPDES permitting options for discharges from MS4s: the Watershed Permit (MIG610000) and the Jurisdictional Permit (MIS049000). Both permits allow an alternative approach to address the TMDL requirement. Under the alternative approach option, an existing monitoring plan, with prioritization and pollutant controls, can be submitted to the Department for approval.

In addition, the Watershed Permit also allows an "Elective Option" (Part I.A.4.b.1)c)). The Elective Option requires a collaborative effort with other watershed partners to implement a monitoring program based on minimum design elements which are defined in the permit. The Department recommends that permittees who opt to pursue the Elective Option use Part One of this document to develop the collaborative monitoring program. More information on the alternative approach and elective option can be discussed further with Department District staff on a case by case basis. Keep in mind, the Department is available for consultation and input on monitoring plans as needed.

Finally, this document was not developed for Illicit Discharge Elimination Programs (IDEP), which require dry-weather screening. There are considerable guidance documents already available for such activities. However, that does not mean these two program components are not interconnected. Therefore, the Department recommends that, where feasible, both the wet and dry weather monitoring programs work together to effectively reduce the discharge of pollutants from MS4s to waters of the state. Additionally, much of this guidance is also applicable to wet weather pollution discharge types and pollutants other than those covered by the MS4 jurisdictional and watershed general permits.

Goals and Challenges of a Wet Weather Monitoring Program

The primary goal of monitoring is to quantify pollutants in wet weather pollution discharges to waters of the state with approved TMDLs. The data are used to understand which discharge points, and their associated catchments (area drained), are most likely to contribute the pollutants of concern within the TMDL watershed. After the initial study, additional monitoring upstream may be necessary to further identify sources, or there may be enough information to effectively develop and prioritize actions to reduce the pollutants of concern.

Monitoring storm water discharges presents many challenges:

- Rain events, and timing and volume of runoff, are highly variable.
- Pollutant concentrations can be highly variable, so a number of samples (and therefore chemical analyses) are required to characterize storm water quality
- Runoff events often occur at inconvenient times (e.g. Sunday at 2:00a.m.).
- Runoff events are difficult to predict, resulting in “false alarms” for monitoring staff.
- Sample collection can be physically difficult, depending on the situation.

Despite the challenges, a well-designed monitoring program can be invaluable for achieving goals, such as:

- Identifying the source(s) of pollutant loads to streams and lakes.
- Assisting in the selection and design of storm water best management practices (BMPs).
- Assessing the effectiveness of storm water treatment practices.

Part One

This section describes recommendations for conducting a comprehensive assessment of storm water quality including the collection of multiple wet-weather samples from individual MS4 storm water discharge points. The recommendations are in operational order and are intended to be executed in that order. Additional information on storm water sampling can be found in Law *et al*. (2008), especially under *Design 1 – Quality of Storm water at the Outfall*.

1. Selection of Discharge Points

The selection of discharge points for sample collection is a multi-step process that involves desktop analysis and site visits. Utilization of land use maps, topographic maps, watershed plans, high resolution aerial photographs, and storm water sewer system maps -- aided by GIS -- can greatly reduce the amount of field work necessary for the site selection process. Locations may also be prioritized based on existing ambient monitoring data or on information gathered as a result of illicit discharge investigations. An ambient monitoring program aimed at systematically sampling relevant portions of the TMDL watershed or upstream drainages may help to inform and focus discharge point monitoring. Reaches or tributaries for which ambient data has demonstrated elevated levels of the parameter of concern can be given a higher prioritization when developing a monitoring program for MS4 wet-weather discharges.

A. **Determine scope of the monitoring area.** Certificates of Coverage (COC), issued under the General MS4 Permits, will identify the specific TMDL(s) the permittee shall address. At a minimum, the monitoring area shall include the TMDL reach and contributing watershed within the urbanized area. However, any sections of the TMDL reach and contributing watershed outside the urbanized area should also be included in a comprehensive monitoring plan. Information on a specific TMDL can be found at: www.michigan.gov/deq. Click on the 'Water' tab, then 'Water Quality Monitoring', then 'Assessment of Michigan Waters', then 'Total Maximum Daily Loads

B. **Locate the MS4 discharge points that discharge to the monitoring area.** To identify all discharge points, regardless of size, it is recommended that storm sewer system maps and as-built drawings of storm water infrastructure be reviewed, interviews with public works personnel and facility staff be conducted, and field inspections be performed. The MS4 permits define a discharge point as any location on the MS4 owned or operated by the permittee that discharges directly to a surface water of the state, or that discharges to any other separate storm sewer system before discharging to a surface water of the state. In some instances, the identified TMDL reach may also be a MS4. This can occur when the TMDL reach, a surface water of the state, is also a designated county drain (a MS4). In these cases, the County agencies should identify their MS4s which discharge into the TMDL reach, even if that reach is also considered their MS4. A surface water of the state includes the Great Lakes and their connecting waters, all inland lakes, rivers, streams, and wetlands.

C. **Determine catchment characteristics of the identified discharge points**. Characteristics to identify include (in part from Law, 2008):

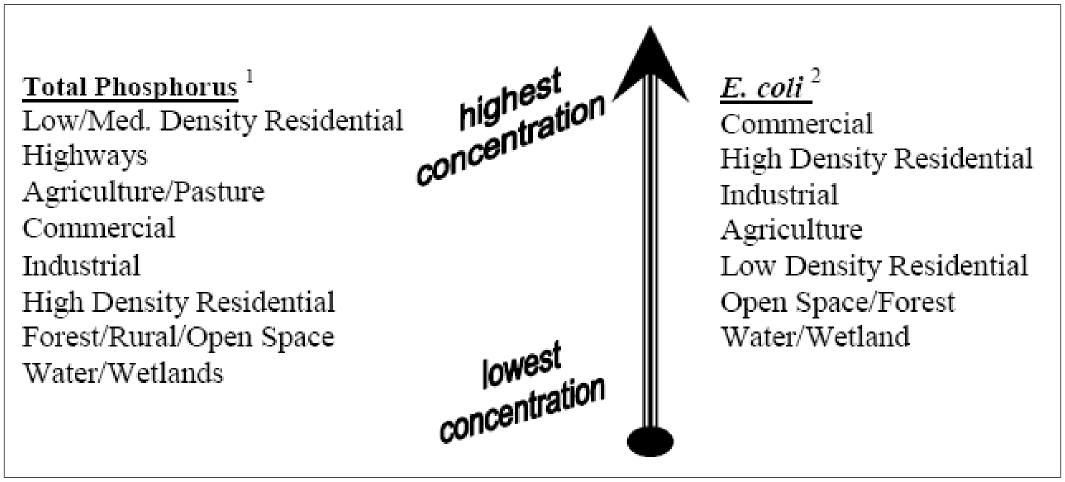
- Catchment size and boundaries
- Predominate land use type and distribution across catchment
- Land cover distribution (e.g. percent impervious cover, forest, wetland)
- Type of conveyance (open or enclosed channel; curbs and gutters or swales)
- Development characteristics (e.g. age, traditional versus low impact)
- Presence and type of storm water treatment practices
- Discharge point cross-section
- Age and maintenance of BMPs

D. **Develop a prioritized list of catchments to target for monitoring**. The following criteria should be considered:

- Catchments with higher potential to generate pollutants of concern based on land use. Figure 1 shows a ranking of urban land uses with regard to potential TP or *E. coli* discharge concentrations[1, 2].
- Age of development (older areas have a higher potential for illicit discharges) and age/maintenance of BMPs.
- Previous Illicit Discharge Elimination Program (IDEP) data.
- Specific local information. For example, golf courses may discharge high phosphorus while areas with known failing septic systems may contribute *E. coli*.
- Site conditions that may affect sampling include adequate safe access for sampling and housing equipment with a minimum potential for vandalism.
- Discharge points that are in close proximity to each other for sampling efficiency.

Ultimately, the prioritized list should be based upon the likelihood of the land use, or catchment, to contribute the pollutant of concern and its dominance in the monitoring area.

Figure 1. Ranking of urban land use potential to discharge TP and *E. coli*.



1. TP from research by the Rouge River National Wet Weather Demonstration Project, Technical Memorandum RPO MOD TM34.00.
2. *E. coli* from Purdue University's L-THIA Basic Model for relative fecal coliform loadings based on land use; cobweb.ecn.purdue.edu/runoff.

E. **Determine the number of discharge points to be sampled.** Since the number of discharge points can vary from less than 10 to hundreds, it is not practical to recommend a specific number to sample. The sample size of discharge points should be sufficient to understand storm water characteristics from all potential sources to the TMDL reach.

General recommendations for choosing sample sizes and their distribution include:

- The permit requires sampling a minimum of 50 percent of major discharge points (≥ 36"). It is recommended that smaller discharge points also be sampled, particularly if they drain land uses thought to be major pollutant sources.
- Sampled discharge points should represent catchments in which one land use predominates (ideally > 80 percent). If the jurisdiction covered by the permit is large, and contains multiple catchments with similar land uses, sample several discharge points for each major land use type. If such homogenous catchments can be identified, data from a subset of them can be extrapolated to other, similar catchments.
- Stratified random sampling can be used to select sampling sites, as described in the following steps:

1. Divide the jurisdiction into catchments with distinct dominant land uses (the 'strata'; first column in Table 1).
2. Number each discharge point in each strata (second column).
3. Select enough random numbers (in Excel or other random number generator) for <u>each</u> land use strata to identify the desired number of discharge points to be sampled (third column). The number of random numbers (= samples) selected for each strata should

be proportional to the number of discharge points in each strata compared to the total number of discharge points; e.g., if 30 percent of the total discharge points occur in Industrial catchments, approximately 30 percent of the samples should be allocated to the Industrial catchments.

Table 1. Example of Using a Stratified Random Design to Select Sampling Sites.

Catchment & Land Use	Discharge Points	Randomly Generated Numbers for Each Land Use (= Discharge Points to be Sampled)
High Density Residential #1	HDR 1 HDR 2 HDR 3 HDR 4	2, 3, 6, 7 (So sample HDR 2, HDR 3, HDR 6, & HDR 7)
High Density Residential #2	HDR 5 HDR 6 HDR 7	
Commercial	C 1 C 2 C 3	2 (So sample C2)
Industrial #1	IND 1 IND 2 IND 3 IND 4	1, 3, 4, 8 (So sample IND 1, IND 3, IND 4, & IND 8)
Industrial #2	IND 5 IND 6 IND 7 IND 8	
	Total = 18 (50 percent = 9)	Number of discharge points sampled = 9

See Gilbert (1987) for additional details on stratified random sampling.

F. **Determine the sample collection technique.** The sample will be from the storm water, at or before the discharge point, not ambient waters after the discharge mixes with the water body. Storm water samples can be collected by either automated sampling or manual sampling. Automated sampling, in which samples are collected using programmable automated samplers ("auto-samplers"), is preferred for most monitoring programs, especially in larger catchments. There are several options for collecting samples with auto-samplers (NRC, 2008); however, flow-weighted composite sampling is the recommended method for storm water. Flow-weighted composite sampling yields a single sample for analysis, whose concentration is the Event Mean Concentration (EMC).

Manual "grab" sampling, in which samples are collected by filling sample bottles by hand, is usually not recommended for storm water sampling for logistical reasons; the necessary sampling frequency (see below) is very labor-intensive and limits the number of stations that can be sampled, and the increased number of samples greatly increases analytical costs. However, manual sampling may be necessary for certain pollutants which cannot be collected using automated samplers due to cross-contamination concerns; these include bacteria, oil and grease, and volatile organic compounds.

Manual sampling across the hydrograph is also the only way to assess pollutant discharge dynamics (e.g., first flush vs. peak flow discharges), and if this is a goal of the sampling program, a flow-weighted EMC can be calculated from manual sample data. If manual sampling must be performed, the following is recommended:

- Record the water level at each station during each sampling period.
- Collect at least 6 samples at each station during a rain event; 2 or more during the beginning of the storm, 2 or more near peak flow, and 2 or more after peak flow. Since hydrograph timing cannot be known during runoff, it is often necessary to collect additional samples that are discarded after runoff is complete.
- Pollutant concentrations are sometimes highest at the beginning of runoff (first flush). This is often true for small catchment areas of less then 400 acres and especially in smaller, paved areas (Law et. al., 2008) as well as for commercial and industrial land uses (NRC, 2008), but not so in larger catchments where the highest pollutant loads are normally observed during peak flow. If first flush data are desired, collect samples within the first 30 minutes to 1 hour of the start of runoff.

Like samples collected by auto-samplers, grab samples can be analyzed individually (the most appropriate method for *E. coli*) or combined to create a flow-weighted composite (appropriate for TP and other constituents). Additional information on automatic and grab sampling or flow and precipitation monitoring can be found in the California Department of Transportation guidance manual (2000).

It should be noted that if submerged discharge points are to be sampled, it may be necessary to use the nearest up-pipe manhole access, provided there are no concerns for additional pollutant input between that point and the discharge point.

G. **Determine the sampling period duration.** Given the variability of all storms, data from a single runoff event are of very limited use. For many study purposes it is desirable to sample at least 5 to 10 runoff events of varying intensities and durations, spread over the seasons, which can equate to at least 1 or 2 years of sampling effort. In addition, some pollutants exhibit roughly predictable season patterns (e.g., chloride inputs in the late spring, or coliform bacteria during the summer and fall), which should be accounted for. Regardless of the sampling program, it is essential that monitoring be conducted by competent personnel who understand safety issues, environmental sampling, and will ensure data collected are reliable, and of acceptable quality.

2. **Other Data Needs**

Rainfall and Flow. To determine the minimum amount of rain that will cause a runoff event, and therefore what minimum storm event can be sampled, it is recommended that historical precipitation records be reviewed early in the process to provide a basis upon which to establish targets for sampling.

Monitoring rainfall amounts can be accomplished a number of ways ranging from establishing a network of inexpensive graduated “direct reading” rain gauges throughout the MS4 watershed that can be maintained by competent volunteers to establishing self-recording electronic “tipping bucket” rain gauges that enable computerized uploads. Permittees should be mindful that there may already be established gauges that can be used throughout a watershed at schools, colleges/universities, news station weather departments, and citizen-based weather station networks, among others. Regardless of the approach used, it is important that information be collected on a scale fine enough to have some confidence in the amount of rainfall that fell in a discharge point's catchment.

Rain gauges should be as close to the sampled catchments as possible, and in larger monitoring areas multiple rain gauges may be necessary. For a small watershed, a recording gauge would be best. But, if the sampling points are dispersed and resources are limited, at least three manual rain gauges should be used (National Research Council, 2008). Ideally, several locations throughout the sampling area should be used and compared to a recording gauge.

Flow should also be measured or estimated at each water sampling location. Similar to water sample collection, flow monitoring can be performed manually or with automated equipment. The lack of flow data can greatly hinder the resulting assessment and interpretation of the sampling information collected (National Research Council, 2008).

3. Selection of a Storm Event for Monitoring

The goal of representative monitoring is to establish an understanding of storm water quality under a typical range of wet-weather conditions. Consequently, some guidelines should be used to define when sampling crews prepare and when sampling should begin. While this guidance attempts to define conditions under which MS4 discharge points are likely to discharge, there will be times when permittees have a better understanding of local conditions and how their systems respond to rain.

As a general guide, sampling should only occur following a dry period of 72 hours or more. Additionally, it is recommended that a storm of 0.25 inches or more within a 24-hour period be used as a minimum for sampling. A range of storm events (size and duration) will help establish the expected discharge quality, with the focus on the typical range of storms seen annually. Unusually heavy or severe storms similar to a 100-year 24-hour event may not be sampled at all and very common small rain events (e.g. < ½ inch) should not be over-represented in a sampling plan with the goal of understanding discharge quality over a range of conditions. .

Ideally, if local rainfall is, or can be, divided into categories that represent rain depth, rain intensity, seasons, and/or dry periods, the use of stratified random sampling of storm events is recommended. A sufficient number of representative storm events under each of those categories need to be sampled.

If possible, an open line of communication or collaborative agreement should be established with local weather monitoring source to aid in forecasting incoming storms and screening them for potential monitoring events. A reliable source of storm tracking and forecasting will help reduce the number of 'false starts' for monitoring crews when a storm doesn't fully form or doesn't produce enough rain to generate a discharge event.

In *Monitoring to Demonstrate Environmental Results: Guidance to Develop Local Storm water Monitoring Studies Using Six Example Study Designs* (Law, 2008) it is mentioned that at least two years of monitoring is needed to get about 20 to 30 representative wet weather pollution events. In addition, it was noted that samples from about half of the storm events have the potential of being discarded due to unexpected conditions and sampling errors.

4. Analytical Methods

Analysis of all samples should be conducted by well-trained, competent staff in a laboratory with rigorous quality assurance and quality control procedures. In some communities, the local publicly owned wastewater treatment facility may have such a laboratory that is able to analyze samples at a reduced cost.

A. **Total Phosphorus (TP):** The recommended method for measuring TP is EPA Method 365.4 – Automated Colorimetric Block Digester method. A copy of this method is available at: www.epa.gov/waterscience/**methods/method**/files/365_4.pdf. Alternate methods that achieve the same detection limit and range of 0.01 to 20 milligrams per liter (mg/L) are also acceptable. Test kits for TP should not be used, as their detection limit (~ 1 mg/L) is too high.

i. **Quantification Limit for Total Phosphorus**. The analytical method for TP cited above has several variations, some of which have different quantification limits (the lowest concentration of phosphorus that can be reliably quantified). A quantification limit of 0.01 mg/L – equivalent to 10 micrograms/liter (µg/L) -- is most suitable for identifying elevated phosphorus in storm water. Not all analytical laboratories achieve this quantification limit. Therefore, this needs to be confirmed when choosing a laboratory. Higher quantification limits (20-50 µg/L) may be acceptable depending on study objectives.

B. ***E. coli:*** Two methods are recommended for measuring *E. coli*:

i. **EPA Method 1103.1** -- Membrane filtration using mTEC agar -- is available from: http://www.epa.gov/waterscience/methods/method/biological/

ii. **The Colilert procedure** is available on the IDEXX web site: http://www.idexx.com/water/colilert/moreinfo.jsp

The pros and cons of the *E. coli* analyses include:

i. EPA Method 1103.1:

- More expensive, and requires a more highly trained operator
- More accurate for highly contaminated samples
- Yields fewer “too numerous to count” results

ii. Colilert:

- Cheaper, and can be performed by less experienced personnel
- More accurate for less contaminated samples
- Maximum value = 2,400 colonies/100 mL, unless sample is diluted

5. Quality Control Procedures

Preparation of a Quality Assurance Project Plan (QAPP) is always a good idea prior to sample collection, and may be required depending on the monitoring program funding source. A QAPP provides a detailed framework for deciding how data will be collected to achieve specific objectives, and describes the procedures that will be implemented to obtain data of known and adequate quality. EPA provides guidance on preparing QAPPs, which is available at http://www.epa.gov/QUALITY/qapps.html

Several important aspects of sampling quality assurance are outlined below.

A. **Sample preservation and hold times.**

i. ***E. coli*** samples should be immediately placed on ice. The hold time for *E. coli* – from the time the sample is collected until the start of analysis -- is 6 hours. This can be significantly limiting. Samples shall be delivered to the laboratory within this 6 hour window for the subsequent data to be useful.

ii. **Phosphorus** samples are preserved in the field with sulfuric acid, to a pH of 2, and placed on ice. Preserved samples shall be refrigerated at 4 °C in the lab, for no more than 28 days prior to analysis.

B. **Duplicates and blank samples.** Precision and accuracy of sampling are accounted for partly through sampling of duplicates and blanks.

i. **Duplicate samples** are simply a second sample collected as close in space and time to the initial sample as possible. Field duplicates can be collected by holding two bottles in the discharge stream simultaneously, or by filling the two bottles within a few seconds of each other. Typically a duplicate is collected for every 20^{th} sample.

a. The precision target for TP duplicates is a relative percent difference (RPD) between the two values of ≤ 20 percent. RPD is calculated as follows:

[(difference of the two values)/(mean of the two values)] x 100%

b. The precision target for *E. coli* duplicates is calculated differently, and the latest edition of *Standard Methods for the Examination of Water and Wastewater* should be consulted for details.

ii. **Blank samples** do not have to be collected if the discharge samples are collected directly into the bottle that will be submitted to the lab. If the sampled discharge is collected with a sampling device in one bottle and then poured into another bottle, it is necessary to collect a field blank to check for cross-contamination, and to decontaminate the sampling device between samples. Decontamination procedures are:

a. <u>Total phosphorus</u>: Rinse the sampling device 3 times with distilled water before collecting a sample at a new station.
b. <u>*E coli*</u>: Rinse the sampling device with a 10 percent bleach solution, followed by 2 rinses with distilled water, followed by 2 rinses with "station water" (the water to be sampled next).

A blank for TP is generated by rinsing the sampler four times with distilled water and collecting the fourth rinse in a sample bottle for analysis. A blank for *E. coli* is generated by rinsing the sampler three times with distilled water and collecting the third rinse for analysis. If a blank is desired for sample bottles used to directly draw samples, rather than collecting in a sampling device first, distilled water is used as the blank.

The optimal precision targets for blanks is a value less than the method detection limit for TP (usually 0.01 mg/L), and less than 10 colony forming units per 100 mL for *E. coli*. Higher values may be acceptable if they are lower than the lowest value of the set of environmental samples. Blanks should be collected at the same frequency as duplicates; one for every 20 samples.

Hold times for duplicates and blanks are the same as for regular samples.

6. Data Interpretation and Format

A. **Interpretation.** The summarization, comparison, and interpretation of the data collected through discharge point monitoring shall be done mindful of the applicable TMDL and associated goals. Data for each discharge point should be analyzed to understand the central tendency of the storm water quality for concentration and load. If permittees are not familiar with descriptive statistical analysis and programs to conduct them, they should seek out assistance to analyze their data. Because the monitoring and characterization of MS4 discharge points is ultimately focused on informing the prioritization of activity, any data analysis should be aimed at summarizing individual discharge point data so that all discharge points can subsequently be ranked and addressed as appropriate to meet TMDL goals.

Individual storm event data are most useful in the context of a larger data set for a particular discharge point. The larger data set is used to demonstrate the quality of the storm water over a range of storm conditions at the particular discharge point. Data for each discharge point should be summarized over all storm events to understand the median, mean, standard deviation of concentration and/or load. Box and whisker plots of the data, grouped by discharge point, can be helpful in graphically representing storm water quality and ranking discharge points so that priorities for future actions to address TMDL goals can be established. Standard deviation information will help clarify the discharge points with the most confident data characterizations, while those with broad deviations may indicate discharge points that need additional monitoring.

For those unfamiliar with summary statistics, such as those previously mentioned, Chapter 7 of Storm water Effects Handbook (Burton and Pitt, 2001) provides an overview of basic statistical analyses relevant to storm water data and some software options available for conducting such analyses.

B. Data Storage/Submittal Format. All data shall be submitted to the Department Water Bureau (WB) with the second progress report. Data should be organized and electronically stored in such a way the information may be easily transferred to the Department or other end user interested in storm water data. In keeping with the format and information used by the National Stormwater Quality Database (NSQD), a spreadsheet template similar to that in Table 2 will be useful for submittal of the data, if required. The example provided in Table 2 is not exhaustive, but provides the needed data for incorporation into the NSQD.

C. Comparing Data to TMDL Goals. While it is not possible to address all future scenarios of TMDL goals, the following offers a general approach that may be useful for a majority of situations.

i. ***E. coli* TMDL.** Typically the numeric targets for an *E. coli* TMDL involve meeting the *E. coli* water quality standards found in the Part 4 Rules that correspond to attainment of the relevant designated uses. That target is 130 *E. coli* per 100 mL as a 30-day geometric mean and 300 *E. coli* per 100 mL as a daily maximum to attain the Total Body Contact designated use from May 1 through October 31, and 1000 *E. coli* per 100 ml as a daily maximum year-round to attain the Partial Body Contact designated use. Keep in mind, these targets are in-stream *E. coli* concentrations.

Based on this, data should be summarized to allow for comparison of *E. coli* concentrations for individual storms, and range of storms, in order to understand where concentrations exceed the target, where the exceedance is consistent, and the degree of exceedance. Load estimations can be used to prioritize locations with consistent and proportionally larger inputs. For example, if *E. coli* data from two discharge points consistently show exceedance of the target, but one discharge point is several times larger in volume than the other, the larger could become a higher priority for remediation.

ii. **Total Phosphorus TMDL.** Primary numeric TMDL targets for TP may focus on either concentration and/or load and so the comparison of discharge data may need to be done for one or both measurements. Similar to *E. coli* prioritization, ranking discharge points by mean TP concentration can be a first step, followed by comparison of loads to identify those discharge points with disproportionally large loads and higher concentrations. Because data will have to be analyzed and compared to TMDL-specific goals, the Department can assist in identifying a reasonable approach for evaluating results.

D. Pollutant Source Tracking. The sampling recommendations described above provide information on the concentration and quantity of pollutants entering a stream during wet weather pollution events, but do not provide much information on the source of the pollutants. Identifying pollutant sources can be time-consuming and expensive, but one relatively simple approach is to sample upstream (within the storm water system) of a discharge point known to be a significant pollutant source. In storm water systems this often entails collecting samples from the downstream end of junctions that isolate branches of the system draining discrete neighborhoods, industries, etc.

Table 2. Example spreadsheet format for data recording, storage, and transmittal.

Unique Discharge Point Identifier	Date	Long (dd)	Lat (dd)	Percent impervious	Drainage Area	Rainfall Amount	Type of Sample[1]	Flow Volume	Parameter Data (TP &/or *E. coli*)

1. First flush, flow weighted, grab, composite

Part Two

This section provides guidance for a single wet weather pollution event sample collection to meet the very minimum MS4 permit requirements.

A representative sample is assumed to characterize discharge quality over a range of seasons, storm size, and storm duration. At least one representative sample of a storm water discharge shall be taken from at least 50 percent of the major discharge points discharging directly to surface waters of the state within the portion of the TMDL watershed in the urbanized area. Without knowing the normal range of storm water discharge quality under a variety of conditions, permittees who opt for the single-sample monitoring plan run a significant risk of generating data that fails to capture the realistic range of variability of the parameters of concern in the discharge, and is therefore unlikely to be truly representative. The permittee will then be left with unreliable data upon which future decisions and actions will be based.

1. **Selection of Major Discharge Points** (Refer to Part One, Section 1 for more details)

    A. For this requirement, a major discharge point is defined in the MS4 permits as a pipe or open conveyance measuring 36 inches or more at its widest cross section that discharges to surface waters of the state.

    B. The sample will be from the storm water, at or before the discharge point, not ambient waters after the discharge mixes with the water body.

    C. The Department recommends permittees prioritize sample locations and timing specific to the TMDL. Emphasis should be on sampling discharge points draining areas with the highest concentration of *E. coli* and/or TP and capturing first flush of TP. Keep in mind, some permittees have both TMDLs. See Part 1, Figure 1, for a ranking of urban land uses with regard to potential *E. coli* and TP discharge concentrations.

    D. The focus area is within, or contributing to, the listed TMDL reach. The municipality's jurisdiction may include land and discharge points upstream of this area. In this case, sampling of discharge points upstream of the TMDL reach should be included, thereby providing valuable information on water quality influences. Upstream sampling is often vital in identifying and addressing pollutant sources and a thorough sampling plan should incorporate this concept by considering discharges upstream of the TMDL reach when identifying and prioritizing the discharge points to be sampled. Information on specific TMDL reaches can be found at: www.michigan.gov/deq. Click on the 'Water' tab, then 'Water Quality Monitoring', then 'Assessment of Michigan Waters', then 'Total Maximum Daily Loads (TMDLs)'.

2. **Sample Event Timing** (Refer to Part I Section 3 for more details)

    A. Because of the difficulties with cold-weather sampling, the Department recommends samples be collected between May 1 and October 31.

    B. Sampling wet weather should occur only after it has been dry for at least 72 hours.

    C. Very small storm events may not generate significant runoff. Therefore, wait until there has been at least ¼ inch of rain within a 24 hour period. The simplest way to measure rain is with an accurate rain gauge placed in an obvious area, such as at the office of the individual in charge of the sampling.

    There will be times when a suitable event has been forecast, causing monitoring efforts to begin, only to have to cancel due to insufficient precipitation.

D. Sampling should be conducted as soon as possible following the start of discharge from targeted discharge points to capture a sample of the 'first flush'. First flush is defined as the runoff discharge at the beginning of a storm event and is assumed to consist of a significant amount of pollutants.

E. Synchronized sampling should be done as often as possible. Synchronized sampling is when several discharge points are sampled at or near the same time. If enough trained staff are available, all sites should be sampled during the same time period.

F. TMDL related storm water sampling shall be completed within three years of COC issuance.

Regardless of the sampling program, it is essential that monitoring be conducted by competent personnel who understand safety issues, environmental sampling, and will ensure data collected are sufficient, reliable, and of acceptable quality.

3. **Analytical Data** (Refer to Part I Section 4 and 5 for more details)

A. Develop and follow Quality Assurance and Quality Control procedures to ensure samples are collected, preserved, and analyzed properly.

B. Estimate and record the flow of the discharge at the time of sampling.

C. Collect *E. coli* or Total Phosphorus as single grab samples. Three samples are not needed for *E. coli* because mixing in the discharge is assumed. *E. coli* shall be delivered to the laboratory within 6 hours of collection.

D. Samples shall be analyzed for the TMDL pollutant, *E. coli*, Total Phosphorus, or both by a reputable laboratory that uses EPA approved methods as discussed further in Part One.

E. All data shall be submitted to the Department's Water Bureau (WB) with the second progress report. Data should be submitted in the electronic format provided by the WB.

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2. California Department of Transportation. 2000. *Guidance Manual: Stormwater Monitoring Protocols*. Second Edition. 303 pp. Available at: http://www.dot.ca.gov/hq/env/stormwater/pdf/CTSW-RT-03-105.pdf

3. Gilbert, R.O. 1987. *Statistical Methods for Environmental Pollution Monitoring*. Van Nostrand Reinhold, New York, NY. 320 pp.

4. Law, Neely L; Fraley-McNeal, Lisa; Cappiella, Karen; Pitt, Robert. 2008 *Monitoring to Demonstrate Environmental Results: Guidance to Develop Local Stormwater Monitoring Studies Using Six Example Study Designs*. Center for Watershed Protection Ellicott City, MD. Available at www.cwp.org.

5. National Research Council, 2008 *Urban Stormwater Management in the United States*. The National Academies Press, Washington, D.C.

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Training and Safety Considerations

Sampling can be hazardous, especially if there are high flows, considerable vegetation, deep pools, or soft sediments. However, most hazards can be avoided by the use of automated samplers, careful site selection and timing, as well as proper training. Therefore, it is important that sampling and safety training be instituted right away.

1. **Safety recommendations:**

    1. Always sample in pairs
    2. Carry 2-way radios or cell phones
    3. Have personal information on you that includes:
        - Emergency contact information
        - Identification
        - Medical alerts
    4. Try to collect all samples from land, especially if during heavy rains.
    5. If you must enter the water, do so cautiously and be prepared to make a quick exit
    6. Never enter a stream where footing is unstable
    7. Never enter a stream where the water is too deep (about 2 feet)
    8. Never enter a stream where the water is too fast (more than 2.5 ft/sec)
    9. Use common sense

2. **Safety Equipment.** Much of the equipment you will need is probably already in your possession or easily bought. The following is a list of items needed for all monitoring:

    1. Boots or waders
    2. Walking stick of known length for balance, probing, and measuring
    3. Long sleeves and pants that are thorn-resistant
    4. Protective gloves
    5. Insect repellent
    6. Sunscreen and hat
    7. Flashlight and extra batteries
    8. Whistle in case of an emergency
    9. Drinking water and snack
    10. Information with location and numbers to call in case of emergency
    11. First aid kit
    12. Rope
    13. Dog/animal repellant
    14. Weather radio (if necessary)
    15. Life jacket (if necessary)
    16. Hand sanitizer or wipes

3. **Monitoring Equipment.** Different equipment for specific chemical and biological monitoring should be reviewed before going into the field. Further information on equipment can be found in the USEPA Volunteer Stream Monitoring: A Methods Manual. Each chapter has a list of equipment needed for specific samples. For all monitoring, the following items should be included:
    1. Camera, Pencil, and field notebook
    2. Measuring tape
    3. Sampling pole
    4. Cooler and ice

Chapter 6
Water Quality Standards and Water Quality-Based Effluent Limits

Introduction

This chapter presents a general discussion of the Water Quality Standards/Water Quality-Based Effluent Limit (WQS/WQBEL) work group's understanding of storm water threats, the State of Michigan's current approach to storm water regulation, and makes recommendations for future rule and policy revisions regarding wet weather pollution discharges. The specific objectives of the workgroup were consolidated into three main ideas: (1) the prioritization of wet weather pollution discharges and the need for water quality standards and water quality based effluent limits, (2) wet weather pollution discharge effects on designated uses, the applicability of current rules, and strategies for establishing WQBELs for various discharge types, and (3) the necessary rule revisions to address the impacts of wet weather pollution events. Specific recommendations have been prioritized and are located at the end of the chapter.

Prioritization of Wet Weather Pollution Discharges and the Need for WQS and WQBELs

Based on the information obtained on the characterization of wet weather pollution discharges, the Monitoring Work Group identified pollutants that could be expected to be discharged above Michigan's allowable levels or federal water quality criteria [7]. The report also identified which pollutants should first be considered for inclusion in a sampling regime.

The WQS/WQBEL work group consolidated the information from the various work groups into a table that lists the major wet weather pollution discharge types and the applicable pollutants for each discharge type for which WQS would apply, and for which WQBELs could be developed (Table 1). These discharge types are considered to represent the most significant impact on the surface water resources in the state in terms of volume, rate of flow, and pollutant concentration, as well as those that are the largest contributors of pollutants originating from wet weather pollution events.

Chapter 7 entitled *Storm Water, Water Quality-Based Effluent Limitation Requirements*, of the Wet Weather Benchmarking Report, focused on capturing the differences in WQBEL requirements that existed between industrial, construction, and MS4 storm water permitting programs [3]. The report indicates that many state agencies acknowledge that storm water is a primary source of impairments to Section 303(d) listed waters, and have statutory authority to develop WQBELs for storm water discharges. However, relatively few states have developed either specific wet weather pollution water quality standards or place WQBELs in industrial storm water permits.

Interestingly, the construction storm water survey from the benchmarking effort showed that 20 percent of the states had developed specific wet weather pollution water quality standards, but none had placed WQBELs in construction storm water permits. Several states provided examples of wet weather pollution water quality standards or WQBELs. Most however, appear to be treatment technology-based limits (TTBELs), and apply only to specific industries, and contain standards/limits unlikely to support aquatic life even for short durations (e.g. 2 mg/l copper, 0.2 mg/l selenium, 0.01 mg/l mercury) let alone longer periods (i.e., does not provide chronic protection).

Table 2 captures the essence of storm water regulation across the nation, and summarizes information from the benchmark report regarding the development of WQS and WQBELs for storm water discharges.

Table 1. Storm water sources and associated problematic pollutants.

Discharge Type	Point Source[1]	pH	Dissolved Oxygen	Microorganisms		Toxics	BCCs	Nutrients	TRC	Oxygen Demanding Substances		Acute WET	Physical Characteristics		Flow Volume and Duration	Temp
				Fecal Coliform	*E. coli*					CBOD BOD SOD	Ammonia		TSS	Other[2]		
Nonpoint Source (NPS) includes agriculture (includes animal waste), residential, urban, forestry, land applied Wastewater Treatment Plant effluent, septage, drain maintenance, landscaping construction activities, and septic systems.	No		X		X	X		X		X	X		X	X	X	
Municipal Storm Water (MS4)	Most		X	X	X			X		X	X	X	X	X	X	
Combined Sewer Overflow/Retention Treatment Basin	Most		X	X	X	X		X	X	X	X		X	X	X	
Industrial Storm Water	Yes	X	X		X	X				X	X	X	X	X	X	X
Construction Storm Water	Varies							X					X	X	X	
OTHER Storm Water	Varies	X	X		X	X				X	X		X	X	X	X
Concentrated Animal Feeding Operation (CAFO) (production area only)	Yes		X		X	X		X		X	X			X	X	
Airports	Varies		X			X		X		X	X		X	X	X	X
Sanitary Sewer Overflow			X	X	X	X		X	X	X	X		X	X	X	
Waste Rock Runoff (mine tailing waste) NPS	No					X						X	X			

[1] Discharge types are categorized as being a point source pursuant to rule R 323.1044 (i.e., point source definition).
[2] Other - Turbidity, oil, and grease.

Table 2. Summary information from Benchmarking Report for combined industrial, construction, and MS4 storm water discharges [3].

Storm water discharge type	Percentage of respondents that acknowledge storm water as a primary source of impairment to listed waters	Percentage of respondents that have statutory authority to develop WQBELs for storm water discharges	Percentage of respondents that have specific WQS for storm water discharges	Percentage of respondents that have developed WQBELs for storm water discharges	Percentage of respondents that have incorporated WET limitations into storm water permits	Specific Comments
Construction	31%	87.5%	20%	0%	0%	
Industrial	73%	90%	35%	26%	<1%	Only Texas has WET limits in permits for storm water
MS4	82%	100%	20%	<1%	0%	

Wet Weather Pollution Discharge Effects on Designated Uses, Applicability of Current Rules, and Strategies for Establishing WQBELs

Based on the information obtained from the other workgroups and the benchmarking report, it was determined that Michigan's surface waters are subject to significant concentrations and amounts of a variety of wet weather pollutants, that when improperly managed, have the potential to impair designated uses [7]. This section summarizes the effects of wet weather pollution discharges on designated uses, and presents information and tools that are necessary for establishing WQBELs. In addition, it includes a discussion on how we currently address wet weather pollution discharge types to protect designated uses, and how we might expand existing programs to more adequately address the impacts of wet weather pollution discharges through the use of standards and effluent limitations.

Effects of Wet Weather Pollution Discharge on Designated Uses

Storm water runoff can threaten designated surface water uses by causing or contributing to an excursion of water quality standards. Designated uses are beneficial uses of the surface waters of the state established under rule R323.1100 (Designated Uses) of the Michigan WQS [8]. The designated uses protected by Michigan's WQS are as follows: agriculture, navigation, industrial water supply, public water supply, coldwater fishery, warm water fishery, other indigenous aquatic life and wildlife, partial body contact recreation, total body contact recreation, and fish consumption.

Both storm water quantity and quality can adversely affect aquatic life, partial and total body recreation, and drinking water designated uses (Table 3). The consensus of the various workgroups is that excessive storm water flow quantity, flow variability, and velocity, resulting from anthropogenic expansion of drainage basin impervious surfaces, are major threats to water quality, biotic habitat, and channel stability. High storm flows can cause sediment scouring and deposition, temperature regime changes, bank erosion, channel straightening, and other adverse impacts. The quality of storm water can also adversely affect designated uses. Pollutants in storm water considered as threats to designated uses include sediment and suspended solids, nutrients, heavy metals, chlorides, pesticides, oil and grease, other toxic pollutants, pathogens, and organic chemicals.

Table 3. Examples of the effect of storm water runoff on common designated uses (Modified from [9] and [7]).

Designated Uses[1]	Water Quantity Effects	Water Quality Effects
Other Indigenous Aquatic Life and Wildlife, Warm Water and Coldwater Fishery, Fish Consumption	Change in stream hydrology resulting in habitat modification and degradation (e.g., change in riffle/pool ratio, streambed alteration, stream incision and stream bank erosion, change in sediment transport, loss in riparian vegetation)	Degradation of receiving water quality that can be detrimental to aquatic life (e.g., addition of toxic compounds (pesticides and heavy metals), increased turbidity and solids, increased temperature, eutrophic effects from increased nutrients) Transport of toxics to sediments Introduction of BCC/other bioaccumulative chemicals

Partial and Total Body Contact Recreation	Alteration of stream channel or lake bathymetry impairing swimming use	Increased bacterial concentrations that pose a risk to human health
Drinking Water	Less opportunities for infiltration to recharge groundwater supplies that serve as public drinking water	Increased pollutant levels that pose a risk to human health (e.g., bacteria, metals, pesticides, nutrients)

[1] The Department does not conduct specific assessments to evaluate support of the agriculture, navigation, and industrial water supply designated uses. The uses are assumed to be supported unless there is site-specific information indicating otherwise.

Applicability of Current Rules to Wet Weather Pollution Discharges

Water quality criteria for controlling storm water effects can be expressed in both numeric and narrative form. However, it may be difficult to determine which specific pollutants are causing the impairment, and thus difficult to establish appropriate criteria and/or WQBELs for pollutants contributed by storm water. In addition, the quantity, flow variation, and velocity of flow, not specific pollutants, are often the underlying problems to address [9].

Storm water flow characteristics are currently unregulated with the exception of MS4 post construction controls. The WQS/WQBEL Workgroup believes the emphasis should change from only limiting specific chemical pollutants in storm water, to beginning to address the problems associated with storm water flow quantity characteristics. Given this understanding, the following discussion outlines the current regulatory framework that is applicable to storm water control, and the limitations that exist.

Water Quality Standards and Water Quality-Based Effluent Limits

The Part 4 Water Quality Standards [8], established under Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, set the minimum requirements necessary to protect public health and welfare, to enhance and maintain the quality of water, and to protect the state's natural resources. The minimum water quality requirements by which surface waters are managed include, but are not limited to, the following substances and water quality conditions (the associated rule is given in parentheses [8]);

- physical characteristics (R323.1050)
- dissolved solids (R323.1051)
- hydrogen ion concentration(pH) (R323.1053)
- taste and odor-producing substances (R323.1055)
- toxic substances (R323.1057)
- radioactive substances (R323.1058)
- plant nutrients (R323.1060)
- microorganisms (R323.1062)
- dissolved oxygen (R323.1064, 1065)
- temperature (R323.1069, 1070, 1072, 1073, 1075)

Under the Part 4 Water Quality Standards, both acute and chronic aquatic life protections from exposure to toxic substances are provided [8]. The WQS/WQBEL work group believes that acute aquatic life protection should apply at all times during wet weather pollution discharge events.

The current approach to water quality-based toxics control, including both the Part 4 Water Quality Standards and Part 8 Rules, was not designed contemplating control of adverse impacts from intermittent wet weather pollution discharges. Instead, the current approach is designed to be used in continuous point source regulation to protect for single exposures, under steady-state conditions. In contrast, intermittent, wet weather pollution discharges are variable, repeated, and vary decidedly on a site specific basis. As a result, the resulting disturbances are pulsed, variable, and accumulative [7]. Toxic effects from intermittent wet weather pollution discharges are also usually expressed in the form of long-term sediment toxicity rather than the water column toxicity the current approach contemplates.

Single exposure-based chronic toxicity aquatic life protection under the current rule should not be applied to intermittent storm water discharges unless storm water discharges exceed four days. The four-day interval is the shortest effective exposure for chronic toxicity effects from fast-acting chronic toxicants, like ammonia. [24] Rather, the Department should consider designing new approaches to address the concept of protection from repeated exposure, and accumulative chronic toxicity. In addition, the Department should consider water quality standards that take into consideration the effects on sediment toxicity resulting from repeated long term exposure.

The existing WQS apply at all flows except under extreme drought conditions. Rule R323.1090 of the Part 4 Rules states that WQS apply at all flows equal to or exceeding the design flow in a lotic (flowing) system. This design flow is also the flow to be used in determining WQBELs for non-wet weather pollution point source discharges. A more restrictive flow than the design flow may be applied where the Department determines such a flow is necessary to protect WQS [8].

Rule R323.1090(2)(a) defines the design flow as the lowest monthly 95 percent exceedance low flow for most cases. Exceptions are flows for human health values, where the design flow is defined as the harmonic mean flow, and wildlife values, where the design flow is the 90-day, 10-year low flow (90Q10). Rule R323.1090(3) allows the use of 4 seasonal design flows (lowest monthly 95 percent exceedance low flow for each season) when determining WQBELs for ammonia or substances not addressed by R 323.1057 (Toxic Substances).

Rule 323.1090 flow definitions are appropriate for continuous point sources, where the concern is maximum pollutant concentration under low-flow conditions. Unlike most continuous discharges, a wet weather pollution discharge would not be expected during drought conditions where critical design low flows, such as the 95 percent exceedance flow, may be encountered. Rule R323.1090(4) states that alternate design flows may be used for intermittent wet weather pollution discharges as necessary to protect the designated uses of the receiving water [8]. During wet weather pollution events, it may be appropriate to apply WQS and to calculate WQBELs at a design flow more representative of conditions in the receiving water. This alternative design flow would affect the amount of initial dilution that is given when determining WQBELs for oxygen demanding substances and other parameters for which chronic toxicity is a concern.

The use of such alternative wet weather pollution design flows should be considered on a case-by-case basis, acknowledging that background and, likely, discharge flow rates will vary between and during wet weather pollution events. The use of hydrologic models may be of use in determining appropriate flows to represent both the background receiving water and storm water discharge flows for use in wet weather pollution discharge WQBEL development.

Water quality standards are translated into WQBELs for the control of continuous point source discharges to protect designated uses via the procedures outlined in Part 8, Water Quality-Based Effluent Limit Development for Toxic Substances rules [11]. However, the procedures outlined in the rules cannot be used as a basis for establishing controls on the discharge of toxic substances from intermittent wet-weather point sources (Rule R323.1201).

The Department has developed WQBELs for a limited number of wet weather pollution discharges using the Part 4 Water Quality Standards as a basis without using the reasonable potential process outlined in the Part 8 Rules. Water Quality-Based Effluent Limits have been developed for combined sewer overflow (CSO) Retention Treatment Basins (RTBs), and limited industrial storm water discharges. Further discussion regarding the establishment of WQBELs for various wet weather pollution discharge types can be found under the section outlining the existing regulation of wet weather pollution discharges existing regulatory programs and specific wet weather pollution discharge types.

Due to the intermittent nature of wet weather pollution discharges, the WQS/WQBEL work group concludes that Rule 57 final chronic values (FCVs) under the current approach, need not be applied under current Rule unless a wet weather pollution discharge is of sufficient frequency, duration (i.e., greater than four days) and flow rate to cause chronic toxicity concerns. [24] Although FCVs would generally not need to be applied, the WQS/WQBEL workgroup concludes that Rule 57 values for bioaccumulative chemicals of concern (BCC) should generally be implemented for intermittent wet weather pollution discharges if present. Additional discussion is needed to determine whether BCC FCVs should always be applied. A rules gap appears to exist for some bioaccumulative chemicals that have human bioaccumulation factors (BAFs) less than 1000. For such compounds, it may still be necessary to apply FCVs to storm water discharges (e.g. selenium) [8] on a case-by-case basis. Finally, the Department should consider whether a new approach is needed to address the repeated, accumulative exposures characteristic of intermittent wet weather pollution discharges in WQBEL development.

Total Maximum Daily Loads (TMDLs)

Water quality standards can also be implemented through the TMDL process (R323.1207) of the Part 8 Rules [11]. TMDLs are developed for waters that are not attaining water quality standards, and that have been listed on the Section 303(d) list. Intermittent point source discharges to non-attaining waters may be regulated using waste load allocations (WLA). Intermittent non-national pollutant discharge elimination system (NPDES)-permitted sources to nonattaining waters may be addressed under a TMDL's load allocation (LA). The LA is implemented through a wide variety of federal, state, and local programs (which may be regulatory, non-regulatory, or incentive-based), as well as through voluntary action by citizens.

Wastewater Discharge Permits and Significant Contributor Designation

The Part 21 Rules provide a mechanism that has currently not been used for controlling pollutants from sources not usually covered under NPDES permits when discharges from these sources may reasonably be expected to adversely affect the quality or uses of that water body (i.e., cause or contribute to excursions of WQS). These sources may be required to obtain an NPDES permit if designated by the Department as a "Significant Contributor" of pollutants.

The Water Bureau Policy and Procedure # WB-03-027, Significant Contributor Designations for Storm Water [13], effective July 28, 2005, was developed to implement the Significant Contributor concept for storm water discharges. A Significant Contributor is defined as a facility with a discharge that:

1. Contributes to a pollutant loading that may reasonably be expected to adversely affect the quality or uses of a water body; or

2. Destabilizes the physical structure of a water body such that the discharge may reasonably be expected to adversely affect the quality or uses of that water body.

Many types of wet weather pollution discharges may fall under the jurisdiction of the Significant Contributor rule, and therefore, could be controlled using existing Water Bureau policies and procedures. Examples of discharge types that may be Significant Contributors of pollutants include the following (Rule R323. 2161(1)(f)):

- Operations such as transfer stations, truck and bus transportation, warehouses, grain elevators, and marinas that would not fall under the industrial storm water regulations because of exceptions such as primary source of income, but for whom runoff quality does not differ from their regulated counterparts, unless the discharger can demonstrate "no exposure."
- Facilities that demonstrate "no exposure" of industrial activities, but which have discharges from nonindustrial areas that do or will contribute to degradation of water quality.
- Commercial operations such as a "superstore" or a mall where the acreage of impervious surfaces, without suitable on-site capture of runoff, results in runoff that does or will contribute to degradation of water quality.
- Commercial operations such as gas stations and truck stops where common exposure of significant materials like gasoline drips and spills contribute to contaminated runoff.
- Municipal Separate Storm Sewer Systems (MS4s) not currently designated for coverage that contribute to degradation of water quality.

If Water Bureau deems that a discharge falls under the definition above, Water Bureau may require the discharge to obtain an individual NPDES permit. Such permits could include WQBELs. For example, a mall complex may be required to limit suspended solids to meet 80 mg/l based on best Professional Judgment (BPJ).

In addition to the above examples of potential Significant Contributors under rule R323.2161, additional designations for small and medium CAFOs may be made under rule R323.2196 [12]. The Water Bureau Policy and Procedure # WB-017, Designations for Small and Medium Concentrated Animal Feeding Operations (CAFO), effective October 30, 2008, was developed to implement the Significant Contributor concept for small and medium CAFOs.

Rule 323.2196 states that the Department may designate any animal feeding operation (AFO) as a CAFO upon determining that it is a Significant Contributor of pollutants. If an AFO is designated a CAFO, the Department may require the facility to obtain an individual NPDES CAFO permit. However, AFOs with numbers of animals below those specified in rule R323.2103(c) [12] shall not be designated as a CAFO unless the following occur:

- Pollutants are discharged from the production area into waters of the state through a manmade ditch, pipe, tile, swale, flushing system, or other similar manmade conveyance.
- Pollutants are discharged from the production area directly into waters of the state which originate outside of the facility and pass over, across, or through the facility or otherwise come into direct contact with the animals confined in the operation.

The Significant Contributor designation cannot be applied to all facilities discharging pollutants. Certain pollutant discharges are exempted from NPDES permits per rule R323.2189 (2)(a), which incorporates by reference, Title 40 of the Code of Federal Regulations (CFR), Section 122.3(e). These exemptions include introduction of pollutants discharged from nonpoint source agricultural activities, including storm water runoff from orchards, cultivated crops, pastures, range lands, and forest lands [14].

Michigan does not have numeric standard(s) for the regulation of storm water quantity characteristics from any discharge. However, the Part 21 Rules provide a mechanism by which storm water discharge flow characteristics could be managed. Significant Contributor NPDES permit provisions could include flow characteristics controls to protect receiving waters from negative physical impacts caused by unregulated storm water flow characteristics.

Existing Regulation of Wet Weather Pollution Discharges

The following discussion summarizes how existing WB programs currently address key wet weather pollution discharge types, and whether or not they currently include WQS and/or WQBELs.

Nonpoint Source Pollution

Three current Departmental programs address NPS pollution:

- Soil Erosion and Sedimentation Control (SESC)
- Construction Storm Water (CSW)
- Nonpoint Source

The SESC program serves to control soil erosion into surface waters. Based on Part 91, Soil Erosion and Sediment Control Rules, SESC permits are required for earth disturbance activities within 500 feet of surface waters, or of ≥1 acre in area. The permits are administered at the county or municipal level, or certain agencies can be certified as Approved Public Agencies (APA). APA's are self-regulated, and therefore are not required to obtain a SESC permit.

The CSW program is wrapped into the SESC program, because SESC permits are an integral component of CSW regulation. Construction activities ≤ 5 acres in size are considered permitted once SESC coverage is obtained, either under an SESC permit, or by designation of a public agency as an APA. Construction activities ≥ 5 acres in size are approved upon filing a Notice of Coverage along with a copy of the SESC permit (if applicable), copy of the SESC plan, and applicable fee.

CSW permitting is a Permit-by-Rule approach. Once the above requirements are fulfilled, a specific CSW permit is not issued, but the entity undertaking the construction activity must comply with Michigan's Water Quality Standards.

Under the Part 91 Rules, any earth change activity must remove sediment caused by "accelerated soil erosion" from runoff water before it leaves the disturbance site [19]. Accelerated soil erosion is defined as the increased loss of land surface that occurs as a result of human activities. Per R323.1709 (2), "A person shall remove sediment caused by accelerated soil erosion from runoff water before it leaves the site of the earth change."

There is a conceptual conflict between the Part 91 Rule requirement and rule R323.1050 (Physical characteristics) under the Part 4 Rules. Part 91 Rules require entities conducting construction activities to remove all sediment before discharge, while the Part 4 Rule, R323.1050(a), prohibits the discharge of unnatural quantities of turbidity which are or may become injurious to any designated use.

The USEPA recently issued a 280 nephelometric unit (NTU) Best Available Technology (BAT) effluent limit guideline for construction storm water control. However, this guideline is much less restrictive than the Part 91 Rule prohibition of any discharge of sediment, and in most instances, the Rule 50 prohibition against unnatural turbidity levels.

The Earth Change workgroup considers the 280 NTU effluent limit guideline inadequate to protect Michigan's surface waters against sedimentation impairment (Dick Mikula, pers. Comm.). In addition, the Earth Change workgroup considers turbidity reductions to levels much less than 280 NTU reasonably achievable using current technologies (Dick Mikula, pers. Comm.).

According to the Earth Change Wet Weather Group, implementation of sedimentation control is hampered by the lack of a numerical standard that would protect surface waters from sedimentation (Dick Mikula, pers. Comm.). Both the Part 17 Rule no loss of sediment requirement, and the Rule 50 no unnatural turbidity WQS are in narrative form. Since there is no specific numerical standard, regulated entities lack a clear target for compliance, and Compliance and Enforcement staff lack clear numbers for monitoring and compliance efforts. Therefore, the Earth Change Group believes a numerical WQS for a parameter such as turbidity or TSS is needed (Dick Mikula, pers. Comm.).

The NPS program's current activities are limited to directing Section 319 grant monies into watershed improvement projects, like steam bank stabilization and buffer strip installation. The projects funded often produce tangible results, but are not based on compliance with WQS, permitting approaches to water pollution control, or WQBELS.

Municipal Separated Storm Sewer Systems (MS4s)

Current regulation of Municipal Separate Storm Sewer Systems in Michigan consists primarily of requirements to implement Best Management Practice controls to reduce the discharge of storm water pollutants to the maximum extent practicable through development of a Storm Water Pollution Prevention Initiative (SWPPI). The core of the SWPPI consists of six minimum measures, which include development and implementation off a Public Education Plan, Public Participation Plan, Illicit Discharge Elimination Plan, Construction Storm Water Runoff Control, Post-Construction Storm Water Control, and Pollution Prevention/Good Housekeeping. Moreover, in the case of *E. coli* and phosphorus, if the MS4 discharges to an impaired water body for which a Total Maximum Daily Loading has been established, then additional action is required to reduce the target pollutant to make progress in meeting the associated WQS. [16] To date, the Department has not issued any NPDES permits containing numeric effluent limitations for MS4 discharges.

Our existing water quality rules appear to provide adequate authorization to impose any requirements/limitations necessary to ensure that WQS are being met. Specifically, as allowed for under Part 31 of the Natural Resources and Environmental Protection Act, Rule R323.3106 "The Department shall establish pollution standards…and issue permits that will assure compliance with state standards to regulate municipal, industrial, and commercial discharges. The Department may set permit restrictions that will assure compliance with applicable federal law and regulations. The Department shall take all appropriate steps to prevent any pollution the Department considers to be unreasonable and against public interest in view of the existing conditions in any lake, river, stream, or other waters of the state." [10]

Combined Sewer Overflows/Retention Treatment Basins

Michigan's regulatory framework for dealing with Combined Sewer Overflows, in the form of both untreated and treated Retention Treatment Basins, is well established. Beginning in the late 1980's the then Michigan Department of Natural Resources (MDNR) and Michigan Water Resources Commission (MWRC) adopted a state-wide CSO Permitting Strategy [15] and began requiring inclusion of CSO control programs in NPDES permits that contain enforceable deadlines for CSO control that would lead to elimination or adequate treatment of all CSO's in

Michigan. Since then approximately 80 percent of all CSOs have either been eliminated or receive treatment to meet WQS.

Under the current approach, when an untreated CSO discharge cannot be eliminated, control facilities or RTBs are required to ensure that adequate treatment is provided during wet-weather events. These control facilities are then designed under a Presumptive or Demonstrative Approach. Under the Presumptive Approach, facilities are presumed to meet WQS without evaluation by either (1) providing retention for transportation and treatment of the 1-year/1-hour storm flows; or (2) providing primary treatment (30 minutes of detention time or equivalent for settling, skimming and disinfection) for the 10-year/1-hour storm flow; or (3) providing treatment for discharges in excess of the 10-year/1-hour storm flows to the extent possible with facilities designed for lesser flows, whichever is limiting. If a facility is not designed large enough to meet the presumptive criteria above, then a Demonstrative Approach may be used. Facilities that are designed under the demonstrative approach may include lesser facilities than required under the presumptive approach. In such a case, a demonstration is required to show that WQS for dissolved oxygen (DO), pathogens, physical characteristics, and toxicity requirements could be met during discharge events from the facility. A successful demonstration eliminates the need for effluent limitations for BOD, DO, ammonia, total residual chlorine (TRC), pathogens, and acute toxicity [16].

CSOs are considered point source discharges, which are subject to NPDES permit conditions including: technology-based (best available technology economically achievable [BAT]; best conventional technology [BCT]); and water quality-based requirements of the Clean Water Act (CWA).

The current CSO control program has been very successful in reducing size, duration, and frequency of CSO discharge events, and has contributed significantly to improved effluent quality when discharges do occur. The existing regulatory framework is, in the opinion of this workgroup, sufficient to achieve the desired goals with respect to control of CSO discharges.

Note, however, that WQBELs in the form of direct application of Part 4 WQS have been incorporated into numerous Michigan CSO/RTB NPDES permits. Each permit for treated CSO or RTB in the state contains the fecal coliform discharge standards (200 cts/100 mL as a 30-day average and 400 cts/mL as a 7-day average) prescribed by rule R323.1062 (Microorganisms). Several CSO/RTB permits contain pH range limits of 6.5 – 9.0 S.U. as prescribed under rule R323.323.1053 (Hydrogen ion concentration). Application of other WQS as WQBELs may be considered, such as the 1 mg/l total phosphorus discharge standard under rule R323.1060 (Plant Nutrients).

The Detroit WWTP's NPDES permit (MI0022802) allows emergency wet weather discharges of primary and secondary effluent to the Rouge River from outfall 050. That outfall contains a daily maximum amenable cyanide limit based on the free cyanide final acute value (FAV) under rule R323.1057 (Toxic Substances). The inclusion of this WQBEL was based on potential effluent quality derived from outfall monitoring data. No other WQBELs are relevant to that outfall. Other situations may exist where effluent monitoring of a wet weather source indicates the need to apply FAVs as WQBELs.

The Milk River CSO RTB permit (MI0025500) is the only known instance where a WQBEL was calculated for a CSO/RTB to meet a WQS. This is the 7 mg/l minimum effluent DO permit limit which was derived from DO modeling targeting the 5 mg/l warm water DO standard in the Milk River at times of RTB discharge. Corresponding $CBOD_5$ and ammonia concentrations used in the modeling for standard attainment evaluation were taken from actual RTB effluent data to represent overflow events. Effluent DO can be controlled by in-basin aerators, whereas effluent

CBOD and ammonia concentrations are highly variable within and between events depending on numerous factors. The RTB permit does not contain CBOD or ammonia limits.

The approach used to develop the Milk River CSO RTB minimum effluent DO WQBEL, along with other DO-based WQBELs or any WQBELs requiring calculations based on receiving water background flows, will not be feasible under almost any other scenario involving a wet weather pollution discharge. This is because that RTB is the headwaters of the Milk River and river flow is controlled artificially through the operation of a recirculation system that pumps a defined, constant flow of water from Lake St. Clair to the RTB and back again to Lake St. Clair during the critical discharge seasons. This allowed the facility to be modeled essentially as a continuous discharge.

Some treated CSO/RTBs contain a target TRC effluent concentration of 1.0 mg/l. However, this is not based on a rule R323.1057 (Toxic Substances) number and is therefore, not a calculated WQBEL, nor a direct application of WQS. Currently, some CSO/RTB facilities are conducting mixing zone studies to define areas of receiving waters impacted by TRC. These studies may result in Water Bureau applying the 0.038 mg/l TRC FAV to some RTB discharges.

Industrial Storm Water (ISW)

Industrial storm water is characterized by contact of precipitation water with industrial sites, equipment, production areas, etc. Consequently, the primary pollutants of concern are toxics, aquatic toxicity, and physical characteristics [16].

Certain industrial facility classifications are required to obtain a general permit for ISW discharges under a general NPDES permit. If the Department determines additional control of storm water pollutants is necessary, the Department may require facilities to obtain individual NPDES permits on a case-by-case basis.

The Department requires controls on industrial storm water for facilities under general and individual NPDES permits using Storm Water Pollution Prevention Plans. The plans specify in narrative form that the storm waters shall not cause a violation of water quality standards in the receiving water [16]. These controls are Best Management Practice (BMP)-based, and generally do not include numeric limitations. However, there are documented situations, where the Department had determined that effluent limitations were necessary to ensure adequate protection of aquatic life and human health. In this particular instance, parameter-specific effluent monitoring requirements and final effluent limitations were included in the permit, but no site-specific WQBELs for toxic substances were developed. The numeric effluent limitations included for toxic substances were derived from the water quality values developed under Rule 57 of the Part 4 Rules, and were actual WQS, or were based on BPJ.

The current WQS appear sufficient to define allowable levels of pollutants in surface waters resulting from industrial storm water discharges. In cases where the Department considers necessary specific numeric limitations for industrial storm water discharges, current Rule allows application of acute standards (Rule 57 water quality values) as end-of-pipe limitations.

The Department may also regulate discharges from non-industrial areas at industrial facilities using the Significant Contributor process mentioned above [13]. As with most storm waters, unnaturally high storm water flow volumes, flow variability, and velocity likely are a concern for ISW discharges, and should be addressed.

Confined Animal Feeding Operations (CAFO)

This class of operation is characterized by the production of large volumes of animal waste. Waste management typically consists of composting solids and land application of liquid wastes and semi-solid wastes. Consequently, conventional nutrient pollutants, suspended solids, and pathogens are of primary concern for this waste type. However, toxic chemicals can also be of concern. As with most storm waters, unnaturally high storm water flow volumes and velocity may also be a concern for discharges from CAFOs. Finally, emerging pollutants of concern (antibiotics/pharmaceuticals, hormones) may also be present in CAFO wastewater.

CAFOs with the potential to discharge wastewaters to Michigan surface waters are required to obtain an NPDES permit under R 323.2196 [12]. One CAFO facility, Vreba-Hoff Dairy, a large dairy operation, has been issued a permit with numeric requirements. However, these requirements are performance standards, and do not apply to any discharge or overflow that may occur from the production areas. These performance standards were included in the permit with other specific waste treatment requirements (e.g. mg/l Nitrogen in land-applied waste; fecal coliform reduction requirements on semi-solid wastes; agronomic rate-based limits on phosphorus application) and operational requirements (e.g. a Comprehensive Nutrient Management Plan) to minimize the impact of runoff from land applied biosolids during wet weather pollution events.

These treatment standards are not based on WQS, and the permit does not contain enforceable WQBELs. The basis of the control requirements are achievable treatment levels agreed to by the permittee, standard agricultural/environmental best management practices, and good environmental stewardship.

Water Bureau also has in place a policy for determining the need for NPDES permits for Small and Medium AFOs, the Water Bureau Policy and Procedure # WB-03-017, Designations for Small or Medium Concentrated Animal Feeding Operations (CAFO), effective October 31, 2008 [17]. Permits similar to the Vreba-Hoff permit, focusing on treatment and best management practices, can also be developed for Small and Medium AFOs if the Department decides such permits are needed based on (1) the significance of pollutant contributions and potential to cause excursions of WQS, or (2) destabilization of the physical structure of a water body that may reasonably be expected to adversely affect water quality [12].

Pollutant loadings from agricultural sources such as CAFOs and AFOs are also being addressed in the Total Maximum Daily Load (TMDL) process (e.g. Phosphorus TMDLs) when the pollutant(s) in question are known to cause designated use impairments.

Agricultural non-point source discharges are the most significant contributors of wet weather pollution impairments on a national basis. [25] This is likely due to the large scale and inherent environmental disruption caused by such operations, the lack of political will to economically impact this fundamental industry, and the resultant lack of effective regulatory tools for addressing these types of discharges.

Summary

Based on the information obtained throughout the process of evaluating wet weather pollution discharge types, it has been determined that, irrespective of what classification a wet weather pollution discharge falls under, the relevant pollutant parameters and associated impacts on water quality are very similar. Although each discharge type has its unique characteristics, in general, the identified pollutants of concern are oxygen demand, nutrients, pathogens, metals, sediment, and flow. As evidenced by our write-ups on the individual wet weather pollution discharge types, the Department has already established several precedents for imposing numeric limitations and has demonstrated that we possess the authority to impose these acute standards to ensure adequate protection for aquatic life and human health. Moreover, by doing so, we have created the basic framework needed to develop a comprehensive wet weather pollution permitting strategy. That being said, it is obvious that no one control document that contains a general suite of requirements and limitations would apply uniformly to all types of wet weather pollution, that is why our current practices of using individual permits to address the most problematic discharges and general permits to address a specific category of discharges seems to represent the best approach. If, as described in the monitoring workgroups report, we focus our efforts on more accurately characterizing each wet weather pollution type, then we would be able to craft better control documents.

Probably the biggest challenge faced by the Department in terms of regulating wet weather pollution discharges will be addressing so called chronic impacts. Primarily, because the long term impacts of wet weather pollution discharges have not yet been well defined and do not fit into the classic definition of chronic exposure. It is evident that additional research is needed to better characterize these chronic impacts. This would allow for the development of more appropriate management practices and possibly provide the scientific basis for the argument that regulatory changes are needed to allow for the development of chronic numeric effluent limitations for wet weather.

Recommendations

This section summarizes the Work Group's recommendations that outline what is necessary for establishing WQBELs for wet weather pollution discharges in order for surface waters to meet WQS. The recommendations are prioritized into tiers with Tier 1 recommendations being of highest priority, since these are needed to proceed with Tier 2 and Tier 3 recommendations.

Tier 1

This tier of recommendations identifies the important information that is lacking and includes actions for filling the gaps.

1. Assess the effectiveness of current CAFO/AFO permitting approaches and determine which facilities adversely affect surface water quality from non-point source sedimentation and flow impacts that are not addressed under NPDES permitting approaches (e.g., production areas).

2. Develop additional WQS and/or WQBEL approaches to address non-point source sedimentation and flow issues that are not covered under current CAFO/AFO permitting approaches.

3. Construct a monitoring database of continuous flow and water quality data for specific discharge types and water bodies that can be used in developing wet weather WQBELs. The relative timing of peak flows/concentrations will have a significant impact on modeling results and thus pollution control requirements. While environmental conditions can be predicted with some accuracy, flows and water quality for each discharge will require a more case-specific determination. Water quality (and to a lesser degree flow) is a function of antecedent conditions. In addition, environmental fate "coefficients" are required for models involving multiple discharge or substances for which ecological transformations are important. While literature values are available for sedimentation, dissolution/precipitation, decay, reaeration and other model coefficients, site-specific data are often needed to calibrate and verify that models are producing accurate results for a specific location. Affordable, but somewhat labor intensive, technology exists for continuously monitoring flow. This is also true for some water quality parameters: pH,

DO, turbidity and conductivity. For most other parameters, flow-activated remote samplers can be used to collect timed, discrete samples that require individual analyses for key parameters (BOD, ammonia, metals). These must be utilized for many events in order to accurately predict how water quality will vary during wet weather pollution events for a given discharge.

4. Recommend that emerging contaminants of concern associated with CAFO/AFO operations be monitored. Such contaminants include, but are not limited to antibiotics, pharmaceuticals, hormones, selenium in feed supplement, copper used in hoof prophylactics, pesticides, and herbicides.

5. Recommend that additional information from Texas and Oregon be obtained to better understand how models that consider stream and discharge flows can be used to develop monthly average WQBELs, and how WQBELs are applied for preventing acute toxicity associated with wet weather pollution events. Learning the nuts and bolts from these states would enlighten future efforts to extend storm water regulations in Michigan.

6. Develop a new approach to address intermittent, long-term exposures, which result in toxic accumulated sedimentation and sediment chronic toxicity disturbances.

Tier 2

This tier of recommendations summarizes what is necessary for developing WQBELs that apply to wet weather pollution discharges.

1. Continue the existing practice of "requiring" installation of BMPs to control wet weather pollution discharges. Where demonstrable ecological/water quality impairments exist, WQBELs should be developed. There are significant challenges to implementing WQBELs. Challenges exist for not only the limitations available under existing authority (discussed in detail in the body of the report), but also in measuring compliance of discharges that vary significantly in both quality and quantity over short time periods, and from one wet weather pollution event to another. For this reason, we recommend a case-specific approach using existing rules and program structure with some revisions to control wet weather pollution discharges.

2. Continue the application of WQS for WQBEL development for Industrial, and CSO/RTB storm water discharges as outlined in the body of the report.

3. Continue the application of performance standards as numeric requirements for CAFO discharges, but also begin exploring the development of WQBELs for such parameters as *E.coli*, pH, and total phosphorus through direct application of water quality (e.g., *E. coli* and pH) and effluent (total phosphorus) standards.

4. Consider whether to implement regulatory controls to agriculture and forestry such as those already implemented by the SESC Program for other earth disturbance activities. Predominant sources of NPS like tilled row crop agriculture and forestry are mostly uncontrolled by current regulations.

5. Develop a numeric water quality standard for turbidity (e.g., total suspended solids) to aid in compliance and monitoring efforts. This may require that a water quality characteristic type equation, much like those used in developing water quality values for metals, be developed, since turbidity may require site specific standards to account for variability in river and stream water quality characteristics. However, instead of a water quality characteristic, the equation may need to include a physical characteristic(s) (e.g.,

slope of land, depth of water body, stream order, etc) as the variable that influences the amount of allowable suspended solids.

Tier 3

This tier of recommendations summarizes the revisions to rules that are necessary in order to implement recommendations from Tier 2.

1. Determine if variances can be used on a case-by-case basis for wet weather pollution discharges. According to R323.1103 (Variances) [8], a variance may be granted from any WQS that is the basis of a WQBEL in an NPDES permit under certain specific circumstances. However, further review is needed to determine the extent that this approach can be used.

2. Regain authority to develop new standards or revise outdated ones under Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended.

3. Determine if Rule 90 (R323.1090(4) of the Part 4 WQS can be further refined to define specific flows that can be used for WQS applicability and WQBEL development for wet weather pollution discharges. Specifically, WQBELs developed for dissolved oxygen, nutrients, oxygen demanding substances, and chronic whole effluent toxicity for wet weather pollution discharges would need to incorporate flow into the development of the limitations to allow for mix.

4. Determine if rule modifications are necessary to address the issue of flow. Only local municipality and county drain commissioners currently address the issue. An example would be requirements for detention ponds at new construction sites that could be designed to reduce the erosive force of high storm flows.

5. Determine rule modifications that are necessary to address the long-term, pulsed, accumulated sedimentation and sediment chronic toxicity disturbances. Due to the intermittent nature of wet weather pollution discharges, the WQS/WQBEL work group concludes that FCVs developed under Rule R323.1057 (i.e., Rule 57) do not need to be applied unless a wet weather pollution discharge is of sufficient frequency, duration (i.e., greater than four days), and flow rate to cause chronic toxicity concerns. However, the frequency and repeated pulsed nature of such discharges may also lead to situations where long-term, accumulated chronic toxicity impact becomes a concern. Since the current approach to controlling toxic effects is based on a single-exposure, steady state chronic toxicity protection, the Department should consider whether rules changes could better address this long-term chronic toxicity disturbance. Deposition and accumulation of contaminated sediments from runoff events has been recognized as a potential cause of impairment to biological communities. [26] This long-term adverse effects from repeated inputs of elevated storm water flows, and pollutant concentrations (e.g., streambed modification, scouring, sedimentation, selenium loading, etc.) should also be addressed.

6. Revise any rules applying "reasonable potential" to a discharge to ensure that definitions of the term do not contradict the implied intent of those rules. Rule R323.2161(1)(a)(ii) [12] states: "Not withstanding the provisions of this subdivision, the Department retains the authority to require national permit authorization, and deny this exclusion, upon making a determination that the discharge causes, has a reasonable potential to cause, or contributes to, a violation of an applicable water quality standard." The term "reasonable potential" is not defined in the Part 21 Rules, so the intent is unclear and may require clarification. Rule R323.1211, of the Part 8 Rules has a definition of

“reasonable potential” as well, but requires that chemical-specific WQBELS be incorporated into an NPDES permit where the Department determines that a toxic substance is or may be discharged into the waters of the state at a level that has the “reasonable potential” to cause or contribute to an excursion above any water quality value.” However, according to R323.1201(1), the procedures in that part cannot be used for establishing controls on the discharge of toxic substances from intermittent wet-weather sources. Therefore, it appears there is a prohibition against using the “reasonable potential” process of R323.1211 to determine if intermittent wet-weather sources are “significant contributors.”

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Chapter 7
Wet Weather Pollution Benchmarking Report
(Introduction Only)

The following is only the Introduction Section of this report. The entire Wet Weather Pollution Benchmarking Report can be found on the Web at: http://css.snre.umich.edu/wetweather

The research team for the benchmarking report was made up of the following individuals from the University of Michigan, School of Natural Resources and Environment, Center for Sustainable Systems:

Jonathan Bulkley, Principal Investigator
Danielle LeFevre, Graduate Researcher
Hilton Clark, Graduate Researcher
Amy Samples, Graduate Researcher
Ria Berns, Graduate Researcher

Introduction

In the fall of 2008, the Michigan Department of Environmental Quality (MDEQ) Water Bureau Chief established a wet weather program designed to improve the understanding of rules, policies and regulations related to the monitoring, control and permitting of wet weather events and wet weather discharges. The program created five Water Bureau staff work groups, tasked with identifying and benchmarking more appropriate ways and means to control and reduce adverse surface water quality impacts of wet weather discharge flows.

The five groups and their individual focus areas are as follows:

1. Wastes to Land - including programs dealing with septage, biosolids, and animal feeding operations of all sizes.
2. Earth Change - including programs dealing with soil erosion and sedimentation, forestry, construction, storm water, and farming other than animal feeding operations.
3. Urban Living - including programs dealing with municipal and industrial storm water, and combined and sanitary sewer overflows.
4. Wet Weather Monitoring - including ambient and discharge monitoring practices of state agencies, permit holders, and external organizations.
5. Water Quality Based Effluent Limits (WQBEL) and Water Quality Standards Applicability.

This proactive approach recognized that the major surface water quality problems currently faced in the State of Michigan are derived from wet weather discharges. The work groups provide a coordinated approach within the Water Bureau that draws on the expertise of Bureau staff to meet the goals of the newly created wet weather program. Each work group was provided with specific research tasks that would yield information on the character of wet weather discharges arising from the various types of activities being considered in individual work groups. For instance, each work group prepared specific questions to be asked of other states and the USEPA for the purpose of benchmarking wet weather policies. The responses to these questions from the states and the USEPA would contribute to a comprehensive understanding of wet weather regulatory policies and programs as practiced in this country.

The work on the questions for the states and the USEPA evolved to a final form of 16 pages from December 2008 through to mid-May 2009. The set of final overall questions are shown in the attached Appendix A (of the Benchmarking Report). Each work group listed questions in priority order.

To complement the detailed work of the five specified work groups and to gather information to respond to the prepared questions, a research team from the University of Michigan submitted a proposed work plan designed to solicit information from the Internet to document the states' and the USEPA's current wet weather practices. In addition to internet based research, the proposal included the design and implementation of appropriate survey instruments serving to obtain information not readily available from the Internet on current wet weather practice from states and the USEPA. The Water Bureau approved this proposal and the research team commenced working in early May 2009.

The approved research plan called for the research team to complete its work and submit a final report by September 30, 2009. As a consequence of the magnitude of the undertaking, a no-cost extension to the research contract extended the due date of the final report to November 30, 2009.

Methods

The initial effort of this research team involved searching the Internet resources of the states and the USEPA to find answers to as many of the questions from the five working groups as possible. While Internet research yielded useful results, many questions required further research. The remaining questions were compiled into a questionnaire for distribution to each state agency, USEPA Regions, and the USEPA Headquarters. In lieu of a more burdensome and costly paper format, an Internet based survey instrument was used, which facilitated the final assembly of responses into a comprehensive report. After review of several different Web based survey instruments (including Zoomerang, UM Lessons, SurveyMonkey), we identified SurveyMonkey as the most suitable tool for our purpose.

In order to ensure efficient and sensitive design of these questionnaires, all researchers obtained certification from the University of Michigan (UM) Program for Education and Evaluation in Responsible Research and Scholarship (PEERRS). Although the Institute for Social Research (ISR) informed us that the factual nature of our questionnaires does not require review by UM's Institutional Review Board, we did receive valuable information from ISR.

Because of the quantity and diverse nature of questions unaddressed on the Internet, the remaining questions were divided into twelve separate questionnaires, according to the following wet weather issues:

- Combined Sewer Overflows (CSOs)
- Sanitary Sewer Overflows (SSOs)
- Industrial Stormwater Permit Requirements
- Municipal Stormwater Permit Requirements
- Wet Weather Monitoring
- Industrial Stormwater WQBEL Requirements
- Municipal Stormwater WQBEL Requirements
- Construction Storm Water WQBEL Requirements
- Construction Nonpoint Source Pollution
- Construction Stormwater
- Land Application of Biosolids & Septage
- Land Application of Manure

Each questionnaire was distributed to the appropriate contact person who was identified as being knowledgeable about a given wet weather issue. In some cases, a contact person may have received more than one questionnaire, as some of the subject areas contain overlapping information. In most cases, the contact person for municipal storm water received both the Urban Living Work Group's questions relating to municipal storm water and the Water Quality Based Effluent Limitations (WQBEL) Work Group's questions relating to municipal storm water.

The results received from the respondents as well as the Internet research are grouped and presented in Chapters 1-8 (of the benchmarking report). Overall, the USEPA Headquarters, 45 states, and nine USEPA Regions responded to one or more of the survey instruments. In addition, two states opted out of survey participation for budgetary and standard policy reasons.

Chapter 8
Summary, Next Steps, and Recommendations

Based on a review of the work group reports, there are several broad conclusions and recommendations that may be made:

1. Improperly managed wet weather pollution discharges have the potential to cause serious problems in surface waters. These problems include:

   - An Increase in the magnitude and frequency of flooding, particularly in urban areas.

   - Widening of stream cross sections, which leads to significant channel erosion, unstable conditions, and associated habitat problems.

   - Coarse sediments contain voids which are filled or smothered by fine sediments Coarse sediments are needed by spawning fish and other aquatic life.

   - Reduced aesthetic value.

   - Increased water column bacteria concentrations to levels that can impair total and partial body contact recreation.

   - Increased phosphorus levels in the water that stimulates nuisance algal and macrophyte growth conditions.

   - The biological communities in-stream are shifted from diverse to much less diverse assemblages that are dominated by species more able to tolerate perturbed conditions.

   - Increased loading of certain toxic chemicals, which can bioaccumulate to levels in fish tissues that necessitate the establishment of fish consumption advisories.

   - Increased difficulty and cost of public drinking water treatment

2. Presently, the detrimental effects of increased E. coli concentrations are the most documented effects from wet weather pollution discharges. These effects are found in both urban and rural surface waters.

3. Urban streams are heavily impacted by flow modifications from wet weather pollution discharges, due to unnaturally high runoff volumes. Increases in impervious surface area, stream channelization, loss of wetland acreage, deforestation, and agricultural field tiling all have led to more rapid and higher volume runoff from storm events or snowmelt. Such unnaturally high runoff volumes can have detrimental physical impacts, causing channel erosion, flooding, and damage to in-stream habitat for aquatic organisms.

4. A large amount of subjectivity that exists in many of the wet weather programs. This subjectivity creates problems and makes it difficult to consistently address the effects from wet weather discharges.

5. A lack of consistent terminology exists across programs that deal with wet weather pollution. For example, the term “agronomic rate” has a different meaning in at least

three programs (Biosolids, Septage, and NPDES CAFO permits). Inconsistent terminology serves to hinder the ability to address the wet weather issues.

6. Measuring the impacts of wet weather pollution is problematic, primarily due to sampling difficulty, a lack of methods to monitor pollutants, and established means to evaluate the impacts of wet weather pollution discharges. There is a need to develop training for wet weather discharge sampling and ambient water quality monitoring.

7. Based on available records, animal wastes are the largest, by volume, wastes that is applied to land in Michigan.

8. Good regulatory mechanism exist for Biosolids, Septage, CAFO permits, CSO, SSO, Industrial Storm Water, Municipal Storm Water (those under permit), Construction Storm Water and Soil Erosion (SESC).

9. Urban infrastructure in Michigan is currently in need of a clearly defined adequate maintenance program. Consideration should be given to developing a Capacity, Management, Operations and Maintenance (CMOM) program to address this need.

10. Effective BMPs need to be identified and BMP standards established.

11. It is difficult to understand and address TMDL obligations for wet weather pollution discharges. This challenge makes it difficult to restore impaired waters.

Based on these broad conclusions and recommendations, the DNRE recommends the following next steps be taken to address wet weather pollution:

1. A pilot project should be developed and implemented to address a specific water quality parameter. E. coli should be strongly considered for this pilot, as the detrimental effects are in both urban and rural areas. In addition there are established sampling methods, analytical techniques, and a numerical Water Quality Standard for E. coli.

2. A pilot project should be developed and implemented to address the flow quantity issue that impacts most urban streams. As a part of this project, incentives should be developed to aid in the implementation of activities that would help stream restoration.

3. Assess BMP effectiveness. This is currently being done to some extent by the USEPA. This assessment by the USEPA should be made a priority.

4. Consideration should be given to establishing monitoring requirements for wet weather pollution discharges that are under NPDES permit. This would assist in determining what impacts are likely from such discharges. However, such requirements need to be concisely directed with appropriate guidance developed to assist those sampling the discharges

5. A voluntary CMOM permit program should be developed, with incentives to encourage participation in the program.

Attachment A

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

INTEROFFICE COMMUNICATION

TO: Mike Worm, Mike Bitondo, Mike Person, Matt Campbell, Chris Alexander, Chris Babcock, Dave Drullinger, Bob Deatrick, Dick Mikula, Elli Hennessy, Chris Conn, John Suppnick, Steve Holden, Karen Boase, Amanda St. Amour, Keith Noble, Tom Knueve, Charlie Hill, Mark Fife, Christe Alwin, Dan Rockafellow, Jerry Saalfeld, Joe Bohr, Kevin Goodwin, Joe Rathbun, Stephanie Swart, Stephanie Kammer, Rachel Matthews, Eric Alexander, Sylvia Heaton, Mike Walterhouse, Erik Sunday, Bill Dimond, Jeff Fischer, Steve Casey

FROM: William Creal, Chief, Water Bureau

DATE: October 29, 2008

SUBJECT: Wet Weather Strategy Development

The purpose of this memo is to notify you of a new work group driven process within the Water Bureau (WB) to improve our understanding of issues related to wet weather discharges and develop a strategy to enable us to more effectively protect water quality from such discharges. Five work groups are being formed for this effort and you have been selected to participate on one or more of the work groups due to your knowledge and experience related to some aspect of wet weather discharges. A kick off meeting for all work group members is scheduled for December 5, 2008 from 9:00 a.m. to 4:00 p.m. in the Great Lakes Conference Room, 6th floor, Constitution Hall, Lansing. An agenda for the meeting is attached (Attachment 1). Please make every effort to attend.

The major surface water quality problems we currently face can be attributed to discharges associated with wet weather. We have struggled and continue to struggle with how to address the many issues related to such discharges. As such, our approach has been largely reactive rather than proactive. It is our desire to better understand these issues in order to move to a more proactive approach and put appropriate mechanisms in place to protect water quality. The work group process we have designed is intended to provide for a coordinated approach within the WB that draws on the expertise of staff from across the bureau to meet our wet weather program goals. Bureau managers have agreed to commit substantial resources to this effort and to be personally involved as sponsors of the work groups. The role of the sponsors is to ensure information is shared among the groups and guide the overall effort and that of the work groups.

The five work groups are:

- Wastes to Land - including programs dealing with septage, biosolids, groundwater discharge and animal feeding operations of all sizes
- Earth Change - including programs dealing with soil erosion and sedimentation, forestry, construction storm water, farming other than animal feeding operations

- Urban Living - including programs dealing with municipal and industrial storm water, combined and sanitary sewer overflows
- Wet Weather Monitoring - including ambient and discharge monitoring
- Water Quality Based Effluent Limits (WQBEL) Development and Water Quality Standards (WQS) Applicability

Work group assignments are provided in Attachment 2. Specific objectives for each of the work groups are provided in Attachment 3. We will be discussing these objectives and more about the work group process at our meeting on December 5.

Please contact your section chief if you have any questions about this process, or you may contact me. I look forward to seeing you all on December 5.

cc/attachments: Frank Baldwin
Jim Cleland
Elgar Brown
Dan Dell
Carrie Monosmith
Peter Ostlund
Diana Klemans
Mike Stifler
Jon Bloemker
Tim Benton
Cheryl Bartley
Mike Worm
Dave Timm
Phil Argiroff
Hae-Jin Yoon
Laura Verona
Jon Russell
Ric Falardeau
Brenda Sayles
Bob Day
Jim Janiczek
Barry Selden
Mike Bray
Eric Alexander
Dennis Bush

ATTACHMENT 1 (of memo)

WET WEATHER STRATEGY KICK OFF MEETING
December 5, 2008

Agenda

9:00 – 9:05	Welcome and Introduction
9:05 – 9:20	Charge to Participants
9:20 – 9:30	Wet Weather Issues, Examples
9:30 – 9:45	Questions/Discussion
9:45 – 9:50	Charge for Break Out Session
9:50 – 10:00	Break
10:00 – 11:30	Break Out Session
11:30 – 12:30	Lunch
12:30 – 1:00	Work Group Reports
1:00 – 1:10	Questions
1:10 – 1:15	Next Steps
1:15 – 4:00	First Work Group Meetings

ATTACHMENT 2 (of memo)

WET WEATHER WORK GROUP ASSIGNMENTS

Wastes to Land (Stevens Conference Room, 5 south)
Sponsors: Bill Creal, Carrie Monosmith
Lead: Mike Worm
Mike Bitondo, Mike Person, Matt Campbell, Chris Alexander, Chris Babcock, Dave Drullinger, Bob Deatrick

Earth Change (Sablich Conference Room, 5 south)
Sponsor: Frank Baldwin
Lead: Dick Mikula
Elli Hennessy, Chris Conn, John Suppnick, Steve Holden, Karen Boase, Amanda St. Amour

Urban Living (Staiger Conference Room, 5 south)
Sponsor: Pete Ostlund
Lead: Keith Noble
Tom Knueve, Charlie Hill, Mark Fife, Christe Alwin, Dan Rockafellow, Dave Drullinger

Wet Weather Monitoring (Great Lakes Conference Room, 6 south)
Sponsor: Dina Klemans
Lead: Jerry Saalfeld
Joe Bohr, Kevin Goodwin, Joe Rathbun, Stephanie Swart, Stephanie Kammer, Rachel Matthews

WQBEL Development and WQS Applicability (Great Lakes Conference Room, 6 south)
Sponsor: Dina Klemans
Lead: Eric Alexander
Sylvia Heaton, Mike Walterhouse, Erik Sunday, Bill Dimond, Jeff Fischer, Steve Casey

ATTACHMENT 3 (of memo)

SPECIFIC OBJECTIVES FOR WORK GROUPS

Wastes to Land, Earth Change and Urban Living Work Groups

- Augment the benchmarking information as needed
- Determine how water quality is protected (i.e. performance standards; specifically required best management practices [BMP]; BMPs selected by permittee; etc.)
- Identify specific BMPs routinely used as control devices
  - Are they required (by regulation or permit) or voluntary?
  - Do they have performance standards associated with them?
  - Is there technical information available to document their effectiveness?
- Determine whether programs related to your work group are proactive (i.e. actions are implemented before water quality problems occur) or reactive (i.e. a water quality problem occurs before an action is taken)
- Identify how success, improvement, and weakness are recognized
- Determine the best and worse parts of programs to deal with wet weather pollution related to your work group's topic
- Identify any information and education requirements for regulatory programs
- Identify the discharges/situations when WQBELs may be needed most
- Identify information and implementation gaps, and provide recommendations to fill them

Wet Weather Monitoring

- Augment the benchmarking information as needed
- Identify information gaps (related to wet weather monitoring) regarding the character of wet weather discharges provided by the Wastes to Land, Earth Change and Urban Living work groups and develop recommendations for filling the gaps
- Determine state of the art science for monitoring wet weather discharges and assessing their impacts on surface waters of the state (SWOS)
- Develop advice for determining what constitutes a "representative sample" of a storm water discharge of phosphorus and *E. coli* from a major discharge point (i.e. pipe or open conveyance of 36 inches or more at widest cross section) covered by the jurisdictional and watershed municipal separate storm sewer system permits
- Develop strategies for determining what constitutes representative samples of other wet weather discharges
- Identify the expected effects of the various types of wet weather discharges on physical, chemical and biological integrity of SWOS
- Develop strategies for designing specific monitoring projects to assess effects of wet weather discharges on SWOS
- Identify missing information, data, and technology required to implement wet weather monitoring
- Identify resource (i.e. personnel, analytical, equipment) and training needs to effectively implement wet weather monitoring of discharges and ambient water

WQBEL/WQS Work Group

- Augment the benchmarking information as needed
- Identify information gaps (related to WQBEL/WQS) regarding the character of wet weather discharges provided by the Wastes to Land, Earth Change and Urban Living work groups and develop recommendations for filling the gaps
- Identify flows at which WQS apply for important ‘wet weather pollutants’
- Prioritize the types of wet weather discharges where WQBELs are most needed
- Develop strategies for establishing WQBELs for wet weather discharges
- Determine whether models are needed to assist in establishing WQBELs and evaluate whether those currently used by WB staff are sufficient
- Identify missing information, data, and technology required to develop WQBELs
- Identify resource (i.e. personnel, analytical, equipment) and training needs to effectively develop WQBELs

Attachment 4 **(of memo)**

Charge to Wet Weather Work Groups

The overall goal of this process is to determine how to appropriately define and handle wet weather discharges to surface waters to meet Michigan's WQS. Your work group is to address the indicated specific area of this overall goal, with a focus on the specific objectives for your work group. The initial desired timeframe to complete the work group work is six months, but this may be adjusted as we see how progress is going on the objectives. Final documentation of your work will be needed to provide a foundation for going forward in this process.

Attachment B

List of Acronyms

AFO	Animal Feeding Operation
APA	Approved Public Agency
BACI	Before-After/Control-Impact
BAF	Bioaccumulation Factors
BAT	Best Available Technology
BCC	Bioaccumulative Chemicals of Concern
BCT	Best Conventional Technology
BEHI	Bank Erosion Hazard Index
BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
BPJ	Best Professional Judgment
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CAFO	Concentrated Animal Feeding Operation
CBOD	Carbonaceous Biochemical Oxygen Demand
CBOD 5	Carbonaceous Biochemical Oxygen Demand 5-day test
CEA	County Enforcing Agency
CFR	Code of Federal Regulations
CMOM	Capacity, Management, Operations
COC	Certificate of Coverage
COD	Chemical Oxygen Demand
CREP	Conservation Enhancement Reserve Program
CSO	Combined Sewer Overflow
CSW	Construction Storm Water
CWA	Clean Water Act
DDD	1,1-bix(4-chlorophenyl)-2,2-dichloroethane
DDE	Dichlorodiphenyl dichloroethane
DDT	Dichlorodiphenyl trichloroethane
DEQ	Department of Environmental Quality
DNRE	Department of Natural Resources and Environment
DO	Dissolved Oxygen

EAC	Environmental Advisory Council
EMC	Event Mean Concentration
EPA	Environmental Protection Agency
FAV	Final Acute Value
FCV	Final Chronic Values
FTE	Full-time Equivalent
GIS	Geographic Information System
IDEP	Illicit Discharge Elimination Program
ISW	Industrial Storm Water
LA	Load Allocation
LAW	Land Applied Waste
LID	Low Impact Development
MDEQ	Michigan Department of Environmental Quality
MDNRE	Michigan Department of Natural Resources and Environment
MEA	Municipal Enforcing Agency
MEP	Maximum Extent Practicable
MiSWIM	Michigan Surface Water Information Management
MS4	Municipal Separate Storm Sewer System
MWRC	Michigan Water Resources Commission
N	Nitrogen
NMS	NPDES Management System
NOC	Notice of Coverage
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NREPA	Natural Resource and Environmental Protection Act
NSWQD NSQD	National Storm Water Quality Database
NTU	Nephelometric Turbidity Units
OSRW	Outstanding State Resource Waters
P	Phosphorus
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
QAPP	Quality Assurance Project Plan

QA/QC	Quality Assurance/Quality Control
RPD	Relative Percent Difference
RTB	Retention and Treatment Basins
SESC	Soil Erosion and Sedimentation Control
SIC	Standard Industrial Classification
SSO	Sanitary Sewer Overflow
SWAS	Surface Water Assessment Section
SWPPI	Storm Water Pollution Prevention Initiative
SWPPP	Storm Water Pollution Prevention Plan
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TRC	Total Residual Chlorine
TSS	Total Suspended Solids
TTBEL	Treatment Technology Based Effluent Limits
TWTDS	Treatment Works Treating Domestic Sewage
UM	University of Michigan
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WARSSS	Watershed Assessment of River Stability and Sediment Supply
WB	Water Bureau
WET	Whole Effluent Toxicity
WLA	Waste Load Allocations
WQBEL	Water Quality Based Effluent Limitations
WQS	Water Quality Standards
WQX	Water Quality Data Exchange
WRD	Water Resources Division
WTL	Waste To Land
WWEC	Wet Weather Earth Change
WWMWG	Wet Weather Monitoring Work Group
WWTP	Waste Water Treatment Plant