Michigan has been experiencing changing precipitation patterns with an increase in large, intense storm events. The Great Lakes Integrated Sciences and Assessments (GLISA) reports that since 1951 total annual precipitation has increased by 14% in the Great Lakes region. Most attribute these increases to the impacts from climate change with greater changes expected in the future. WRD recognizes that uncertainty exists when evaluating climate change; however, areas of Michigan have already experienced the costly impacts from a changing climate in the form of flooding, damaged infrastructure, property loss, and degraded water quality.

In 2016, WRD developed the policy WRD-046 "Considering Climate Change in Water Resources Division Programs." Since that time, WRD programs have been working to consider climate change adaptation and mitigation measures to accomplish the goal of minimizing the detrimental effects of climate change on Michigan's water resources.

A series of requirements and recommendations were developed to begin planning for projected changes in wet weather patterns in Michigan. This document describes the following requirements and recommendations by program:

- Requirements to use the most up-to-date precipitation estimates available for permitted design storms (i.e., National Oceanic and Atmospheric Administration [NOAA] Atlas 14 as of this publication).
- Requirements to implement a resiliency factor as part of wet weather programs.
- Recommendations for water quality programs to increase awareness of climate change strategies and evaluate best practices for Michigan.
- Best management practice recommendations for the Resources Program.
- Support for periodic updates of precipitation estimates to account for temporal trends and develop adjustment factors using future climate model projections.

Wet Weather Programs

For the past several years, WRD has been considering climate change as part of the Combined Sewer Overflow (CSO), Sanitary Sewer Overflow (SSO), and Municipal Separate Storm Sewer System (MS4) Programs. The following are examples of updated program requirements to address observed increases in precipitation related to climate change and promote infrastructure resiliency.

- The post-construction performance standards for storm water runoff volume control at new development/redevelopment sites required in MS4 regulated areas were extended to the CSO area (or an approved alternative) to manage storm water runoff volume at the source (e.g., infiltration to the ground) and reduce the discharge to the combined sewer system. This approach promotes consistency in expectations for developers in areas served by separate storm sewers and areas served by combined sewers to reduce runoff volume off-site

and allows communities to better provide capacity within the combined sewer during wet weather events.

- The CSO, SSO, and MS4 Programs require the use NOAA Atlas 14 published in 2013 as the precipitation data source for the permitted design storms. The precipitation frequency estimates included in Atlas 14 reflect a greater period of recorded precipitation and denser data networks compared to previous precipitation data sources (e.g., Huff and Angel, 1992. Rainfall Frequency Atlas of the Midwest [Bulletin 71]. Illinois State Water Survey, Champaign, Illinois). The precipitation estimates for the permitted design storms using Atlas 14 generally increased for programs resulting in additional storage volume requirements.

GLISA climate models project the Great Lakes region will experience a greater increase in total precipitation in the future than most other regions of North America. Although progress has been made to address climate change and promote resilient wastewater and storm water infrastructure, the focus to date has been on updating regulatory requirements based on currently available precipitation data (i.e., Atlas 14). Moving forward, climate-driven changes in precipitation have the potential to significantly impact infrastructure, water quality, and public health and safety. Once installed, infrastructure often far exceeds the intended life span by decades; therefore, infrastructure designed for today must consider the future service or design life to withstand climate changes throughout the 21st Century.

WRD has determined that incremental actions are needed to continue to address the projected impacts and potential risks associated with climate change. The following sections define the updated regulatory requirements by wet weather program based on a review of supporting information from the Michigan Department of Transportation, regional planning agency groups, and research findings. A climate change resiliency factor (RF) is identified for each of the wet weather regulatory programs along with a schedule for implementation. The RF requires managing an incremental increase in volume above the permitted design storm for each program. The RF is necessary to responsibly design infrastructure to address future impacts associated with climate change.

Addressing additional volume as part of the CSO, SSO, and MS4 Programs is a step to creating more resilient infrastructure; however, adjustments to this approach will be needed to fully consider the future impacts and risks associated with climate change throughout the 21st Century. An ongoing review of available information is needed to ensure design standards reflect current and projected precipitation estimates to maintain the useful life of infrastructure and protect communities and water resources from increased risk. As a next step, WRD is planning to create stakeholder workgroups to continue discussing the effects of climate change on wet weather regulatory programs. The stakeholder workgroups will provide an opportunity for WRD and local

partners to learn from experiences throughout the state, share current information, and discuss future updates and actions.

The following sections identify the climate change RF for each wet weather regulatory program, including additional actions required and the schedule for implementation.

CSO Program

The CSO Control Program provides two primary options for controlling untreated CSOs. The first is completion of sewer separation projects that eliminate untreated CSO discharges. The second is to provide treatment facilities that provide for adequate treatment of overflows from combined sewers. Adequate treatment is met either presumptively or through a demonstration program that ensures that Michigan's water quality standards are met at times of discharge. Such projects result in treatment facilities often referred to as retention treatment basins (RTB). RTB discharges are treated discharges from facilities installed to collect, store, and adequately treat overflows. RTBs operate under National Pollutant Discharge Elimination System (NPDES) permits, to meet state and federal CSO control requirements.

The CSO Program includes requirements based on design storms, which inherently includes resiliency considerations. As precipitation data sets are developed or updated, resulting from consideration of additional precipitation data that has been collected, a particular design storm should reflect, to some degree, changes in rainfall. WRD has adopted NOAA Atlas 14 as the source for precipitation frequency estimates for the CSO Program. While updated precipitation frequency estimates may provide better planning for CSO correction, WRD has identified the importance of additional resiliency planning and considerations.

The following implementation strategy for the CSO Program considers the most current rainfall data, a RF to increase storage and treatment volume above current CSO design requirements and reducing the amount of storm water entering the combined sewer system. The regulatory basis and rationale for a RF is based on Section 4108(1) of Part 41, Sewerage Systems, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), which states, in part, that "the department shall exercise due care to see that sewerage systems are properly planned, constructed, and operated to prevent unlawful pollution of the streams, lakes, and other water resources of the state..." In addition, justification for additional control measures can be further based upon infrastructure resiliency, and to mitigate increased runoff volume and rainfall intensity resulting in the increased frequency of treated discharges or lesser treated discharge quality over time due to climate change.

CSO Program RF Implementation

- Use of the most up-to date precipitation frequency estimates (i.e., NOAA Atlas 14 as of this publication) or the selected design storm event.

- Inclusion of an RF to provide a 10 percent increase in storage volume for RTBs designed based on design storm.
- Inclusion of a requirement in NPDES permits, to apply MS4 post-construction performance standards in CSO areas that are within and/or adjacent to MS4 regulated areas. This requirement will further reduce the volume of storm water runoff to combined sewers.
- For RTBs designed based on influent sewer capacity, no storage increase required.

SSO Program

Discharges of raw or partially treated sewage from separate sanitary sewerage systems are illegal. State and federal regulations require either the elimination of such discharges, or treatment to the federal categorical secondary wastewater treatment standard. WRD acknowledges that total elimination or secondary treatment of all SSOs is not practical or economically feasible. WRD does not authorize the discharge of raw or partially treated SSOs. However, enforcement discretion will be considered for communities experiencing SSOs that are implementing a corrective action program which is equivalent to the remedial design standard (RDS). WRD has developed and implemented a SSO policy, via a stakeholder process, that establishes criteria for eliminating and correcting SSOs. The SSO Policy requires that separate sanitary sewerage systems provide adequate transportation and treatment for flows generated by the RDS. The RDS is defined as the 25-year, 24-hour precipitation event, using acceptable distribution (Soil Conservation Services type II, or equivalent), growth conditions (April 1 to November 1) and normal soil moisture.

WRD's SSO elimination approach includes requirements based on a design storm, which inherently includes resiliency considerations. As new precipitation data sets are established or updated, resulting from consideration of additional precipitation data that has been collected, a particular design storm should reflect, to some degree, changes in rainfall. WRD has adopted Atlas 14 for precipitation frequency estimates. While updated precipitation frequency estimates may provide better planning for SSO elimination and correction, EGLE has identified the importance of additional resiliency planning and considerations.

The following implementation strategy for the SSO Program considers the need for the most current rainfall data, a RF to increase storage volume above current SSO remedial design requirements, and where necessary, infiltration and inflow (I/I) removal in the collection system to ensure separate sanitary sewerage infrastructure is designed to handle 21st Century climate change. The regulatory basis and rationale for a RF is based on federal and state regulations that do not authorize the discharge of raw or partially treated SSOs.

SSO Program RF Implementation

- Use of the most up-to- date precipitation frequency estimates (i.e., NOAA Atlas 14 as of this publication) for the RDS.
- Inclusion of an RF to provide a 10 percent increase for design values determined using the RDS (storage volume, flows requiring transportation and treatment).
- Where appropriate, inclusion of a schedule in an NPDES permit to perform I/I removal in collection system. For systems determined to have flows that are in excess of the federal excessive I/I definition, require I/I removal in the collection system.
- Option to consider a 10 percent increase in rainfall used in hydrologic and hydraulic modeling. For this option, WRD would need to confirm that model assumptions are appropriate (i.e., not artificially reducing flows/volumes through parameter adjustments).

MS4 Program

MS4 permits include a requirement to maintain or restore stable hydrology in surface waters by limiting storm water runoff volume and rate from new development and redevelopment projects as part of a Post-Construction Storm Water Runoff Program. To meet this requirement, MS4 permittees must subject development projects to a Channel Protection Performance Standard (CPPS) focused on maintaining the pre-development runoff volume and rate up to the 2-year, 24-hour storm event for the post-development land use. The MS4 Program requires the use of NOAA Atlas 14 as the rainfall data source for the design storm. Best management practices (BMPs) are installed at the project site to manage the runoff volume (e.g., infiltration BMPs) and control the rate of discharge off-site. Once installed, BMPs are expected to have service lives that span decades with proper operation and maintenance.

Knowing the decades-long service life expected from BMPs and projected and realized increases in precipitation, a RF is necessary to begin making progress toward designing more resilient storm water infrastructure. This update requires an additional 10 percent of the calculated CPPS be managed at the project site, primarily through infiltration or offsets. Managing this additional volume is consistent with regional climate modeling, updated precipitation frequency estimates developed by neighboring states, and recent wet weather events in Michigan.

MS4 permittees have included language in recently updated post-construction design standards and ordinances providing the authority to require additional runoff volume control in areas where infrastructure cannot currently support wet weather conditions. WRD understands that not every site will be able to manage the CPPS and additional RF volume; however, the site plan review process must consider every opportunity to reduce runoff volume, including low impact development design, green infrastructure installation, distributing BMPs throughout the project site, and off-site BMPs.

The following implementation strategy for the MS4 program considers the need for current and projected rainfall data, an RF to increase runoff volume reductions above current MS4 permit requirements, and regional collaboration to ensure storm water infrastructure is designed to handle 21st Century climate change. The regulatory basis and rationale for a RF is based on Part 21, Rule 2161a(3)(e), which states, in part, that the ordinance or other regulatory mechanism shall be designed to prevent or minimize water quality impacts, including resource impairment resulting from extreme flow volumes and flow conditions, and shall include strategies for implementation of structural or non-structural, or both, best management practices appropriate for the community.

MS4 Program RF Implementation

- Continue support for regulations requiring an update to NOAA precipitation frequency estimates on a regular basis (e.g., once every 10 years).
- Inclusion of an RF to provide a 10% increase in the calculated CPPS runoff volume using current NOAA precipitation frequency estimates.
- Require the RF on all EGLE-funded storm water projects where channel protection is addressed.
- Require the RF in MS4 permits after the next round of MS4 permit reissuances expected to be complete in 2025 or as part of any new MS4 permit issuances.

Other Water Quality Programs

Concentrated Animal Feeding Operations (CAFO) Program

Certain types of CAFOs store production area waste in large, open air, storage structures. CAFOs are required to provide adequate storage for the wastes generated from the CAFO, along with precipitation events that come into contact with the waste. Currently, average monthly rainfall amounts are used in production area storage calculations for precipitation driven requirements. As the frequency and intensity of severe storm events in Michigan increases, CAFOs may be more susceptible to frequent, extreme precipitation events. Waste reduction from storage structures can be difficult during prolonged or frequent precipitation events due to permit restrictions for land applying CAFO waste on saturated ground, other unfavorable field conditions or due to standing crops being grown on those fields.

Moving forward, climate-driven changes in precipitation have the potential to significantly impact infrastructure, water quality, and public health and safety. Once installed, infrastructure often far exceeds the intended life span by decades; therefore, infrastructure designed for today must consider the future service or design life to withstand climate changes throughout the 21st Century.

The following recommendations for the CAFO program are focused on increasing awareness of climate change strategies and evaluating best practices for Michigan.

CAFO Program Recommendations

- Continue use of NOAA Atlas 14 precipitation frequency estimates for designing storage structures.
- Continue discussions with the Natural Resources Conservation Service to adequately address wet weather and climate resiliency strategies.
- Engage stakeholders to identify opportunities to manage CAFO waste to withstand climate changes throughout the 21st century and optimize waste handling during dry conditions.

Biosolids Program

Since 2011 Michigan wastewater treatment plants have generated as much as 338,000 dry tons of sewage sludge each year that must be disposed. Approximately 1/3 of that amount is beneficially used as land applied biosolids. Managed agricultural soils with biosolids can contribute to the mitigation of greenhouse gas emissions based on their potential to sequester carbon. The remaining amount is either dewatered and disposed in landfills or incinerated. Even if all the sewage sludge generated annually in Michigan were land applied as biosolids at a typical agronomic application rate of 3 tons per acre, this would treat just under 113,000 acres of agricultural fields. However, biosolids have not been a fully realized source of organic carbon. Of the 3,000,000 dry tons of biosolids disposed in Michigan between 2011 and 2021 only 30 percent were land applied. Increasing the percentage of biosolids that are land applied in Michigan should be part of a systematic approach to improve soil management and would use a currently available external source of stable organic carbon having the potential to increase soil organic carbon sequestration.

It is also recognized that the limited use of biosolids land application may in part be due to geographically related economic conditions where costs associated with transporting and application of biosolids to an end use field are higher than the disposal costs of biosolids via incineration or landfilling for some utilities.

Therefore, strategies must be developed to improve the quality of biosolids being generated at water resource recovery facilities throughout the state, as well as to create economic and environmental incentives that increase the use of land application, while reducing disposal of sewage sludge via incineration or landfilling. Such strategies align well with those of the Utility of the Future concept including the Nutrient-Energy-Water (NEW) Paradigm.

Biosolids Program Recommendations

- Strengthen pre-treatment requirements to further prevent non-beneficial contaminants from entering sewerage systems thereby reducing risk associated with biosolids.
- Develop strategies to encourage the recovery of beneficial nutrients such as nitrogen and phosphorus to enhance the beneficial qualities of biosolids while improving water quality through reductions in the discharge of such nutrients.

Resources Program

For the past several years, WRD has been considering climate change as part of the Resources Program through incorporating climate change adaptation best management practices. Best management practices are based on site-specific conditions and are part of program requirements to avoid and minimize impacts from construction activities. Climate change efforts in the Resources Program include:

- The laws administered by the Resources Program require that applicants consider alternative project locations and designs (including size, configuration, and methods) that will avoid and minimized impacts to wetlands, lakes, streams, and other regulated resources. In reviewing applications, EGLE must consider the extent and permanence of project impacts, as well as the societal benefits that will be affected or eliminated by a project (e.g., of flood storage, sediment removal, wildlife habitat, and nutrient cycling provided by a wetland). Furthermore, the Resources Program has been putting additional focus on areas where historical wetland loss has been high, as these areas are hardest hit from the impacts of climate change.
- Regulatory permit application reviews result in protection of significant amounts of wetlands, lakes, streams, and other regulated resources directly through the permitting process. In addition, compensatory mitigation is required when impacts are more than minimal. In some cases, the permanent protection and stewardship of remaining on-site water resources is also a condition of a permit.
- The Resources Program requires that culverts be properly sized to increase stream connectivity, decrease flooding and erosion, and provide aquatic organism passage which are all desired from a climate change adaptation perspective. Sizing to the bankfull channel has become the standard for the program, with additional capacity to 1.2 bankfull for increased floodplain connectivity and wildlife corridors being desired.
- Storm water management best management practices are regularly incorporated into permits issued in the Resources Program using the standards from WRD's wet weather programs. For example, applicants are required to consider green infrastructure alternatives to reduce the amount of storm water runoff from a site, including the incorporation of rain gardens, bioswales, green roofs, and impervious surfaces. Remaining storm water treatment provided through detention basins and other structural methods are required to be sized appropriately to treat runoff from the site, and manage quantity, quality, and rate of discharge to any regulated wetlands, lakes, or streams.
- Over the past several years, the Resources Program has incorporated best management practices to address the water quality and habitat impacts of shoreline protection. These best management practices include incorporation of natural shoreline techniques and buffer strips.

- Other best management practices included a condition of permits in the Resources Program include type and timing of construction methods, invasive species or vegetation restoration requirements, and others.
- The Resources Program has increased funding and staffing in its Dam Safety Program to help with better compliance with current dam safety requirements and with early detection of dam deficiencies. It has also introduced a new grant program to provide funding to reduce dam risks through repairs or removal. These are designed to result in less frequent dam failure events, which are largely driven by changing hydrologic events and aging infrastructure. Dams in Michigan are also required to be operated at run-of-river flows, which helps prevent flood surges or dam failures which might result in the dam operator passing too much or too little flow during a flood event.
- The Resources Program has incorporated climate change adaptation and resiliency measures into its grant programs. This includes a focus on measures to improve overall community and resource resiliency though improved planning at local, regional, and state levels and demonstration of resilient construction projects in the Coastal Management Program.
- The Resources Program has created a Voluntary Wetland Restoration Program is a partnership with the Department of Natural Resources to encourage the restoration of wetlands. Through this program, permit applications for wetland restoration projects are prioritized while ensuring that appropriate best management practices are incorporated.

Resource Program Recommendations

Continue to adapt the storm water management best management practices used to ensure that the RF described in the MS4 Program information and the most up-to-date precipitation frequency estimates (i.e., NOAA Atlas 14 as of this publication) described above will be incorporated.

Pursue legislative amendments to Part 315, Dam Safety, of the NREPA, that would change design standards that rely heavily on past rainfall data to determine the appropriate flow capacity of dams to standards that require high and significant hazard potential dams to safely pass flows based on theoretical maximum rainfall events. This will result in dams being designed to standards that provide much more resiliency against future changes in rainfall patterns and intensities.

Additional best management practices, adaptation strategies, and resiliency planning tools developed by the Resources Program can be found at:

- Climate Change Adaptation Plan for Coastal and Inland Wetlands in the State of Michigan White Paper
- Best Management Practices for Climate Change Adaptation: Spotlight on Michigan Coastal Wetlands
- Climate Change Adaptation and Local Planning Project
- Michigan's Resilient Coast