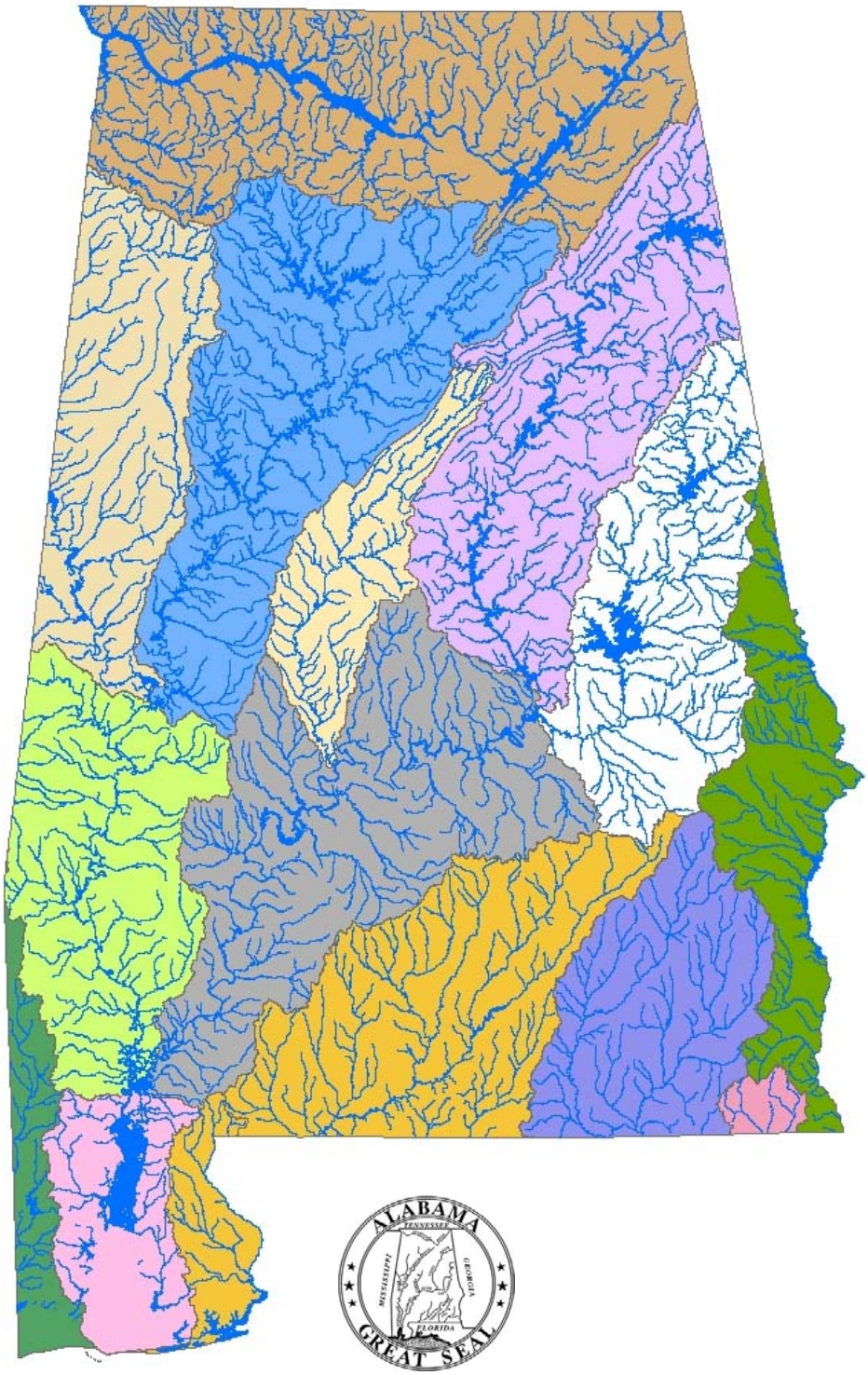
State of Alabama
Water Quality Monitoring Strategy



Alabama Department of Environmental Management
January 2017

State of Alabama

Water Quality Monitoring Strategy

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LIST OF ACRONYMS

ACNPCP	Alabama Coastal NonPoint Pollution Control Program
ADAI	Alabama Department of Agriculture and Industry
ADCNR	Alabama Department of Conservation and Natural Resources
ADEM	Alabama Department of Environmental Management
ADPH	Alabama Department of Public Health
AEMA	Alabama Environmental Management Act
AFO	Animal Feeding Operations
ALAMAP	Alabama Monitoring and Assessment Program
ALAWADR	Alabama Water Quality Assessment and Monitoring Data Repository
ASMC	Alabama Surface Mining Commission
ASSESS	ADEM Strategy for Sampling Environmental Indicators of Surface Water Quality Status
AU	Assessment Unit
AWIC	Alabama Water Improvement Commission
AWPCA	Alabama Water Pollution Control Act
AWW	Alabama Water Watch
BEACH	Beaches Environmental Assessment and Coastal Health
BMP	Best Management Practice
CAFO	Concentrated Animal Feeding Operations
CALM	Alabama's Consolidated Assessment and Listing Methodology
CBI	Compliance Bioassy Inspection
CDC	Centers for Disease Control
CSGWPP	Core Comprehensive State Ground Water Protection Program
CSI	Compliance Sampling Inspection
CWA	Clean Water Act
CWMP	Coastal Waters Monitoring Program
DEVAS	Data Evaluation and Assessment
EABT	Even Annual Basin Target
EAST	Even Annual Statewide Target
EPA	United States Environmental Protection Agency
FDA	Food and Drug Administration

LIST OF ACRONYMS (CONTINUED)

FOD	Field Operations Division
FTMP	Fish Tissue Monitoring Program
GAP	Groundwater Assessment Program
GDG	Generalized Disturbance Gradient
GSG	Generalized Stressor Gradient
GSA	Geological Survey of Alabama
GWPAC	Ground Water Programs Advisory Committee
HUC	Hydrologic Unit Code
IBI	Index of Biotic Integrity
IWQMAR	Integrated Water Quality Monitoring and Assessment Report
LA	Load Allocation
LDI	Landscape Disturbance Intensity Index
MU	Monitoring Unit
NCCA	National Coastal Condition Assessment
NED	National Elevation Dataset
NEP	National Estuary Program
NHD	National Hydrography Dataset
NLCD	National Land Cover Dataset
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NPS	Non-Point Source
NRCS	National Resource Conservation Service
NWCA	National Wetlands Condition Assessment
NWQMC	National Water Quality Monitoring Council
OEO	Office of Education and Outreach
OWR	Office of Water Resources
QAPP	Quality Assurance Project Plan
RRMP	Rivers and Reservoirs Monitoring Program
RSMP	Rivers and Streams Monitoring Program
SHU	Strategic Habitat Unit

LIST OF ACRONYMS (CONTINUED)

SIC	State Indirect Discharge
SOP	Standard Operating Procedures
SPCC	Spill Prevention Control and Countermeasure
SRRU	Strategic River Reach Unit
STORET	Storage and Retrieval Database
SWQMP	Surface Water Quality Monitoring Plan
TMDL	Total Maximum Daily Load
TSS	Total Suspended Sediment
TVA	Tennessee Valley Authority
UIC	Underground Injection Control
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WD	Water Division
WDG	Watershed Disturbance Gradient
WFMU	Wadeable Flowing Monitoring Unit
WLA	Waste Load Allocation
WMP	Watershed Management Plan
WMP	Wetlands Monitoring Program
WQB	Water Quality Branch
WQS	Water Quality Standard

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INTRODUCTION

In 2003, the U.S. Environmental Protection Agency (EPA) released *Elements of a State Water Monitoring and Assessment Program* (2003). The purpose of this document was to outline basic recommended components for monitoring programs performed by states receiving Clean Water Act (CWA) §106 funds. States are required to develop a formal written monitoring strategy that addresses ten broad categories: Monitoring Strategy, Objectives, Design, Water Quality Indicators, Quality Assurance, Data Management, Data Analysis and Assessment, Reporting, Programmatic Evaluation, and Support Planning. Each state's monitoring strategy document should describe how the state is currently incorporating the "Ten Elements" recommendations in their monitoring programs, identify elements not sufficiently addressed, and outline a ten-year timeline for full implementation of these missing elements. The desired effect of the "Ten Elements" is the development and implementation of more comprehensive monitoring strategies by each state and enhanced comparability of data and assessments on a national scale.

In the following document, the Alabama Department of Environmental Management (ADEM) presents an overview of how its monitoring programs will address the "Ten Elements" recommendations, 2015-2019. These are presented in Sections I-X. Section XI provides a timeline of relevant past, current, and future monitoring activities and the date, or projected date, of incorporation into monitoring programs. Section XII provides a summary of the ten elements information for each of the ADEM individual monitoring programs.

The first ADEM monitoring strategy was developed in 1997. Originally entitled 'The ADEM Strategy for Sampling Environmental Indicators of Surface Water Quality Status' or '*ASSESS*', the strategy was implemented on a five-year rotation cycle. An integral part of *ASSESS* was a thorough review of the Strategy at the end of each monitoring cycle. As part of the ADEM Monitoring Strategy review process, personnel from the Field Operations Division (FOD), Water Division (WD) and Office of Education and Outreach (OEO) met in 2004 to review results from the first five-year monitoring cycle. The purpose of the 2004 meeting was to conduct a comprehensive review of the ADEM surface water quality monitoring programs, to include identification of data needs not met by *ASSESS*, and discussion of potential changes to the monitoring design that could address these needs. Based on the identified needs and recommendations, the Monitoring Strategy was revised, updated, and implemented in 2005. A

second comprehensive review, revision, and update was completed in 2011-2012, having been delayed one year by extensive tasks required by the Deepwater Horizon oil spill to the Gulf of Mexico in 2010.

The 2015 Monitoring Strategy is intended to be the next step in an ongoing, iterative planning process. The Strategy sets forth a 5-year plan to address the "Ten Elements" and is based on the in-depth review of the 2005-2014 dataset completed by ADEM, 2014-2015. This strategy document continues to build on existing monitoring capabilities and progress towards addressing all state waters over time. ADEM views each 5-year Monitoring Strategy as an opportunity for long-term planning and to that end, includes discussion of future initiatives and a timeline to address incremental improvements necessary to incorporate requirements outlined in the 10 Elements document, and to satisfy monitoring goals and requirements pursuant to the Alabama Water Pollution Control Act (AWPCA), the Alabama Environmental Management Act (AEMA), and the federal Clean Water Act (CWA).

I. MONITORING PROGRAM STRATEGY

The ADEM has maintained a surface water quality monitoring program since 1974, but did not develop a coordinated monitoring strategy until 1997, with the publication of the *ASSESS* document. This document was developed in an effort to focus and document the Department's surface water quality monitoring mission. The strategy was updated in 2005, with the 2003 EPA *Elements of a State Water Monitoring and Assessment Program* as the basic framework. The 2005 Strategy outlined quality assurance plans, data management, data analysis, reporting, program review, and overall resource needs. The objectives and design of the Strategy were summarized in the Monitoring Objectives and Monitoring Design sections of the document.

The ADEM 2005 Monitoring Strategy was a coordinated monitoring approach designed to characterize water quality, to identify impacts from a variety of sources, and to provide a systematic and integrated framework for gathering necessary information to support the ADEM decision-making processes. The Strategy was comprised of four programs defined by wadeability and waterbody type:

- the Rivers and Streams Monitoring Program (RSMP), wadeable rivers and streams,
- the Rivers and Reservoirs Monitoring Program (RRMP), nonwadeable rivers and reservoirs,
- the Coastal Waters Monitoring Program (CWMP), coastal waters and
- the Wetlands Monitoring Program (WMP), wetlands.

Each program incorporates specific protocols and methodologies to ensure that monitoring activities provided the highest quality information and made the most efficient use of available resources. To the extent possible, the protocols and methods used in each program corresponded with the minimum data requirements for each waterbody type in Alabama's Listing and Assessment Methodology. The overall strategy was implemented on a 5-year rotation by basin and incorporated a combination of targeted, probabilistic, and long-term monitoring stations to meet state monitoring goals and objectives. Concentrating monitoring in one basin group enabled ADEM to identify opportunities to meet multiple monitoring objectives at a single site, increasing overall efficiency. It also created a comprehensive dataset to develop the criteria and indicators

needed to meet other ADEM objectives. This approach was continued in the 2012 Monitoring Strategy, providing statewide data from two full monitoring cycles.

The ADEM began development of the 2015 Monitoring Strategy in 2014, with a comprehensive review of the 2005 and 2012 Strategies. The review was conducted by personnel from the FOD, WD, and the OEO to ensure that the Strategy met overall monitoring objectives, as well as the objectives of the assessment/§303(d) listing, Total Maximum Daily Load (TMDL), and Non-Point Source (NPS) programs; to identify the Department's 2015-2019 monitoring priorities; and revise the Strategy as needed to meet these new priorities. At the same time, the Assessment/§303(d), TMDL, and NPS were also undergoing internal reviews to identify priorities for these programs. The ADEM used these individual reviews as an opportunity to improve coordination among these programs to facilitate assessment and restoration.

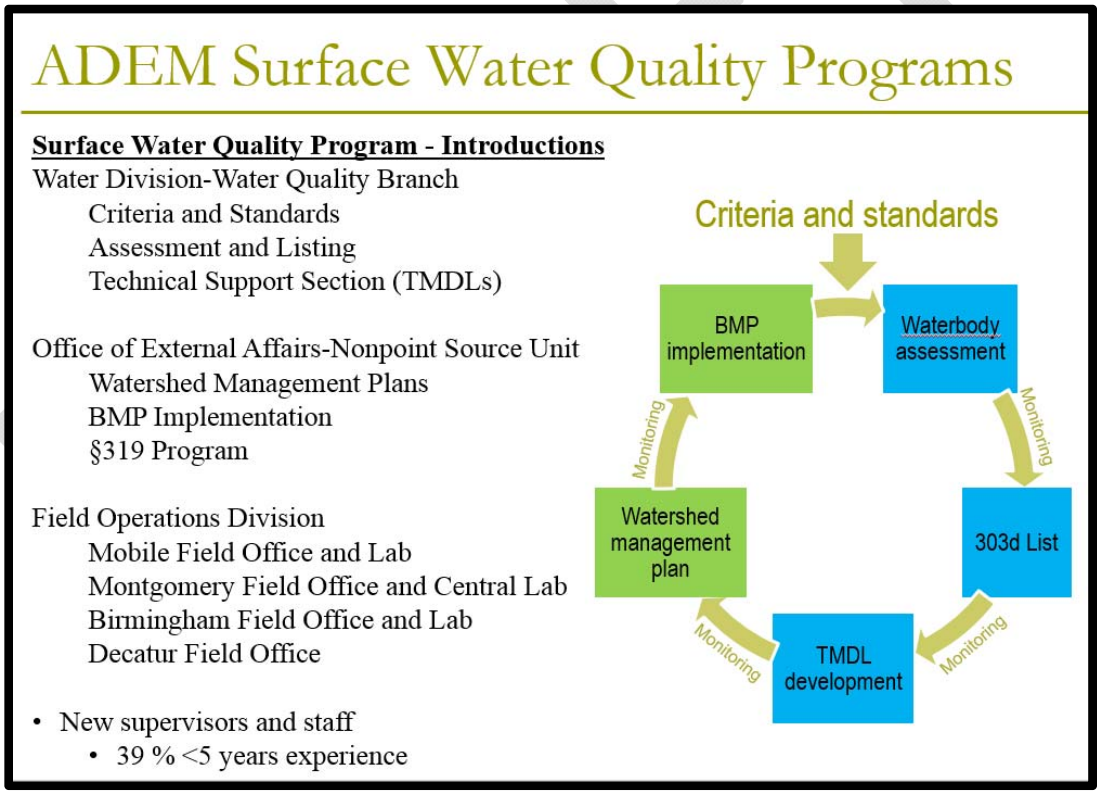

Figure 1. ADEM Surface Water Quality Programs

Priorities identified by the Department during this process included monitoring impaired, unimpaired, and un-assessed waters, evaluating the effectiveness of restoration efforts, and

collaborating with partner agencies and stakeholders when possible. The ADEM 2015-2019 monitoring priorities are described more fully in Section II Monitoring Objectives.

Progress made during the last 10 years, and changes to program priorities within ADEM and EPA, will allow ADEM to conduct monitoring statewide each year, while continuing to meet the ADEM monitoring goals over a five-year period. This change will enable ADEM to provide frequent, intensive monitoring within each basin group to more accurately measure trends in water quality before and after implementation of restoration efforts, respond to data needs more quickly, and to minimize the impact of weather-related events on data collected within any one basin. Statewide monitoring enables ADEM to continue to concentrate efforts on development of indicators and water quality standards for additional stressors and waterbody types. It also provides a level of consistency year-to-year that makes better use of the ADEM four field offices and laboratories, and provides better opportunities for young staff to gain training and experience.

II. MONITORING OBJECTIVES

The objectives of the ADEM Monitoring Strategy are consistent with the CWA, as well as Alabama's statutory and regulatory monitoring requirements and data needs. They are applicable to all waters of the State, including wadeable rivers and streams, nonwadeable rivers and reservoirs/lakes, estuaries, coastal waters, wetlands, and groundwater. The programs are designed to support management decisions and priorities, and to meet Alabama's statutory and regulatory monitoring requirements and data needs. They provide technically sound data and information for the development and implementation of new criteria and indicators, TMDLs, Waste Load Allocations (WLAs), and Watershed Management Plans (WMPs), as well as permit compliance and enforcement.

The objectives of the ADEM Monitoring Strategy can be described in seven broad categories:

1. Establish, review, and revise water quality standards;
2. Determine water quality standards attainment;
3. Identify high-quality waters;
4. Identify causes and sources of water quality impairments;
5. Evaluate program effectiveness;
6. Estimate water quality trends; and,
7. Estimate overall water quality.

A brief description of each of these broad objectives follows.

1. Establish, review, and revise water quality standards

Data collected as part of the ADEM Monitoring Strategy are used to develop and refine use classifications and water quality standards. The data are used to determine designated uses that can be supported or attained and for the establishment of criteria to protect existing designated uses. A primary goal of the ADEM 2005, 2012, and 2015 Monitoring Strategies is developing a comprehensive dataset that can be used to develop biological, nutrient, and sediment criteria and water quality standards. To meet this goal, natural reference conditions are identified on an ecoregion basis for refinement of water quality standards.

2. Determine water quality standards attainment

Alabama has defined seven designated uses for all surface waters and criteria intended to protect these uses. Designated uses are listed in Chapter 335-6-11 of the ADEM Water Quality Program regulations; water quality standards are listed in Chapter 335-6-10 of these regulations. Both are available from the ADEM website at: http://www.adem.alabama.gov/programs/water/waterquality.cnt. The assessment process is described more fully in Alabama's Consolidated Assessment and Listing Methodology (CALM). The CALM is updated every other year, and included in Alabama's Biennial Integrated Report to Congress, also available at: http://www.adem.alabama.gov/programs/water/waterquality.cnt.

All Alabama waters are assigned to one or more designated uses. Attainment of water quality standards is determined by comparing collected data to both the numeric and narrative criteria established for its highest use classification. These data include physical, chemical, and biological data. The data are used to place each monitored location into one of five categories, with category 1 "Fully Supporting" all use classification criteria and category 5 "Not Supporting" one or more use classification criteria. In addition, this same process is used during Use Attainability Analyses to help determine the highest use classification that a waterbody can be reasonably expected to achieve.

Monitoring is conducted to assess attainment of water quality standards within specific waterbodies or waterbody segments. Alabama's CALM and the ADEM monitoring programs are designed to complement each other, so that the sampling routinely conducted at each site meets or exceeds the minimum data required to fully assess each monitoring location, generally within one year of sampling.

3. Identify high-quality waters

The overall objective of the Clean Water Act is defined in Section 101(a): To restore and maintain the chemical, physical, and biological integrity of the Nation's waters. The routine monitoring conducted at each site enable ADEM to identify high quality Tier 2 waters, where water quality is better than the levels necessary to support the existing use classification(s) within the waterbody.

The ADEM partnered with Mobile Bay National Estuary Program (NEP), the Geological Survey of Alabama (GSA), EPA Headquarters, and other state and federal agencies and stakeholders to conduct a Healthy Watersheds Assessment of Mobile Bay and all Alabama waters as an additional tool for identifying high quality waters (EPA 2014). High-quality waters identified by stakeholders, volunteer organizations, or other state and federal agencies are prioritized for monitoring. The ADEM monitors a network of minimally- and least-impaired ecoregional reference reaches throughout the state. Data collected from these waters are used to define site classes and to establish a basis of comparison to apply narrative criteria on an ecoregional basis. The ADEM uses GIS information to find areas with high percent natural and forested land cover, and public lands. These sites are classified as candidate reference reaches. See Appendix B for a detailed summary of the ADEM Ecoregional Reference Reach Network.

4. Identify the cause(s) and source(s) of water quality impairments

The ADEM monitoring strategy is designed to identify waterbodies or waterbody segments that do not meet water quality standards. The strategy meets the Department's minimum data requirements to fully assess each monitoring location, generally within one year of sampling, to include identification of the cause(s) and source(s) of impairment; this is essential to listing the waterbody as impaired, and developing TMDL(s) and WMPs to restore the waterbody. Additional data are collected as needed for this purpose. Waterbodies or segments where a cause and/or source of impairment cannot be determined are prioritized for further monitoring.

5. Evaluate program effectiveness

Specific and intensive monitoring conducted to evaluate program effectiveness was identified as a 2015 Monitoring Strategy priority. These types of studies include monitoring conducted to determine if permits are within appropriate limits, TMDL changes have been effective, or non-point source control practices have resulted in improvements, etc. This type of survey has been conducted since the inception of the ADEM monitoring programs. The ADEM is investigating methods to accurately monitor and document small, incremental improvements towards fully meeting all designated uses.

6. Estimate water quality trends

Long term trends in water quality can be estimated for any of the ADEM fixed monitoring locations, including its intensive and compliance sampling stations sampled as part of its Rivers and Reservoirs Program, Rivers and Streams Program, and Coastal Waters Monitoring Program. A network of 89 long-term ambient trend sites are also sampled to identify trends in water quality statewide and to provide data for the development of TMDLs and water quality criteria. See Appendix A for detailed summary of the ADEM ambient trend network.

7. Estimate overall water quality

The ADEM maintains a network of approximately 990 monitoring sites that together, represent all of the downstream-most wadeable, flowing streams throughout the state. A subset of these sites are sampled each year to reflect both overall water quality conditions, as well as the complete gradient of potential human disturbances. The ADEM is investigating methods to use this information in conjunction with physical, chemical, and biological data to estimate overall water quality on basin, statewide, and regional scales.

In addition, the ADEM participates in the National Coastal Condition Assessment (NCCA), an EPA probabilistic monitoring survey conducted every five years nation-wide. The purpose of the assessment is to determine the condition of estuarine waters and coastal resources both on a state and national scale.

2015-2019 Goals

These objectives have remained relatively consistent since the 1997 ASSESS document was published. However, on December 5, 2013, the EPA announced a new collaborative framework for implementing the Clean Water Act (CWA) §303(d) program (EPA 2013). In this framework, the EPA provided states with much more freedom to define their own program goals and approaches to problems. Through the extensive review of the 2005 and 2012 Monitoring Strategies conducted in 2014-2015, the ADEM defined seven specific priorities for 2015-2019:

1. Develop numeric nutrient criteria, concentrating on tributary embayments, estuaries, and coastal waters;
2. Develop tools to assess siltation impacts, develop siltation TMDLs, and track restoration efforts;

3. Continue to develop chemical, physical, and biological metrics and indicators;
4. Continue to collect data to define natural or background conditions, particularly within wetland and blackwater systems;
5. Establish reference reaches in protected areas;
6. Monitor waters in all five categories; and,
7. Monitor the effectiveness of implemented watershed management plans and TMDLs.

In addition to these priorities, the Department identified three over-arching goals to improve ADEM water quality monitoring programs. These included,

a) improve coordination and communication among the individual monitoring, assessment/listing, TMDL, and NPS programs,
b) provide opportunities, training, and experience to young staff in overall planning, and,
c) collaborate with agency partners and stakeholder groups to meet common goals.

These three goals are discussed more fully in Sections IX. Programmatic Evaluation and X. General Support and Infrastructure Planning.

III. MONITORING DESIGN

The current ADEM monitoring strategy is a coordinated monitoring approach designed to characterize water quality, identify impacts from a variety of sources, and provide a systematic and integrated framework for gathering necessary information to support the ADEM decision-making processes. The monitoring strategy is currently comprised of four programs defined by waterbody type, tidal influence, and wadeability; the RSMP (wadeable rivers and streams), the RRMP (nonwadeable rivers and reservoirs), the CWMP (coastal waters) and the WMP (wetlands). The objectives and monitoring design of each program are summarized in Section XII. The key aspects of the ADEM overall strategy are described below.

Basin Groups

The ADEM Basin Groups, used by the Department since 1996, are an important component of the 2015 Strategy. In 2014, a small change was made to the Escatawpa/Mobile/Tombigbee and SE Alabama (SEAL) River Basin Groups. The Perdido River Basin was added to the Escatawpa/Mobile/Tombigbee (EMPT) River basins, based on the planning and reporting needs of both the EMPT and the SEAL (Figure 2).

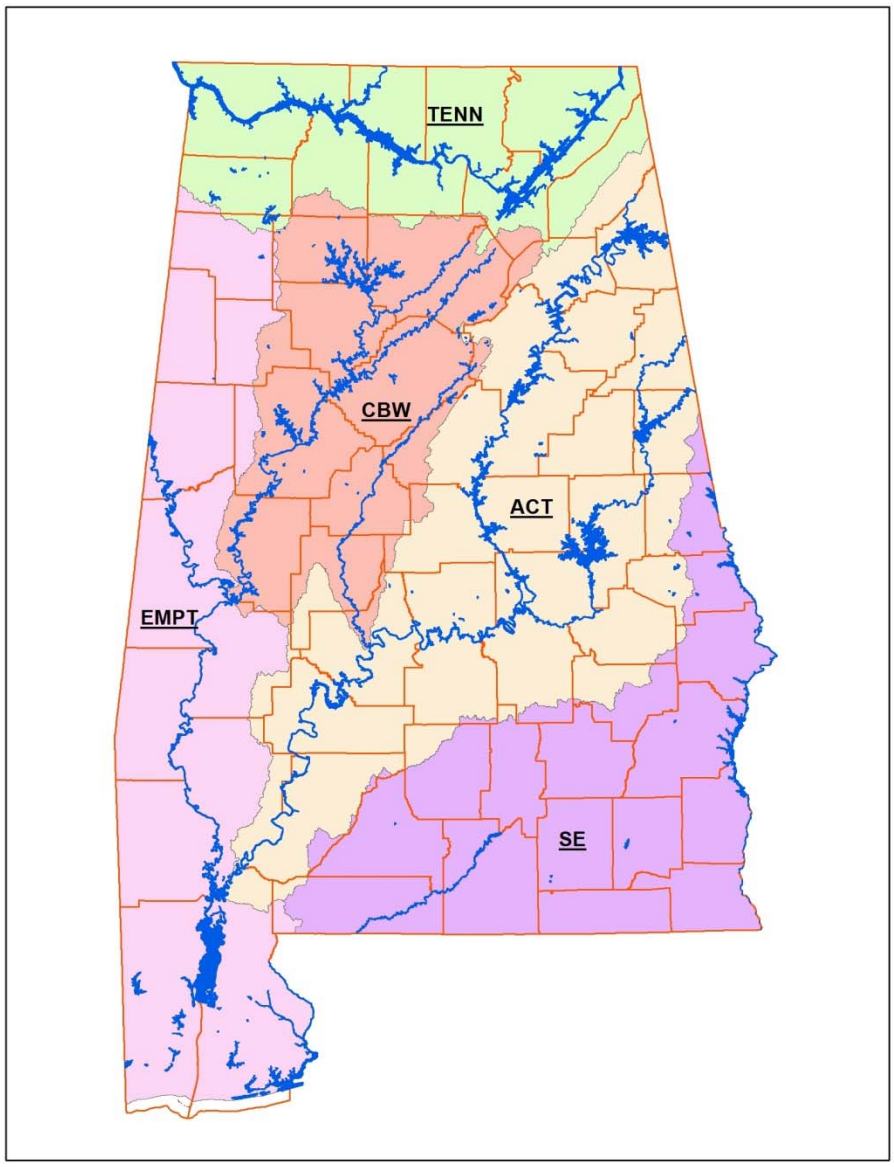

Figure 2. Basin groups of the 2015 Monitoring Strategy: ACT-Alabama, Coosa and Tallapoosa River Basins; CBW-Cahaba and Black Warrior River Basins; EMPT-Escatawpa, Mobile, Perdido, and Tombigbee River Basins; SE-SE Alabama River Basins; TENN-Tennessee River Basin.

Monitoring Targets

Two targets are used to plan surface water monitoring each year. The ability to reach these targets is dependent on available resources.

Even Annual Statewide Target (EAST): The ADEM set a statewide target number of approximately 320 monitoring locations, based on analysis of the 2010-2014 stations and

samples. This number represents the average number of locations monitored annually during this timeframe (the last 5-year basin rotation).

Even Annual Basin Targets (EABT): The ~320 monitoring locations were divided among the five basin groups. The target number of stations for each basin group was based on the average number of stations monitored in that basin group, 2010-2014.

These approaches enable ADEM to provide more frequent, intensive monitoring to stakeholders within each basin, and to accurately measure trends in water quality over time. They also provide level loading each year for the ADEM labs and field offices, making better use of available resources. Spreading data collection for each basin group over a five year period may also lessen the impact of extreme weather events on the dataset collected within any one basin.

Monitoring Schedule

Between 1996 and 2014, monitoring was conducted on a 5-year rotation by basin group. The basin rotation concentrated monitoring conducted for all programs into one basin group, making the most of limited resources and increasing overall program efficiency. It also enabled ADEM to develop a comprehensive dataset for indicator and criteria development.

The 2015 Strategy changes this approach in two ways:

The RSMP was revised to conduct monitoring within each of the five basin groups each year. Progress made in indicator and criteria development and documentation of reference conditions throughout the State during the last ten years make this change possible. Progress made in TMDL development and NPS restoration efforts make this change necessary.

The RRMP, CWMP, and FTMP were revised to conduct statewide monitoring on a 3-year basin rotation. The rotation provides two full sets of data for the IWQMAR over the six-year assessment period, as defined in the CALM. It also provides a comprehensive, multi-year dataset for the development and implementation of nutrient criteria in reservoir embayment and estuary systems. Maintaining a consistent and achievable level of effort year-to-year was an important factor in establishing the rotation.

Inventory of Surface Water Resources

Alabama is faced with a tremendous challenge to accurately monitor and report on the condition of approximately 129,769 miles of perennial and intermittent streams and rivers, 463,587

acres of publicly-owned lakes and reservoirs, 610 square miles of estuaries, 50 miles of coastal shoreline, 2.3-3.1 million acres of wetlands, as well as groundwater reserves estimated at about 533 trillion gallons. To date, 1,493 assessment units and 1,484 12-digit HUCs have been delineated statewide.

12-digit HUCs

The ultimate goal of the Department is to implement a comprehensive monitoring program that serves all water quality needs and addresses wadeable rivers and streams, nonwadeable rivers and reservoirs, estuaries, coastal areas, wetlands, and groundwater to the extent allowed by available resources. To assist with this process, the 2015 Monitoring Strategy uses 12-digit HUCs to plan, prioritize, and track monitoring activities statewide. To the extent possible, sites are located to fully assess each 12-digit HUC.

Site Selection

In very general terms, the ADEM Monitoring Strategy incorporates a combination of long-term fixed network sites, targeted sites, and monitoring units:

- The ADEM has established networks of long-term, fixed monitoring sites that became part of the RSMP, RRMP, and CWMP. They are permanent monitoring locations established to identify long-term trends in water quality, develop TMDLs and water quality standards, and establish regional "reference" conditions for comparison with other similar waterbodies. Several changes were made to these networks to support the 2015-2019 Monitoring Strategy priorities. These changes are fully discussed in Appendix A.
- The ADEM maintains two networks of monitoring units to estimate overall water quality within its coastal area and wadeable rivers and streams. A subset of each of these networks is sampled to reflect overall water quality conditions. These two networks are more fully described in the RSMP and CWMP summaries provided in Section XII.
- Targeted sites are incorporated into the RSMP, RRMP, CWMP, and WMP. They support the 2015-2019 monitoring priorities, and are selected by the ADEM Water Quality Branch (WQB), NPS Unit, FOD, other local, state or federal agencies, the

Clean Water Partnership of Alabama, or volunteer groups to provide data for use support and assessment, TMDL development, program evaluations, use attainability analyses, or education and outreach. These sites are monitored on a short-term basis, generally one to five years.

Sampling Protocols

The ADEM monitoring programs are defined by wadeability and waterbody type: wadeable rivers and streams (RSMP), nonwadeable rivers and reservoirs (RRMP), coastal waters (CWMP), and wetlands (WMP). Each program incorporates specific protocols and methodologies to ensure that monitoring activities provide the highest quality information and make the most efficient use of available resources. The protocols and methods used in each program correspond with the minimum data requirements for each waterbody type in Alabama's Listing and Assessment Methodology. They are specified in ADEM's annual Surface Water Quality Monitoring Plan (SWQMP) and 5-year Quality Assurance Program Plan (QAPP).

Communication

An important aspect of the ADEM Monitoring Strategy is communication. The ADEM 1997 Monitoring Strategy established a process of internal programmatic review and communication as an integral part of each 5-year monitoring cycle. Since 2005, this process has included a Monitoring Coordinator, as well as a small group of surface water quality program managers in the ADEM FOD, WD, and NPS. In 2014, Basin Teams were developed to improve communication among project managers, field staff and ADEM management within FOD, WD, and NPS. Surface Water Quality Facilitators were also appointed to ensure consistency among the teams. The roles and responsibilities of each entity are described below.

Surface Water Monitoring Coordinator: A Departmental Surface Water Quality Monitoring Coordinator was appointed in 2005 to improve communication within ADEM and with other agencies, and to ensure consistency in monitoring activities. A primary contact was also established for the Central and Branch Field Offices to assist with coordination and communication throughout ADEM.

Surface Water Quality Program Managers: Surface Water Program Managers within FOD, WD, and NPS are responsible for setting Surface Water Program goals and objectives in terms of

assessment and listing, TMDL development, restoration, criteria development, and monitoring. They review Monitoring Strategy results from the previous five-year monitoring cycle, identify data needs that were not met by the previous 5-year monitoring strategy, discuss and prioritize the goals of the next 5-year monitoring strategy, and determine how best to meet these goals.

Surface Water Quality Facilitators: Senior-level staff or management responsible for implementing the Monitoring Strategy, developing tools to assist the Basin Teams with the development of the Annual Surface Water Quality Monitoring Plan, and answering questions and addressing issues as needed.

Basin Teams: Basin Teams are comprised of the Basin Coordinators and project managers within FO, WQB, and the NPS, and field staff from each field office conducting monitoring within that basin. Responsibilities of the Basin Team include development of the annual basin plan for their respective basin group, tracking and documenting Surface Water Quality Monitoring Plan (SWQMP) decisions and revisions, basin team status summaries, data requests and reviews, and review of final reports. They also meet in the fall to review the SWQMP results, identify any data needs that were not met, discuss and prioritize the goals for the following year, and other factors that need to be considered during the development of each annual SWQMP, which summarizes the sampling locations, sampling frequencies, and sampling parameters to be monitored in the coming year.

Participation in Basin Teams provides opportunities for team members to become familiar with the data needs and issues within their basin, and supports the ADEM goal of providing a high performance work environment for staff. It also provides extensive opportunities for staff training and experience.

Field Operations Division continues to support the Department's Strategic Operations goals of building credible relations with external stake holders. Every two years, ADEM hosts the State Agency Water Quality meeting to improve communication and coordination among all agencies involved in water resource and water quality activities. In addition, a primary goal of ADEM surface water programs is to support common program goals as effectively and efficiently as possible by coordinating monitoring efforts among partner agencies and stakeholders throughout Alabama, and by monitoring of priority waters identified by these entities.

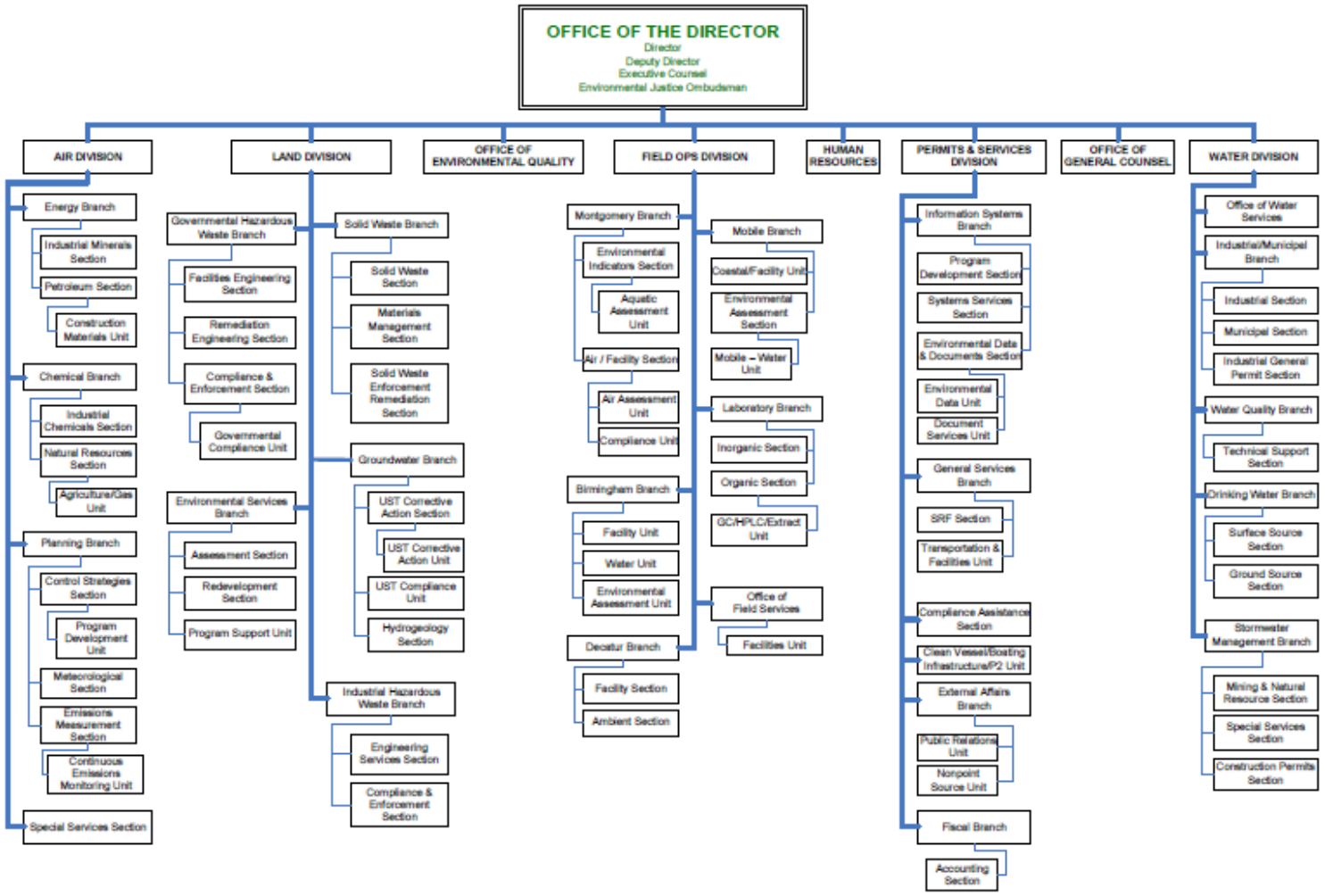

Figure 3. ADEM Organizational Chart.

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IV. CORE AND SUPPLEMENTAL WATER QUALITY INDICATORS

EPA guidance calls for state monitoring programs to include "a core set of baseline indicators selected to represent each applicable designated use, plus supplementary indicators selected according to site-specific or project-specific decision criteria." ADEM addresses these requirements in *Alabama's Biennial Consolidated Assessment and Listing Methodology (CALM) (ADEM 2014a; ADEM 2014b)*. Core criteria are determined by use classification, wadeability, and tidal influence. These documents are included in the Biennial Integrated Report to Congress, and available at: (http://www.adem.alabama.gov/programs/water/waterquality.cnt).

Since 2005, the ADEM Monitoring Strategy has been designed, to the extent possible, to meet the minimum data requirements outlined in the CALM, so that all stations monitored can be fully assessed and categorized in the Integrated Report. Review of the ADEM 2005-2014 dataset led to revisions that improved coordination among the individual surface water programs. The review revealed some minimum data requirements that the Department was unable to meet within a one-year timeframe. Minimum data requirements for assessment of these parameters were modified to better reflect routine monitoring. In some cases, review of the 2005-2014 dataset and current data needs led ADEM to adjust its routine monitoring to better meet the needs of the assessment process. Core and supplemental indicators collected to assess coastal, non-wadeable rivers and reservoirs, wadeable rivers and streams are summarized at the end of each program description in Section XII.

By conducting intensive monitoring of chemical, physical, and biological indicators over a range of watershed conditions, the ADEM 2005 and 2012 Monitoring Strategies developed a comprehensive dataset to make more informed decisions regarding whether a waterbody is meeting its designated uses, as well as to refine existing water quality criteria to better protect these uses, and to continue to refine the ADEM bioassessment methods, indices and criteria for wadeable streams and rivers. Using this approach, the ADEM collected the data necessary to develop statewide indices for its Wadeable Multi-habitat Macroinvertebrate Bioassessment method. Additionally, the Geological Survey of Alabama (GSA), in cooperation with the ADEM and the Alabama Department of Conservation and Natural Resources (ADCNR), completed development and calibration of Alabama's Fish Community Index of Biotic Integrity (IBI), a comprehensive fish community bioassessment tool for use in wadeable, flowing streams and rivers throughout the

State. In the 2016 CALM, the IBI is used as supplemental data when available. The ADEM is currently investigating how to more fully integrate these tools into the assessment process.

ADEM 2015-2019 Surface Water Program Priorities

The ADEM is currently developing indicators that support the 2015 Monitoring Strategy priorities identified during the programmatic reviews.

Development of numeric nutrient criteria for tributary embayments, estuaries, and coastal waters: The ADEM is currently monitoring reservoir embayments and estuaries to provide data to develop criteria for these waterbody types in 2017 and 2018, as outlined in Alabama's Nutrient Criteria Implementation Plan. Monitoring these waterbodies will provide data to establish nutrient criteria and standards, to assess overall water quality, and may also serve as an indicator of water quality in upstream tributaries to provide a basis for establishing nutrient criteria protective of upstream uses. The ADEM is conducting 72-hr diurnal dissolved oxygen surveys within reservoir embayments. The surveys are conducted in accordance with the RRMP and CWMP 3-year basin cycles.

Development of siltation indicators: There are 55 water bodies listed for siltation (habitat alteration) on Alabama's 2016 §303(d) list of impaired waters. These impairments are visually evident in the stream, and evident in the assessment of the biological communities. However, high concentrations of total suspended solids or turbidity in either wadeable or non-wadeable streams may not be reliably measured during baseline water quality monitoring conducted monthly through the growing season.

ADEM is in the process of developing and testing rain event sampling methods to collect and measure long term Total Suspended Sediment (TSS) and turbidity during high flow events, when sediment loading would be expected to occur. The purpose of these investigations is to develop methods that can be used to collect data for TMDL development, documenting load reductions due to TMDL and Best Management Practice (BMP) implementation, to establish background conditions for criteria development, and to potentially establish a correlation between turbidity and TSS for future indicator development. To assist in this effort, ADEM is coordinating with the US Geological Survey (USGS) to set up real time flow and rain gauges at siltation-impacted streams and comparable reference reaches. Longterm turbidity probes and pressure sensors to estimate flow are also being deployed at additional locations.

These types of surveys are both expensive and logistically difficult. ADEM is therefore also developing and testing siltation survey methods that would be used to screen for siltation impairment, and to prioritize locations for more intensive monitoring.

Define natural or background conditions of wetland and blackwater systems: The ADEM is monitoring least-impaired reference reaches located within the coastal plain. The effort is focusing on two stream types: 1) clear water streams characterized by a high percentage of (≥10%) of freshwater forested/shrub wetlands; and 2) braided, blackwater stream systems. The purpose is to determine if these streams represent distinct waterbody types, with distinct natural conditions, so that these stream types can be assessed accurately. Routine RSMP monitoring is being conducted at these locations. Dissolved organic carbon and color are also being collected to determine if these are reliable indicators of blackwater stream systems.

Continue to develop biological metrics and indicators: The ADEM continues to refine its Wadeable Macroinvertebrate and Fish Community Bioassessment indices for use in different stream types throughout the State. Development of Macroinvertebrate and Fish Community Bioassessments for nonwadeable streams and rivers and wetland systems is also ongoing. Wadeable periphyton protocols have been developed. The ADEM is currently focusing on processing and identifying historical diatom samples, and increasing capacity to complete these tasks in-house.

Watershed condition: GIS-based indicators of watershed conditions are an essential component of the ADEM Monitoring Strategy. They are used in the planning process, defining water body types and site classes, stressor identification, causal and trend analysis, and estimating overall water quality throughout the State. In 2012, the ADEM worked with EPA Headquarters, Mobile Bay NEP, and other state and federal agencies to complete a Healthy Watersheds Assessment throughout Alabama, and the Mobile River Basin (EPA 2014). In 2016, the Department began working with EPA Headquarters to update the watershed information for approximately 1,420 existing watersheds. This information was incorporated into a Recovery Potential Screening tool designed by EPA.

Priority parameters: Collection and analysis of samples for low level mercury (LL Hg) was identified as a data need in the 2005 and 2012 Monitoring Strategies, and the 2014 Programmatic

review. With current resources, LL Hg sampling is conducted at approximately 20 RRMP sites each year. Long term ambient monitoring locations are also sampled.

Collection of E. coli samples was also increased as part of the RRMP, to monitor the safety of common inland swimming areas.

Future Initiatives

It is anticipated that ADEM will make significant progress in the development of these indicators if ADEM has the resources to continue these monitoring efforts through this five year cycle. However, because of the complexity of assessing and addressing nutrient and siltation impacts, it is anticipated that these initiatives will continue to be a focus of the ADEM 2020 Monitoring Strategy. Priority parameters will continue to be identified through the annual and 5-year review processes, and addressed as resources allow.

V. QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

Quality Management Plan

All of the monitoring efforts and related activities are performed under the ADEM quality system Quality Management Plan (QMP). The QMP is revised by the Department and approved by EPA Region 4 on a five-year cycle following procedures outlined in SOP #8303 *Preparation, Review, Approval, Distribution, and Archival of the Departmental Quality Management Plan (QMP)* with the current version approved by EPA in June of 2013. The ADEM Quality Assurance Manager (QAM), who is also the Chief of the Office of Environmental Quality (OEQ), has the overall responsibility for the development, implementation, and continued operation of the Department's QA program.

Quality Assurance Program/Project Plans

One of the primary tools for QA management is the QA Program/Project Plan (QAPP). The monitoring program is responsible for producing and/or reviewing/updating these documents for approval by the QAM. The QAPPs are developed in accordance with ADEM SOP #8302 *Preparation, Review, Approval, Distribution, and Archival of Quality Assurance Program/Project Plans (QAPPs)* and *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5, 2001).

The *Quality Assurance Program Plan (QAPP) for Surface Water Quality Monitoring in Alabama* (1/9/2013, as amended) describes the standard activities and supporting documents to conduct this program. Routine and certain special studies including program monitoring activities are implemented under this generic program QAPP and specific annual study plan documents. Unique special studies have a QAPP specific to each particular study. Special studies involving an immediate public health threat or criminal investigation most often will be carried out under the generic program QAPP due to the limited time frame for response and obtaining samples. In addition to fulfilling the federal grant requirements, the QAPPs are intended to serve as a historic record of the activities and assessment methods used to ensure the quality, accuracy, precision, and completeness of the data collected and analyzed for each project and describes the data quality objectives for the final use of the data.

Standard Operating Procedures

Field Operations Division is responsible for developing, reviewing, and revising standard operating procedure (SOP) documents following procedures outlined in SOP #8301 *Preparation, Review, Approval, Distribution, and Archival of Standard Operating Procedure (SOP) Documents*, as well as implementing the SOPs for all activities related to water quality data generation (field and laboratory). Field-related SOPs document the various procedures for sample collection/processing, field instrument calibration and measurement, and sample chain-of-custody. Laboratory–related SOPs document the procedures for analytical laboratory sample prep/extraction, sample analysis, general housekeeping and data management, and biological community sample processing/identification/analysis. The OEQ maintains document control through standard procedures for document numbering, formatting, review and revision documentation/tracking, approval, and archival/retirement.

Quality Document Accessibility and Archival

Current copies of the QMP, Laboratory Operations QA Manual, QAPPs/Study Plans, and field and laboratory SOPs are maintained on the ADEM intranet by the OEQ to allow Department-wide access to all approved quality documents. Additional documents available on the intranet include: sample chain-of-custody forms, required sample preservation/holding times/containers/sample volumes, approved field and laboratory forms/data sheets, and database user manuals. Monthly Department-wide email notifications are sent by the QAM listing all updates to the intranet Quality Assurance website. All QA documents (QMP, QAPPs, and SOPs) are archived in FileNet by the OEQ.

QA/QC Procedures

Physical/Chemical Field Procedures

Field procedures to determine the quality of the physical/chemical data collected are documented in SOP #9021 *Field Quality Control: Measurements and Samples*. These procedures include replicate water samples collected at five percent and field parameters collected at ten percent of sampling events conducted as part of any special projects and the ADEM annual Surface Water Quality Monitoring Plan. Replicate data are used as a relative measure of sample collection and processing or measurement precision.

Blank samples are also collected at the same frequency as replicate samples by filling sample containers with deionized water at the site and processing deionized water through any collection and/or filtration equipment in the same manner as regular samples. This allows staff to monitor the on-site sampling environment, sampling equipment decontamination, sample container cleaning, the suitability of sample preservatives and analyte-free water, and sample transport and storage conditions.

Biological Community Field Procedures

Side-by-side macroinvertebrate assessments, including the physical characterization and habitat assessment, are conducted to ensure comparability of bioassessment techniques between sampling events and collectors. In addition, during the sampling year, replicate samples are taken to ensure that results obtained can be duplicated, are representative of the sampling location, and to establish measurement precision of the ADEM standard collection procedures. (ADEM 2010a, ADEM 2012d)

QA/QC Laboratory Procedures/Methods

Biological Laboratory Procedures

Biological laboratory quality assurance procedures are an integral part of all biological programs. The bioassay program QA/QC encompasses all activities that affect the quality of effluent toxicity data. Quality control in the bioassay laboratory is a day-to-day routine that incorporates every aspect of organism culturing, general lab maintenance, and toxicity testing. Quality control is also measured with monthly bioassay reference tests to ensure comparability of test organisms. The Department assesses the efficiency of all in-lab sample processing and the between-investigator comparability of macroinvertebrate or fish identifications. In addition, a specimen of each macroinvertebrate and fish taxon identified is maintained in reference collections (ADEM 2009, ADEM 2012e). The microbiological program conducts verification of colony identifications, water and glassware sterility checks, and equipment functionality checks, as well as completing annual proficiency testing studies (ADEM 2011b).

Analytical Laboratory Procedures

Laboratory Support

Laboratory Analytical Support for the Department is provided by the ADEM Laboratory System with locations in Montgomery, Birmingham, Mobile and Decatur. The laboratory is responsible for organic, inorganic, and radiochemical analyses for the Department's water quality monitoring programs. Analyses are performed using protocols approved in 40CFR136 and documented in SOPs available on the ADEM intranet. In addition, the Central Laboratory in Montgomery is fully certified by EPA Region 4 for the analysis of all regulated inorganic and organic chemical drinking water contaminants.

It is the mission of the analytical Laboratory to provide quality data to support Departmental monitoring programs. This is achieved by maintaining a fully equipped environmental laboratory and a technically skilled, properly trained, and dedicated staff that produces physical and chemical data of a known and defensible quality. All ADEM laboratories maintain documentation tracking laboratory staff training activities and analytical competency qualifications.

It is the policy of the Laboratory that all data generated by the Laboratory is of the quality that meets or exceeds the data quality objectives of the associated project. Managers and analysts of the Laboratories share the responsibility of insuring that analytical methods, instruments, and parameter detection/quantification are such that the data produced are scientifically sound and defensible. It is of utmost importance that the quality of all data produced by the Laboratory be defined and communicated to the end user(s) of the data. This policy is implemented by:

- having in place and following a complete and systematic process of quality control activities to assist in defining data quality;
- insuring that data quality is documented and communicated to all users of the data by assigning appropriate qualifier codes according to prescribed procedures; and,
- implementing a review process to verify that data are generated in accordance with sound and appropriate technical procedures and to insure that all activities associated with the analyses, calculations, and data reduction are complete and accurate.

The ADEM Laboratory System maintains a separate *Laboratory Operations and Quality Assurance Manual (LOQAM)* that deals specifically with the laboratory quality system through a

coordinated effort between the laboratory managers and the QA staff. The document is reviewed annually and approved by the Laboratory location managers, the Laboratory Quality Assurance Officer (LQAO), and the Quality Assurance Manager (QAM). (LOQAM Chapter 1 Rev 2.0 June 2010)

QA Program Oversight

The ADEM quality system oversight is conducted by the Office of Environmental Quality (OEQ). The OEQ is charged with the ongoing development/enhancement of the Department-wide quality system through continued dialogue with all Divisions regarding issues related to quality processes, quality documentation, data quality/management, and laboratory needs. Additionally, the OEQ works to enhance compliance with QA/QC procedures via "quality assistance", quality assurance, quality document review, and internal quality assessments.

The OEQ conducts internal quality assessments of: 1) field data collection and documentation activities, 2) laboratory methods, standard processes, and documentation; 3) field staff entry accuracy into the ALAWADR database. Results of these assessments are communicated through the chain-of-command to the Branch Chief and the applicable Monitoring or Laboratory Coordinator.

In addition to the OEQ staff, each FOD Branch has a partial work-year allocated as *Field Office Quality Assurance Coordinator.* This staff member serves as the point-of-contact for OEQ staff to disseminate new information and/or procedures and as a focal point for quality-related questions and suggestions. Senior staff members assigned by management may provide assistance to OEQ auditors as technical experts during quality assessments of field data collection activities.

Current and Future Initiatives

ADEM will continue to enhance the quality system over the next five years. This process will use the *Guidance for Developing Quality Systems for Environmental Programs* (EPA QA/G-1) as its primary resource. OEQ staff will continue to provide assistance with implementation and coordination of additional quality control activities, as needed.

VI. DATA MANAGEMENT/STORAGE

Background

ALAWADR is an open architecture centralized ORACLE database developed by the ADEM to manage its surface water quality data. The database table structure, completed in two phases, 1996-2005, was modeled after the EPA's Storage and Retrieval Database (STORET) design. Development of the user interface began in 2007 with funding from EPA Region 4. The main modules of ALAWADR to enter chemical/physical and observational data were completed in 2008. Two biological (macroinvertebrates and fish) community assessment modules were completed in 2009. In 2010 and 2011, the ADEM developed query, download, and reporting tools, and completed the data export to WQX.

Enhancements to ALAWADR have continued steadily since 2007 because of the ADEM approach to development and implementation. The most important components of this approach include a modular design to continue development toward the ADEM overall data management system, and development of an ALAWADR workgroup composed of database administrators and programmatic and information systems experts. The workgroup conducts a thorough requirements analysis for each module. In addition to documenting database requirements and design, the workgroup uses this process to improve communication and planning throughout its overall Surface Water Program. ADEM has been committed to sharing its database management system to assist EPA Region 4 and other state agencies and provide opportunities to share future enhancements.

In 2009, the ADEM began an application initiative by providing ALAWADR to the Mississippi Department of Environmental Quality (MDEQ) and the Kentucky Department of Environmental Protection (KY DEP) to use as the basis of their data management systems. EPA Region 4 became involved to help coordinate the efforts of the three states to increase the potential for sharing future enhancements. The Open Architecture Multi-State Configurable System (MSCS), based on ALAWADR as it existed in 2009, is used by ADEM, MDEQ, KY DEP, and, more recently, the Tennessee Department of Environmental Management (TDEC). The MSCS workgroup, comprised of program and IT experts from these four state agencies and EPA R4, was also formed to discuss future projects and current issues.

With the main module of ALAWADR, MS DEQ and KY DOW were able to use their funds to revise ALAWADR to fit their individual program needs and to develop additional modules to enhance the system's ability to track individual projects, indices, and criteria, improve user and reporting capabilities, and develop biological reference tables and a user interface that allowed for greater flexibility for program testing and development.

In 2013, the ADEM received a grant to incorporate enhancements to MSCS developed by KY DEP and MDEQ back into ALAWADR. As part of the project, the ADEM modified the table structure to manage its biological community assessment data. This enabled ADEM to begin entering biological data collected in wetlands and non-wadeable streams and rivers into ALAWADR. It also enabled ADEM to enter diatom taxonomic information into the database. In 2014 and 2015, respectively, the ADEM modified its macroinvertebrate and fish IBI community assessment modules to use the new table structure and accommodate onsite data entry and automated imports of taxonomic data.

In addition, ADEM started development of its Data EValuation and ASsessment (DEVAS) module, based on a module initiated by MDEQ. The development of DEVAS supports EPA's Water Quality Framework, as well as the Department's own efforts to coordinate its Water Quality Standards (WQS), Monitoring, Assessment, TMDL, and Nonpoint Source (NPS) Programs to clearly define program priorities, improve communication and planning, and to develop individual program strategies (e.g., 2015 Monitoring Strategy, 2016 Consolidated Listing and Assessment Document, and 2014 Nonpoint Source Management Programs).

DEVAS was designed as a tool to:

- Manage and track assessment units
- Manage and track criteria and water quality
- Compile internal and external data
- Screen monitoring data against water quality standards
- Conduct station-level assessments
- Conduct assessment unit (AU) assessments
- Manage and track AU actions (AU management, assessment, causes, sources)
- Translate data and generate XML
- Submit data and information to ATTAINS

Future initiatives

Future initiatives will focus on completion of the following:

- Incorporate corrective action table into QA/QC module;
- Develop portable module for on-site data entry of forms, including grid and transect data;
- Completion and implementation of surface water data entry forms;
- Develop, test, and implement the Assessment Unit Management module of ALAWADR;
- Develop, test, and implement the Water Quality Criteria Tracking module of ALAWADR;
- Develop, test, and implement Bio-DEVAS (Metric and Index Tracking; community-level results);
- Completion of Staff Data Flagging Process;
- Complete functionality to compile internal and external data for data evaluation and assessment;
- Complete functionality to screen monitoring data against water quality standards;
- Complete station-level DEVAS module;
- Complete Assessment Unit-level DEVAS module;
- Complete module to automate submission of IWQMAR reports;
- Add station attribute and land use reference and data tables;
- Complete GIS/Data Analysis Tools module.
- Complete module to manage and track assessment unit "actions" (AU assessment, causes, sources, TMDL development, etc);
- Complete module to translate assessment data and generate XML to submit data and information to ATTAINS; and,
- Development of additional biological modules as methods are developed.

VII. Data Analysis/Assessment

Background

Alabama's Consolidated Assessment and Listing Methodology (CALM) provides a full description of the Assessment and Listing process, a definition of assessment categories, and minimum data requirements by waterbody type. Designated uses are listed in Chapter 335-6-11 of the ADEM Water Quality Program regulations; water quality criteria are listed in Chapter 335-6-10 of these regulations. It is updated by the Department every two years, as part of the Biennial Integrated Water Quality Monitoring and Assessment Report to Congress. The 2014 programmatic evaluations of the ADEM 2005 and 2012 Monitoring Strategies and Alabama's 2012 and 2014 Consolidated Assessment and Listing Methodology resulted in increased coordination between the 2015 Strategy and the 2016 CALM. Alabama's Biennial Integrated Reports, which include the associated CALM are available at: http://www.adem.alabama.gov/programs/water/waterquality.cnt.

2015 Data Analysis and Assessment

Analysis of the 2005-2014 Dataset

The ADEM 2005 and 2012 Monitoring Strategies were designed as watershed-based monitoring programs to link watershed conditions to assessment results. Between 2005 and 2014, the ADEM monitored approximately 1,560 wadeable and nonwadeable streams, rivers, reservoirs, coastal, and wetland monitoring locations, representing a range of watershed conditions. By conducting intensive monitoring of chemical, physical, and biological indicators over a range of watershed conditions, the 2005 and 2012 Monitoring Strategies developed a comprehensive dataset to make more informed decisions to refine and develop metrics, indicators, indices and criteria.

With these data, the ADEM was able to develop Biological Condition Gradients (BCG) for macroinvertebrates and fish for wadeable streams and rivers in North Alabama and the Coastal Plain. The ADEM has also begun development of stressor-specific metrics and indices using its macroinvertebrate data, including an Observed/Expected model to predict nutrient conditions, as well as to provide an estimate of overall water quality.

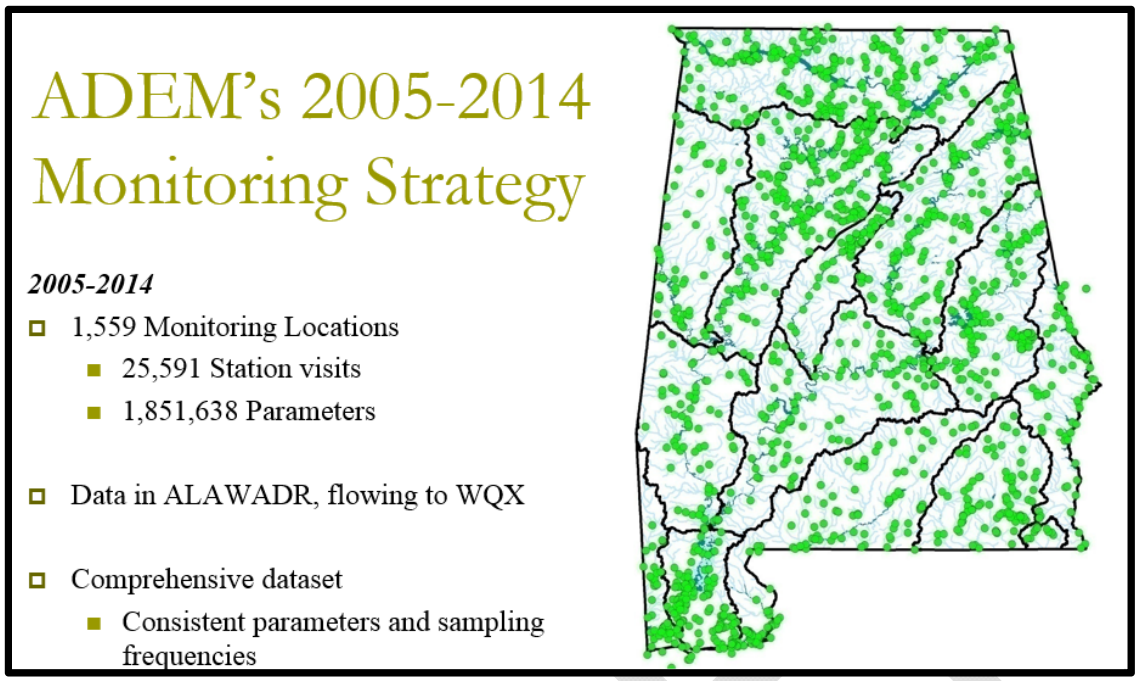

Figure 4. ADEM 2005-2014 monitoring locations.

Results of the 2014 Monitoring Strategy and CALM reviews

Review of the 2005-2014 dataset revealed additional minimum data requirements that were needed within a one-year timeframe. Minimum data requirements for assessment of these parameters were modified to better reflect routine monitoring.

In some cases, review of the 2005-2014 dataset and current data needs led ADEM to adjust its routine monitoring to improve coordination between programs. For instance, implementing the ADEM RRMP and FTMP on a 3-year basin rotation provides two full sets of data for each site within the six-year assessment period. This negated the need for separate RRMP nutrient criteria compliance sampling efforts that were instituted following development of criteria for each reservoir.

The increased coordination is also reflected in the 2015 Monitoring Strategy priorities identified during the programmatic reviews.

- *Continue to collect data to define natural or background conditions…* and *Establish reference reaches in protected areas*: The importance of both of these priorities is directly related to the classification and assessment of unique waterbody types. Monitoring least-disturbed reference reaches provides data to document background

conditions; comparison of data from these sites is used to define distinct sites classes. This information provides ADEM with a clearer picture of natural/background conditions, and deviations from this state caused by impairment.

- *Monitor waters in all five categories*: Historically, the assessment/§303(d) listing and TMDL programs within ADEM, and many other state agencies have focused monitoring efforts on potentially impaired waters to identify or verify impairment on the States §303d list, and listed waters to gather data for the development of TMDLs to address those impairments. Monitoring waters in all five categories provides data to fully assess Category 2 and 3 waters as meeting or not meeting their use classifications. Category 1 waters are monitored to ensure that water quality is maintained and to establish reference conditions. Category 4a waters are monitored to measure and document improvements in water quality due to the implementation of TMDLs, WMP, and BMPs, another 2015 Monitoring Strategy Priority.

Focusing the assessment/§303(d) listing and TMDL programs on monitoring waters in all five categories supports the ADEM overall Monitoring Strategy of monitoring the full gradient of water quality conditions for indicator and method development. It supports NPS Program requirements. It also better-reflects overall water quality conditions on basin and statewide scales.

- *Monitor the effectiveness of implemented watershed management plans and TMDLs*: This priority is a challenge for many reasons including:
  1. The high degree of impairment within 303(d) listed waters, where TMDL and NPS restoration projects are focused;
  2. The slow recovery associated with nonpoint source impacts, which can take decades, in contrast to the much shorter project reporting deadlines; and,
  3. The percent of sources of impairment voluntarily addressed, versus the total number of nonpoint sources contributing to impairment within a watershed.

Despite these significant challenges, program "success" is currently defined as fully meeting all water quality standards. For these reasons, the ADEM is investigating methods to accurately monitor and document small, incremental improvements towards fully meeting all

designated uses, and defining the process by which the assessment program will document these improvements in water quality.

Development of data analysis tools

DEVAS: The ADEM has also started development of its **D**ata **EV**aluation and **AS**sessment (DEVAS) as a data analysis module in ALAWADR. The purpose of the module is to document the dataset used to make management decisions, to facilitate data analysis, and to support ADEM efforts to coordinate its Water Quality Standards (WQS), Monitoring, Assessment, TMDL, and NPS Programs. See Section VI. Data Management/Storage for more details.

GIS tools: The use of GIS-based tools continues to grow. The Department is currently working with EPA Headquarters to update the watershed information for approximately 1,420 existing watersheds. Additionally, percent landuse from the 1993, 2001, 2006, and 2011 National Land Cover Datasets was also calculated for these watersheds to assist with interpretation of longterm and before/after datasets. To the extent possible with available resources, the ADEM plans to increase GIS capabilities, and to centralize these capabilities within ALAWADR. Future initiatives include auto-delineation of watersheds as stations are created, auto-delineation of GIS-based watershed information to assist with evaluating watershed conditions for planning, stressor identification, and causal analysis, and managing this information within ALAWADR.

VIII. REPORTING

Background

Historically, data collected by the ADEM monitoring programs are provided to the requesting Division or compiled into reports that are designed to meet requirements of the Clean Water Act, fulfill EPA grant requirements, and/or inform stakeholders. Improvements to the ADEM data management system have enabled the Department to meet many of the reporting needs identified in the 2005 and 2012 Monitoring Strategies, including improved content and applicability of reports and increased number of report writers. Data can now be downloaded directly from ALAWADR by the requesting Division. All ADEM water quality and observational data is also available for download directly from STORET (https://ofmpub.epa.gov/storpubl/) and the National Water Quality Monitoring Council (NWQMC) Water Quality Data Portal (http://www.waterqualitydata.us/).

Data Compilation for Reports

In the past, it has been difficult to compile the data collected by ADEM monitoring programs for reports to be completed for the Water Quality Standards (Use Attainability Analyses), Assessment/§303(d) Listing, TMDL (TMDL and delisting documents), and NPS Programs (NPS Success Stories). With improvements to ALAWADR, data can be downloaded for completion of required reports. Over the past several years, the ADEM has put emphasis on increasing availability of its reports on its website. Information concerning the ADEM Water Quality Programs, and many reports, including the following, are available at:

http://www.adem.alabama.gov/programs/water/waterquality.cnt

- Water quality regulations and standards
- Biennial Integrated Water Quality Monitoring and Assessment Reports; the associated CALM document is included with each IWQMAR
- §303(d) Lists and Fact Sheets

Approved TMDLs: http://adem.alabama.gov/programs/water/approvedTMDLs.htm

Approved delistings: http://adem.alabama.gov/programs/water/delistings/

Alabama's §319 Nonpoint Source Success Stories are available at: https://www.epa.gov/polluted-runoff-nonpoint-source-pollution

Monitoring Program Reports

Improvements to ALAWADR have led to improved content and availability of ADEM Monitoring Program reports. CWMP, RRMP, and RSMP Monitoring Summary Reports are generally completed within two years of data collection, and are available by year at: http://www.adem.alabama.gov/programs/water/wqsurvey.cnt.

Bacteria levels monitored at public recreational beaches along the Gulf Coast for the Coastal Alabama Recreational Waters Quality Monitoring Program (BEACH) are posted at: http://adem.alabama.gov/programs/coastal/beachMonitoring.cnt. Advisories are publicized through press releases and posted on signs at each of the 25 sampling locations.

Projects to assess water quality in the coastal watersheds are generally conducted over a two-year sampling period. The reports summarizing these projects are sent to the funding agency, the National Oceanic and Atmospheric Administration (NOAA).

Current and Future Initiatives

- Develop a probabilistic report for wadeable streams that provides a statistical assessment of 100% of wadeable streams;
- Develop methods to document and report incremental changes in water quality;
- Develop a method of documenting changes in watershed conditions over time;
- Incorporate Basin Team Report reviews as part of the reporting process, beginning with the 2015 Even Annual Statewide Monitoring Reports;
- Automate submission of IWQMAR reports to improve accuracy and efficiency of reporting;
- Complete module to manage and track assessment unit (AU) "actions" (AU assessment, causes, sources, TMDL development, etc) to improve communication and transparency within ADEM surface water programs, as well as with EPA and stakeholders; and,

- Complete GIS/Data Analysis Tools module to create more “user-friendly” reports, and increase accuracy of management decisions.

IX. PROGRAMMATIC EVALUATION

Since 1997, programmatic evaluation of ADEM Monitoring Programs and Strategy has been an integral part of the ADEM Monitoring Strategy. It is conducted every five years, during the last year of each 5-year monitoring cycle. In addition, an annual coordination meeting is conducted to discuss and develop the annual Surface Water Quality Monitoring Plan.

5-Year Programmatic Review

The ADEM began development of the 2015 Monitoring Strategy in 2014, with a comprehensive review of the results of two full 5-year monitoring strategies. The review was conducted by the surface water quality program managers in the Field Operations Division, Water Division, and the Office of Education and Outreach to ensure that the Strategy met overall monitoring objectives, as well as the objectives of the assessment/§303(d) listing, TMDL, and NPS programs; to identify the Department's 2015-2019 monitoring priorities; and revise the Strategy as needed to meet these new priorities. The Department Water Quality Monitoring Coordinator is responsible for the Monitoring Strategy development, review, and revisions.

The 2014 programmatic review included an analysis of staff and resources within each of the individual programs and four field offices and laboratories, to include analysis of the 2010-2014 stations and lab loadings. In 2014, approximately 50 staff in the Field Operations Division, Water Division, and the Office of Education and Outreach were involved in water quality monitoring, assessment, listing, and restoration. At that time, 39% of staff and management throughout the programs had less than 5 years of experience.

Multiple meetings were conducted to discuss implementing statewide sampling in the RSMP, and 3-year basin rotations in the RRMP, CWMP, and FTMP; expansion of the Trend Station Network; and the development and role of Basin Teams. A two-day Monitoring Strategy Workshop was conducted at ADEM Central Office, September 11-12, 2014, to introduce the changes to the Basin Teams.

Figure 5. Purpose of the ADEM two-day Monitoring Strategy Workshop, conducted September 11-12, 2014.

Annual Surface Water Quality Monitoring Plan

In the past, the annual coordination meetings were conducted in the fall by managers of surface water quality programs in ADEM Field Operations Division, Water Division, and the Office of Education and Outreach. This process was successfully implemented, 2004-2014.

As part of the 2015 Monitoring Strategy, annual Surface Water Quality Monitoring Plans are now developed by Basin Teams. This provides opportunities for team members to become familiar with the data needs and issues in their basin, as well as among the individual programs, increasing their level of knowledge and experience. Consequently, it increases opportunities for staff training and experience throughout the monitoring, assessment/303d listing, TMDL, and NPS programs. In 2014, five individual basin team meetings were conducted, October-November, to develop individual Surface Water Quality Monitoring Plans for each basin. The meetings were facilitated by programs managers. In 2015, the basin team meetings were conducted in October, and facilitated by program managers and staff-level facilitators.

Collaborate with agency partners and stakeholder groups

An overarching goal of the ADEM 2015 Monitoring Strategy is to support common program goals as effectively and efficiently as possible by both coordinating monitoring efforts among partner agencies and stakeholders throughout Alabama, and to conduct monitoring of priority

waters identified by these entities. Basin Teams work with state and federal agencies, and other stakeholders to plan and coordinate monitoring efforts within priority watersheds.

State Agency Water Quality Meeting

Initiated in 2011, The State Agency meeting is conducted every other year. The meeting, organized by the ADEM Water Quality Coordinator, is attended by the ADCNR, GSA, Alabama Department of Public Health (ADPH), and Office of Water Resources (OWR). The primary purpose of this meeting is the discussion of issues related to water monitoring that are important to the agencies, status reports on monitoring and activities, and coordination of future monitoring activities.

Workplans and End-of-Year Reports

Annual Section 106 Workplans are developed with EPA Region 4, and contain monitoring program commitments for the coming fiscal year. In addition, the Department also assists EPA in mid-year and end-of-year reviews of progress toward implementation of these Workplan commitments.

Current and Future Initiatives

The 2014 Programmatic Evaluation was conducted by managers of the ADEM Surface Water Quality Programs. By 2019, the Basin Teams should be prepared to fully participate in the programmatic evaluation of the 2015 Monitoring Strategy and the development of the 2020 Monitoring Strategy.

X. General Support and Infrastructure Planning

Demands for water quality monitoring programs continue to increase each year while funding decreases. To continue at its current level of effort, it is critically important that support and infrastructure for ADEM surface water quality programs increases.

The current initiatives identified throughout this document support 2015 Monitoring Program priorities:

1. Develop numeric nutrient criteria, concentrating on tributary embayments, estuaries, and coastal waters;
2. Develop tools to assess siltation impacts, develop siltation TMDLs, and track restoration efforts;
3. Continue to develop chemical, physical, and biological metrics and indicators for wadeable and nonwadeable streams, rivers and estuaries;
4. Continue to collect data to define natural or background conditions, particularly within wetland and blackwater systems;
5. Establish reference reaches in protected areas;
6. Monitor waters in all five categories; and,
7. Monitor the effectiveness of implemented watershed management plans and TMDLs.

Given the accelerated pace of water quality monitoring program needs and incorporation of new techniques, the following table of current support and infrastructure resources is considered to be only an estimate of the resources needed to meet the annual monitoring target established as part of the 2015 Monitoring Strategy. Continued improvements in monitoring programs over time will be contingent upon available resources, qualified staff, and core program changes and additions.

Table 1. Current support and infrastructure resources.

Program Status	**Annual FTEs**
RRMP, RSMP, CWMP, WMP • Data collection, processing and identification, data entry data analysis, and reporting	34
QA/QC and Database Support	3
Laboratory	20

XI. MONITORING PROGRAM TIMELINE

The following timeline spans the development of current and future monitoring program activities. Historical information is provided as a reference to current program development and the projected future course. All programs and projects listed are included because of the commitment of staff and resources to all of these efforts and the related effect to schedules and timelines. Water quality monitoring demands continue to increase to enable ADEM to address very complicated and resource intensive water quality issues, such as nutrient enrichment and siltation. The future course and schedule of program development will depend heavily on availability of resources, core program changes/additions, future priorities, and emerging issues.

- Initiation of fish tissue contaminant sampling and analyses: **1970**
- Initiation of National Pollution Discharge Elimination System (NPDES) Compliance Sampling Inspections (CSIs): **1973**
- Initiation of Ambient Trend Monitoring Program: **1974**
- Initiation of Wasteload Allocation and Time-of-Travel Studies: **1983**
- Initiation of Use Attainability Analyses Studies: **1984**
- Initial EPA/ADEM statewide reservoir water quality monitoring survey: **1985**
- Initiation of Water Quality Demonstration Studies: **1985**
- Initiation of NPS Intensive Surveys: **1988**
- Initiation of state groundwater monitoring: **1989**
- ADEM/Auburn University statewide reservoir water quality monitoring survey: **1989**
- ADEM Reservoir Monitoring Program initiated: **1990**
- EPA/ADEM/Auburn University Clean Lakes Program Phase I Intensive Reservoir Surveys: **1990-1998**
- Fish Tissue Monitoring Program (FTMP) initiated: **1991**
- Ecoregional Reference Reach Monitoring Program initiated: **1991**
- Initiation of Coastal Watershed Surveys: **1993**

- Coastal Alabama Monitoring and Assessment Program (ALAMAP) probabilistic water quality assessments: **1993-1999**
- Initiation of Intensive Fecal Surveys: **1996**
- Development of Basinwide Screening Assessment methods for streams and wadeable rivers: **1996**
- Development of Upland Alabama Monitoring and Assessment Program (ALAMAP) with EPA-Corvallis: **1996**
- Development of initial monitoring strategy, ASSESS: **1997**
- Implementation of watershed approach/basin rotation in monitoring programs: **1997**
- Implementation of Basinwide Screening Assessments of streams and wadeable rivers: **1997-2004**
- Implementation of Upland Alabama Monitoring and Assessment Program (ALAMAP) probabilistic stream water quality assessments: **1997-2004**
- Completion of monitoring and assessment targeted at §303d-listed waterbodies to meet consent decree: **1999-2004**
- Initiation of Coastal Alabama Recreational Waters Monitoring Program: **1999**
- ADEM statewide probabilistic groundwater assessment: **2000-2002**
- National Coastal Assessment monitoring: **2000-2006**
- Initiation of EPA-Required Nutrient Criteria development: **2000**
- Development and implementation of Nutrient Criteria for Alabama Lakes: **2001-2016**
- Initiation of compliance monitoring for lakes nutrient criteria: **2001**
- Development and implementation of periphyton assessment techniques: **2002-2019**
- Initiation of annual Surface Water Quality Monitoring Coordination Meetings: **2003**
- River segment monitoring incorporated into Reservoir Monitoring Program: **2004**
- Programmatic Evaluation of ASSESS: **2004**

- Environmental Quality Unit established: **2004**
- Cahaba River/Hatchet Creek Intensive Survey for Nutrient Target Development: **2004-2006**
- Initiation of the Alabama Coastal Nonpoint Pollution Control Program (ACNPCP) Marina Water Quality Study: **2004**
- Mobile Bay Water Quality Study conducted: **2004**
- New ADEM Central Laboratory construction: **2005-2006**
- Initiation of Assessment Database (ADB): **2005**
- Initiation of database module development for STORET upload: **2005**
- Designation of Water Quality Monitoring Coordinator: **2005**
- Initiation of Water Quality Assessment and Listing Methodology Documents: **2005**
- Implementation of revised Monitoring Strategy: **2005**
- Expansion of Ambient Trend Monitoring Network: **2005**
- Rivers and Streams Monitoring Program initiated: **2005**
- Rivers and Reservoirs Monitoring Program initiated: **2005**
- Initiation of Mobile Bay NEP Sub-estuary study: **2005**
- Initiation of Elk River Watershed TMDL Development study: **2005**
- 316b Regulations and required Biological Assessments: **2005**
- Development and Implementation of Clean Sampling/Trace Metals Collection/Analysis Techniques: **2005-2011**
- Nonwadeable/Large River Macroinvertebrate Bioassessment method Development and Implementation: **2005-2019**
- Coastal Waters Monitoring Program Development and Initiation: **2005-2011**
- Surface Water Quality and Biological Database Development, Implementation, and Historical Data Migration Completion: **2005-2011**

- Stream Fish Index of Biotic Integrity (IBI) Development: **2005-2012**
- Annual ADEM Water Quality Monitoring Coordination meetings: **2006-2014**
- Initiation of National Lakes Assessment monitoring: **2007**
- Development of Nutrient Criteria for Estuarine and Coastal Waters: **2007-2021**
- Development of The ADEM 2008 Macroinvertebrate Indices: **2008**
- *E. coli* criteria development and implementation: **2008-2009**
- Auburn University Algal Toxin Program Participation: **2009-2014**
- Southeast Wetlands Monitoring Intensification Project: **2009-2013**
- National Coastal Condition Assessment: **2010, 2015**
- Weeks Bay Nutrient Sources Fate, Transport, and Effects Study: **2010-2012**
- Tallapoosa River Basin-Nutrient Criteria Development for Wadeable Streams Project: **2010-2012**
- Assessment of Water Quality Near Surface Coal Mining Facilities in the Black Warrior River Basin: **2010-2012**
- National Wetlands Condition Assessment: **2010-2012**
- Implementation of the 2012 Monitoring Strategy: **2010-2014**
- Programmatic Evaluation of the 2005 Monitoring Strategy: **2011-2012**
- Biennial State Agency Water Quality Meeting Initiation: **2011**
- Completion of the first ADEM 5-year Wetlands Program Development Plan: **2011**
- Alabama and Mobile Bay Integrated Assessment of Watershed Health: **2012-2014**
- Development and implementation of Alabama's Wetland Workgroup: **2012-2015**
- Initiation, development, and implementation of Siltation Surveys: **2012-2019**
- Nonwadeable/Large River Fish Community Bioassessment Method Development and Implementation: **2012-2019**

- Development of the ADEM 2013 Macroinvertebrate Indices: **2013**
- Programmatic Evaluation of 2005 and 2012 Monitoring Strategies: **2014-2015**
- Calibration of Biological Condition Gradients for macroinvertebrate and fish communities in North Alabama streams and wadeable rivers: **2014**
- Initiation of Rain Event Sampling: **2014**
- Forested Wetland Classification Surveys: **2014-2017**
- Implementation of 2015 Monitoring Strategy: **2015-2019**
- National Coastal Condition Assessment: **2015**
- Expansion of Ambient Monitoring Network: **2015-2016**
- Implementation of Basin Teams: **2015-2019**
- Implementation of Even, Annual Sampling (EAST and EABT): **2015-2019**
- Calibration of Biological Condition Gradients for macroinvertebrate and fish communities in Alabama's Coastal Plain streams and wadeable rivers: **2015**
- Completion of Macroinvertebrate Data Entry Module: **2015**
- Development and Implementation of Wetland Nutrient Criteria Workgroup: **2015**
- Five-year update ecoregional reference reach guidelines: **2015**
- Annual review and update ecoregional reference reach status: **2015-2019**
- Development of Nutrient Criteria in Coastal Areas, Estuaries, and Reservoir Embayments : **2015-2021**
- Implementation of RRMP, CWMP, and FTMP on 3-year monitoring cycle: **2015-2019**
- Completion of Fish Community Data Entry Module: **2016**
- Intensive Survey of Cahaba River/Hatchet Creek: Post-TMDL implementation assessment: **2016**
- Delineation of Coastal Waters along 10 Foot Contour Line: **2016**

- Revision of CWMP: **2016**
- Revision of Ambient Monitoring Network: **2016**
- Propose nutrient criteria for selected nutrient-sensitive wetlands: **2017**
- Propose nutrient criteria for estuarine and coastal waters: **2017-2018**
- Propose nutrient criteria for rivers and streams: **2017-2018**
- Programmatic Review of the 2015 Monitoring Strategy: **2019**

XII. SUMMARY OF ADEM WATER QUALITY PROGRAMS

A summary of each of the ADEM monitoring programs follows. These summaries are generally arranged by major monitoring program: Coastal and Estuary Monitoring Programs, Rivers and Reservoirs Monitoring Program, Rivers and Streams Monitoring Program, Wetlands Monitoring Program, Fish Tissue Monitoring Program, Groundwater Monitoring, and General Surface Water Quality Programs. Different types of monitoring that have historically occurred are conducted under these major programs using procedures that are consistent for the types of waterbodies in which they occur.

COASTAL WATERS MONITORING PROGRAM (CWMP)

Background

ADEM began monitoring water quality of coastal and near coastal waters in the 1970s, as part of the ADEM Ambient Monitoring Network. In 1993, Coastal Sub-watersheds Monitoring was implemented to assess the conditions of small sub-basins within Baldwin and Mobile Counties (ADEM 1997). During that same year, ADEM also implemented Coastal ALAMAP, a probabilistic monitoring program designed to assess 100% of the larger, estuarine receiving water bodies within Alabama's coastal area (ADEM 1997). In 1998, the Alabama Coastal Nonpoint Pollution Control Program (ACNPCP) was implemented to document water quality conditions within Mobile and Baldwin Counties and to evaluate the effectiveness of restoration efforts. In 1999, in cooperation with the Alabama Department of Public Health, the ADEM implemented the Coastal Alabama Recreational Waters Program (BEACH) to routinely monitor bacteria levels at five public recreation beaches along the Gulf Coast.

In 2011, the ADEM initiated the CWMP and documented a more comprehensive Program in the 2012 Monitoring Strategy. The 2012 CWMP focused on monitoring wadeable and nonwadeable waters in the coastal area. It added routine assessments and water quality data collection (*in situ* parameters, nutrients, chlorophyll-a, and toxics (including metals) at: 1) historical trend sites; 2) permanent fixed sites located in 12 coastal watersheds where additional long term monitoring data are needed; 3) targeted sites selected to verify and document current conditions at 303(d)/TMDL stream segments; and 4) targeted sites within watersheds selected as priorities by the ADEM NPS Management Program. Sampling was conducted 3 to 12 times per year as needed and as resources allowed.

The 2012 CWMP was designed to complement the monitoring activities listed below:

a. **Coastal Alabama Beach Monitoring Program:** monitoring involves the collection of water samples from twenty-five public recreational sites in Alabama's coastal waters. Samples are analyzed for the indicator bacteria, *Enterococci*. The objective of this program is to increase public awareness and provide valuable water quality information to help the public make more informed decisions concerning their recreational use of

Alabama's natural coastal waters. A summary and data from this program are available at: http://adem.alabama.gov/programs/coastal/beachMonitoring.cnt

b. **Alabama Coastal Non-Point Pollution Control Program (ACNPCP):** implements Coastal Alabama Targeted Water Quality Studies that are designed to locate sites, identify and document baseline water quality conditions that exist within the two coastal counties. These studies are designed to correlate BMPs as they relate to land uses and potential nonpoint source (NPS) impacts in close proximity to waterbodies within the Mobile and Baldwin County sub-watershed areas. Completed reports are available at: http://www.adem.alabama.gov/programs/coastal/watershedSurvey.cnt or http://www.adem.alabama.gov/programs/water/wqsurvey.cnt.

c. **National Coastal Condition Assessment (NCCA)**: an EPA probabilistic monitoring survey conducted every five years nation-wide. The purpose of the assessment is to determine the condition of estuarine waters and coastal resources both on a state and national scale. NCCA reports are available at: http://www.adem.alabama.gov/programs/coastal/ncaReport.cnt.

Objectives

The objectives of the CWMP are to:

1. Establish, review, and revise water quality standards;
2. Determine water quality standards attainment;
3. Identify high-quality waters;
4. Identify causes and sources of water quality impairments;
5. Evaluate program effectiveness;
6. Estimate water quality trends; and,
7. Estimate overall water quality.

In addition, development and implementation of numeric nutrient criteria for estuaries by 2018 was identified as a priority in the 2014 Nutrient Criteria Implementation Plan and the 2015 Monitoring Strategy.

Design

For regulatory purposes, Coastal Waters were redefined in 2015 as waters delineated within the 10' contour line. A 3-year rotation of these waters was established for the CWMP, with the coastal area divided into the Western (W), Eastern (E), and Mobile (M) Bay areas. The rotation corresponds well with the six-year data assessment period required for the IWQMAR. A map of the 3-year basin cycle is provided below.

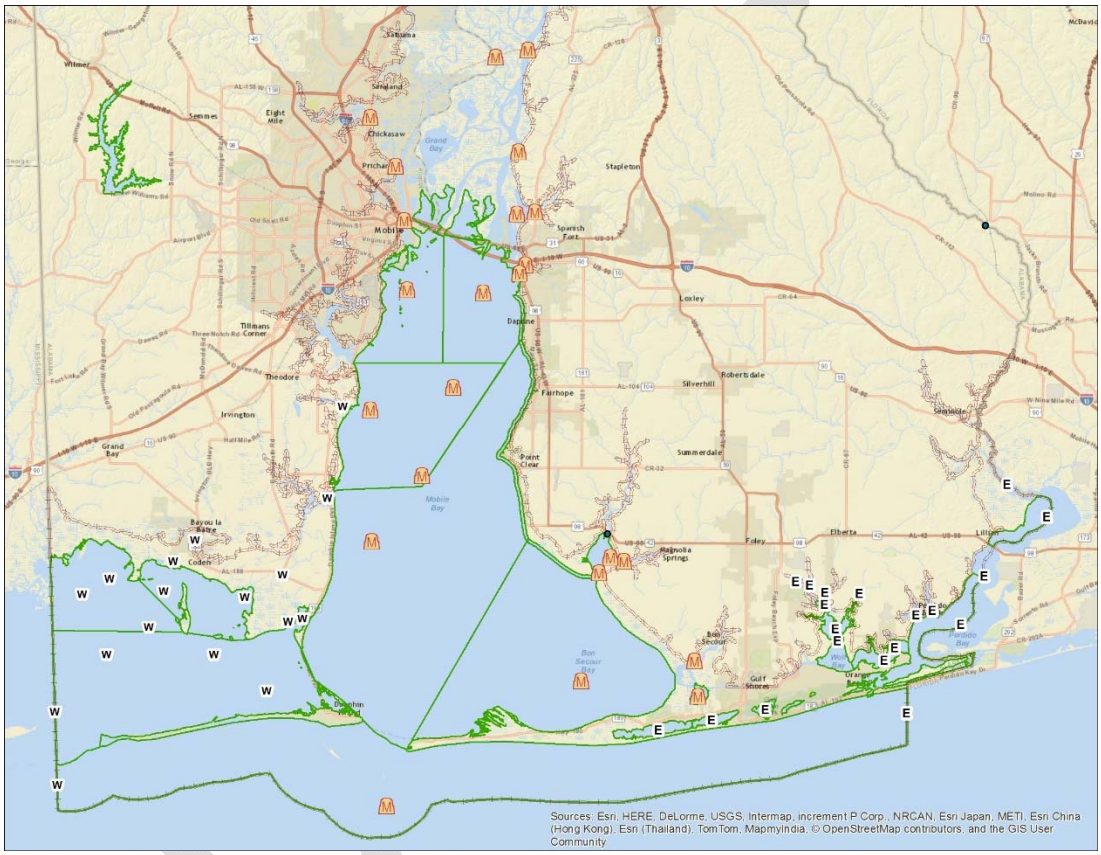

Figure 6. Location of ADEM CWMP stations.

Site selection

The 2015 CWMP incorporates a combination of long-term fixed network and targeted sites. The ADEM maintains a network of long term, fixed ambient monitoring stations, as part of the RSMP, RRMP, and CWMP. They are permanent monitoring locations established to identify long-term trend in water quality and develop TMDLs and water quality standards. The details of this

network are fully described in Appendix A.

Collection of data to establish nutrient criteria for estuaries was identified as a priority of the 2015 Monitoring Strategy. As part of this effort, intensive monitoring is conducted at each coastal station monthly, March-October, on a three-year rotating basin schedule. This data will provide a comprehensive determination of water quality throughout the algal growing season and can be used to develop nutrient criteria and total maximum daily loads.

In addition, targeted monitoring is conducted in watersheds to document water quality conditions before and after best management practices are implemented. These studies are conducted in conjunction with the ACNPCP and the Mobile Bay NEP, both of which focus restoration efforts within the 12-digit HUC sub-watersheds of the Escatawpa, Mobile-Tensaw, and Perdido River basins located within Baldwin and Mobile Counties. Pre- and post- restoration monitoring is also conducted for the ADEM statewide §319 and TMDL programs, and the National Water Quality Initiative of the NRCS.

Core and Supplemental Water Quality Indicators

Core Indicators: Secchi transparency, photic depth, total depth, water temperature, turbidity, total dissolved solids, total suspended solids, specific conductance, alkalinity, dissolved oxygen, pH, salinity, ammonia, nitrate+nitrite-nitrogen, total Kjeldahl nitrogen, dissolved reactive phosphorus, total phosphorus, chlorophyll *a*, 5-day carbonaceous biochemical oxygen demand, field observations (recent/current weather, air temperature, and flow conditions).

Supplemental Indicators: *E. coli*, *Enterococcus,* hardness, ultimate carbonaceous biochemical oxygen demand, total/dissolved metals, algal growth potential tests, low level mercury, 72-hour diurnal dissolved oxygen and other in situ parameters.

RIVERS AND RESERVOIRS MONITORING PROGRAM (RRMP)

Background

ADEM began monitoring lake water quality statewide in 1985, followed by a second statewide survey in 1989. In 1990, the Reservoir Water Quality Monitoring Program was initiated by ADEM. In 2005, the Program was changed to the Rivers and Reservoirs Monitoring Program with the addition of free-flowing, nonwadeable rivers. The RRMP assesses the water quality and trophic status of nonwadeable rivers and publicly-owned lakes/reservoirs in the state, with monitoring in the Tennessee River system conducted through a collaborative monitoring effort between ADEM and the Tennessee Valley Authority (TVA). ADEM has defined publicly-owned lakes/reservoirs as those that are of a multiple-use nature, publicly-accessible, and exhibit physical/chemical characteristics typical of impounded waters. Lakes designated strictly for water supply, privately owned lakes, or lakes managed by the ADCNR strictly for fish production are not included in this definition. Currently, forty-one lakes/reservoirs meet this definition of being publicly-owned.

In the 2012 Monitoring Strategy, monitoring of lakes/reservoirs and nonwadeable rivers occurred at two levels of effort under the RRMP:

1. Intensive monitoring of river, main-stem reservoir, and tributary embayment stations conducted monthly, April-October, on a 5-year basin rotation;
2. Compliance monitoring of reservoirs with established nutrient criteria conducted monthly, April-October, at least once every three years.

Since 1885, monitoring conducted within these waterbodies provided an extensive dataset that the Department used to develop appropriate criteria and standards for each of the State's 41 publicly-owned lakes/reservoirs. Progress made as a result of the 2005 and 2012 Monitoring Strategies enabled ADEM to implement revisions to the design of the RRMP to better meet the needs of the Alabama's assessment/listing program and 2014 Nutrient Criteria Implementation Plan.

Objectives

Objectives of the RRMP are to:

1. Develop and maintain a water quality database for all rivers and publicly-accessible lakes in the state sufficient to conduct comprehensive assessments of water quality, categorize waters for the Integrated Assessment Report, develop criteria, and determine criteria compliance;
2. Establish trends in river and lake trophic status that are only established through long-term, consistent monitoring efforts; and,
3. Conduct assessments of water quality for all publicly-accessible lakes as required by Section 314 of the Clean Water Act.

Additionally, development and implementation of numeric nutrient criteria for tributary embayments by 2018 was identified as a priority of the 2015 Monitoring Strategy during the extensive 2014 review. Monitoring of public water supply lakes was also identified as a priority to ensure public safety and to establish criteria appropriate for these waters.

Design

Results of the 2014 RRMP review

In 2015, the RSMP went from a 5-year basin rotation to annual statewide monitoring as a result of the 2014 review. However, monitoring all reservoirs in a river system during the same year was determined to be an important data need for programs that rely on RRMP data. With an intensified sampling effort, all stations would be monitored every three years, eliminating the need for a nutrient criteria monitoring rotation for reservoirs.

Monitoring Schedule

A 3-year basin rotation was established for the RRMP, as well as the Fish Tissue Monitoring Program (FTMP). The rotation corresponds well with the six-year data assessment period required for the IWQMAR. A map of the 3-year basin cycle is provided below. Maintaining a consistent and achievable level of effort year-to-year was an important factor in establishing the rotation.

3-Yr RRMP Rotation

BASINS	# STA
Year 1	**78**
TALLAPOOSA	21
CAHABA	2
TENNESSEE	34
ALABAMA	21
Year 2	**76**
COOSA	45
TOMBIGBEE	31
Year 3	**78**
CHATTAHOOCHEE	19
ESCATAWPA	5
BLACK WARRIOR	41
PERDIDO-ESCAMBIA	13

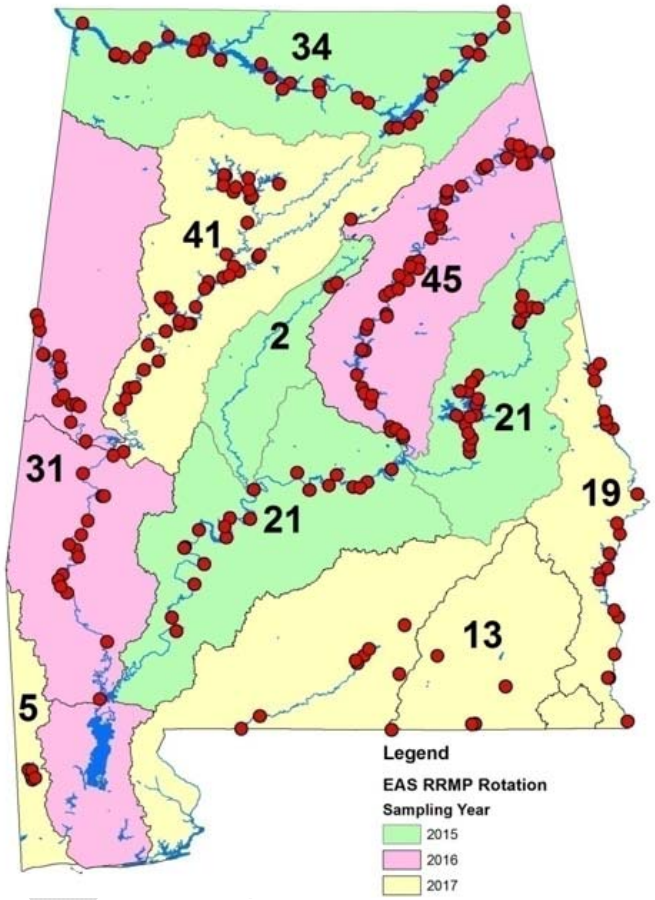

Figure 7. RRMP station locations.

Site selection

Reservoirs and lakes monitored for the program range in size from 350 to 45,200 acres. Smaller lakes have a minimum of one station, typically in the dam forebay. In larger reservoirs, additional stations are added in the mid-reservoir and upper reservoir (transition area) as needed. Tributary embayment stations are established in larger embayments and/or those with larger inflows, with selection of embayments distributed throughout the range of human disturbance. River stations are located along the length of the flowing reach to the extent that resources allow, with stations partitioned according to tributaries and point/nonpoint sources.

Intensive monitoring

Intensive monitoring of river, main-stem reservoir, and tributary embayment stations is conducted monthly, April-October, on a three-year rotating schedule to provide a comprehensive determination of water quality throughout the algal growing season and provide data that can be used to develop nutrient criteria and TMDLs. Data are analyzed at the end of the sampling season to determine use support.

Indicators

At each station, collection of water samples and *in situ* measurements (depth, temperature, dissolved oxygen, pH, and conductivity) are conducted at the thalweg. Water samples are collected as a photic zone composite. *In situ* measurements are conducted at one-meter intervals. Beyond thirty meters in depth, measurements are made at five-meter intervals to the bottom if there is little observed change in measurements. Corrected chlorophyll *a* concentrations are used to calculate Carlson's Trophic State Index for determinations of oligotrophic, mesotrophic, eutrophic, and hypereutrophic conditions.

Current Initiatives

The ADEM is currently monitoring reservoir embayments to provide data to develop criteria for reservoir embayments in 2018, as outlined in Alabama's Nutrient Criteria Implementation Plan. Monitoring embayment tributaries will provide data to establish nutrient criteria and standards and to determine water quality of these portions of the rivers and reservoirs. In addition, monitoring tributary embayments may also serve as an indicator of water quality in upstream tributaries, and provide a basis for establishing nutrient criteria protective of upstream uses. The ADEM is also conducting 72-hr diurnal dissolved oxygen surveys within reservoir embayments. The surveys are conducted in accordance with the RRMP 3-year basin cycle.

Collection and analysis of samples for low level mercury (LL Hg) was identified as a data need in the 2005 and 2012 Monitoring Strategies, and the 2014 Programmatic review. With current resources, LL Hg sampling is conducted at approximately 20 RRMP sites each year. Long-term ambient trend monitoring locations are also sampled.

Core and Supplemental Water Quality Indicators

Core Indicators: Secchi transparency, photic depth, total depth, water temperature, turbidity, total dissolved solids, total suspended solids, specific conductance, alkalinity, dissolved oxygen, pH, ammonia, nitrate+nitrite-nitrogen, total Kjeldahl nitrogen, dissolved reactive phosphorus, total phosphorus, chlorophyll *a*, 5-day carbonaceous biochemical oxygen demand, chloride, field observations (recent/current weather, air temperature, and flow conditions).

Supplemental Indicators: *E. coli*, hardness, ultimate carbonaceous biochemical oxygen demand, total/dissolved metals, algal growth potential tests, low level mercury, 72-hour diurnal dissolved oxygen and other in situ parameters

Reporting

Rivers and Reservoirs Monitoring Program summary reports can be found at: http://www.adem.alabama.gov/programs/water/wqsurvey.cnt

RIVERS AND STREAMS MONITORING PROGRAM (RSMP)

Background

The ADEM Rivers and Streams Monitoring Program (RSMP) assesses the chemical, physical, and biological conditions of non-navigable, flowing waters in the state. It is a watershed-based monitoring program designed to provide data that links watershed condition and assessment results. A Watershed Disturbance Gradient (WDG), based on landuse and other factors, was developed in 2004 to classify each potential monitoring location by the level of disturbance within its watershed. Implemented on a 5-year basin rotation, the RSMP used this information to plan biological monitoring activities along a full disturbance gradient to produce a dataset representing both the full stressor gradient and the full biological condition gradient. A primary goal of this monitoring design was to provide stressor-response data that can be used to develop criteria and indicators.

Two full 5-year monitoring cycles were completed using this approach. With these data, statewide indices for wadeable streams and rivers have been developed for macroinvertebrate and fish community assessments to make aquatic life use support determinations. Biological Condition Gradients have also been developed for macroinvertebrate and fish communities in both upland and coastal plain wadeable stream systems.

Objectives

The objectives of the RSMP are to provide data to:

1. Develop or revise water quality standards;
2. Determine water quality standards attainment;
3. Identify impaired waters;
4. Identify the causes and sources of impairment;
5. Identify high-quality waters;
6. Estimate water quality trends;
7. Evaluate program effectiveness;
8. Support management decisions; and,

9. Estimate overall water quality.

2015-2019 Goals

Through the extensive review of the 2005 and 2012 Monitoring Strategies conducted in 2014-2015, the ADEM defined seven specific priorities for 2015-2019, six of which were implemented as part of the RSMP:

- Continue to develop chemical, physical, and biological metrics and indicators, through analysis of the 2005-2014 dataset and collection of new data;
- Continue to collect data to define natural or background conditions, particularly within wetland and blackwater systems;
- Establish reference reaches in protected areas;
- Monitor waters in all five categories;
- Monitor the effectiveness of implemented watershed management plans and TMDLs; and,
- Develop tools to assess siltation impacts, develop siltation TMDLs, and track restoration efforts.

In addition to these priorities, the Department identified three over-arching goals to improve its surface water programs. These included,

- Improve coordination and communication among the individual ADEM monitoring, assessment/listing, TMDL, and NPS programs;
- Provide opportunities to young staff for training and resource planning; and,
- Collaborate with agency partners and stakeholder groups to meet common goals.

Design

Monitoring Schedule

Progress made as a result of the 2005 and 2012 Monitoring Strategies, and changes to program priorities within ADEM and EPA, will allow ADEM to conduct monitoring within each basin each year, while continuing to meet the ADEM monitoring goals over a five-year period. This will

provide frequent, intensive monitoring within each basin group to more accurately measure trends in water quality before and after implementation of restoration efforts, respond to data needs more quickly, and to minimize the impact of weather-related events on data collected within any one basin. Statewide monitoring enables ADEM to continue to concentrate efforts on development of indicators and water quality standards for additional stressors and waterbody types, and to continue to collect data in ecoregions where data are limited. It also provides a level of consistency year-to-year that makes better use of ADEM field offices and laboratories, and provides better opportunities for young staff to gain training and experience.

12-digit HUCs

The 2015 RSMP uses 12-digit HUCs to plan, prioritize, and track monitoring activities statewide. The advantages to this approach include:

- EPA, NPS, and NRCS already work on this scale;
- 12-digit HUCs are already delineated;
- Access to readily available, statewide information; and,
- Help to prioritize waters for monitoring.

Prioritization Framework

A prioritization framework was developed to help focus and prioritize RSMP monitoring within each basin group. The framework was based on the monitoring priorities identified for the 2015 Monitoring Strategy. To the extent possible, this information was provided in GIS layers and organized in an ArcMap Project to help basin teams prioritize waters for monitoring.

Table 2. Example of factors used to help prioritize water bodies for monitoring.

Prioritization Factors				
Monitor waters in all 5 assessment categories	**Evaluate program effectiveness**	**Establish Eco-refs in protected areas**	**Develop criteria and indicators**	**Collaborate with agencies and stakeholders**
AU cat and AU pollutant cat	WMP/BMP implem. status	ADEM's Watershed Disturbance Cats	ADEM's watershed Disturbance Cats	CWP priority HUCs
HUCs not monitored as planned previous year	LA and WLA (TMDL) implem. status	National Ecological Framework	Siltation-impaired waters	AWW priority HUCs
		Protected Areas		SHUs and SRRUs
		Permits		ADCNR, USFWS, GSA, River keepers, Others
		Make sure that we have ref reach for all requested stations		

Watershed Characteristics

Defining natural watershed characteristics is an essential step in identifying well-defined waterbody types that exhibit distinct natural or background conditions, a priority of the 2015 Monitoring Strategy. Ecoregions are relatively homogeneous geographic areas that define the patterns and composition of biotic and abiotic characteristics (Wiken 1986, Omernik 1987, 1995), including geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. The ADEM delineates its RSMP watersheds to categorize each station by ecoregion and other natural watershed characteristics, such as drainage area and gradient. Data collected from least-impaired reference reaches in each ecoregion are compared to distinguish groups of stations with distinct "natural" conditions. Watershed characteristics within these groups are then analyzed to identify important site classes. Data collected from minimally- and least-disturbed reference reaches within each of these site classes serves as the basis of comparison of water quality parameters, habitat, and biological communities to other waterbodies within the same site class.

Measure of Watershed Condition

A Watershed Disturbance Gradient (WDG), based on landuse and other factors, was developed in 2004 to classify each potential monitoring location by the level of disturbance within its watershed. The Landscape Development Intensity Index (LDI) or disturbance gradient, used by the Florida Department of Environmental Protection, relates water quality conditions (physical, chemical, and biological) to human activity within a watershed (Fore 2004), using landuse data

and a development-intensity measure derived from energy use per unit area (Brown and Vivas 2004).

Between 2005-2010, ADEM applied the Florida LDI to all Wadeable Flowing Monitoring Units (WFMU) within each basin group using EPA's National Land Cover dataset (NLCD), Departmental permit databases, population estimates, and the number of road crossings to place each WFMU into one of eight WDG categories (1=least potential for disturbance and 8=greatest potential for disturbance). In 2012, the WDG scores were updated to reflect the 2006 NLCD coverage and statewide WDG categories.

Analysis has shown the WDG to be predictive of some stressors, including nitrate+nitrite and total phosphorus, and also correlated with the ADEM wadeable macroinvertebrate indices to some degree. Improving the correlation between watershed disturbance, stressors and biological conditions would improve the overall estimate of water quality within each basin. The ADEM is currently testing methods that have the potential to improve these correlations.

The WDG is used to plan monitoring activities along a full disturbance gradient to produce a dataset representing both the full stressor gradient and the full biological condition gradient. A primary goal of this monitoring design was to provide stressor-response data that can be used to develop criteria and indicators. It is used to identify potential reference and impaired reaches. The information is helpful in causal analysis and the stressor identification process. It is also a component of the ADEM overall estimate of water quality in wadeable rivers and streams.

Site Selection

The RSMP incorporates a combination of long-term fixed network sites, targeted sites, and monitoring units:

- The ADEM maintains a network of long-term, fixed ambient trend monitoring stations as part of the RSMP, RRMP, and CWMP. They are permanent monitoring locations established to identify long-term trends in water quality and develop TMDLs and water quality standards. The details of this network are fully described in Appendix A. In addition, the ADEM has also established a network of fixed monitoring locations at ecoregional "reference" reaches for comparison with other similar waterbodies statewide, which is fully discussed in Appendix B.

- The ADEM maintains a network of monitoring units (MU) to estimate overall water quality within its coastal area and wadeable rivers and streams. ADEM defines a WFMU as the watershed directly upstream of the downstream-most, accessible, and completely wadeable, 300-foot reach. All stream reaches meeting these requirements are delineated using the 2010 12-digit hydrologic unit codes (HUCs), National Hydrography Dataset (NHD), and the National Elevation Dataset (NEDs). Statewide, approximately 990 WFMUs have been delineated. They are classified by Watershed Disturbance Gradient (WDG) and ecoregion. A subset of each of these networks is sampled to reflect overall water quality conditions.
- Targeted sites are incorporated into the RSMP. They support the 2015-2019 monitoring priorities, and are selected by the ADEM WQB, NPS Unit, FOD, other local, state, or federal agencies, the Clean Water Partnership of Alabama, or volunteer groups to provide data for use support and assessment, TMDL development, program evaluations, use attainability analyses, or education and outreach. These sites are monitored on a short-term basis, generally one to five years.

Sampling Protocols

The RSMP incorporates four specific protocols to ensure that monitoring activities provided the highest quality information and made the most efficient use of available resources. The four protocols include Wadeable-BIO, Wadeable-Water, Nonwadeable Bridge-Deep, and Nonwadeable Bridge-Shallow Stations. These protocols are more fully described in Section III. Monitoring Design.

Sampling Frequency

Monitoring at each site is conducted so that each site can be fully assessed, generally within one year. Habitat and biological surveys are conducted at a subset of wadeable, flowing stream sites. To the extent possible, intensive water quality monitoring is conducted monthly, March-October, to identify the cause(s) of any water quality impacts.

Core and Supplemental Indicators

Core Indicators: Flow (where appropriate), Total stream depth, Sampling depth, Water temperature, Dissolved oxygen, pH, Specific conductance, Turbidity, Total suspended solids,

Total dissolved solids, Hardness, Alkalinity, Ammonia-nitrogen, Nitrate+nitrite-nitrogen, Total Kjeldahl nitrogen, Total phosphorus, Dissolved reactive phosphorus, Chlorophyll *a*, Total organic carbon, Five-day carbonaceous biochemical oxygen demand, Chlorides

Supplemental Indicators: Supplemental indicators are determined by the data needs at each targeted site and may include: Total and dissolved Aluminum, Total and dissolved Iron, Total and dissolved Manganese, Total Mercury, Dissolved Antimony, Dissolved Arsenic+3, Dissolved Cadmium, Dissolved Chromium+3, Dissolved Copper, Dissolved Lead, Dissolved Nickel, Dissolved Selenium, Dissolved Silver, Dissolved Thallium, Dissolved Zinc, Habitat assessment/physical characterization, Macroinvertebrate Assessment, Periphyton Bioassessment, Fish IBI Assessment, Diurnal dissolved oxygen surveys, Intensive bacteriological studies, pesticides, semi-volatiles, Atrazine, Glyphosphate

Data Analysis

Since 2005, ADEM Monitoring Strategies have been designed in part to provide stressor-response data that can be used to develop indicators and criteria. It is based on the two relationships depicted in Figure 8. ADEM biological monitoring activities were planned along a full disturbance gradient to produce a dataset representing both the full stressor gradient and the full biological condition gradient. The ADEM is in the process of analyzing the biological and chemical datasets to develop indices and metrics, and to plan future monitoring in areas where it is needed. Approximately 800 macroinvertebrate bioassessments were scheduled at 670 stations, 2005-2014. Of those, only 630 macroinvertebrate surveys could be completed at 520 stations due to drought and other unforeseeable factors.

Current Initiatives

Indicators of nutrient enrichment: Biological indicators of nutrient enrichment (nutrient optima/tolerance values for macroinvertebrates, fish, and diatoms) to adopt the most appropriate nutrient criteria for wadeable streams and rivers was identified as a priority of the 2005 and 2012 Monitoring Strategies. However, as stated in the State of Alabama's 2014 Nutrient Criteria Implementation Plan, it has been difficult to establish links between biological and nutrient conditions, due to the complexity of nutrient enrichment issues, including the presence of confounding factors at many sites. The ADEM is currently working with EPA Headquarters and Region 4 to analyze the ADEM 2005-2014 dataset to identify nutrient sensitive and opportunistic

taxa and develop a biological predictive model to identify nutrient risk based on the sensitivity and optima metrics. A similar approach has been used by New York State (Smith et al., 2007).

The data analysis proposed in the project supports current ADEM efforts to develop criteria for reservoir embayments by providing data to determine if nutrient criteria developed for these systems would be protective of upstream uses. It also complements these efforts by providing potential indicators and criteria for streams that do not have reservoir embayments.

Identification of diatom samples: Many recent studies suggest that diatom community assessments may be the most effective and consistent indicator of nutrient enrichment. The ADEM collected approximately 220 diatom community bioassessments, 2005-2014. The ADEM is building in-house capacity to process and identify these samples. Progress has been made, but continued progress is dependent on available resources.

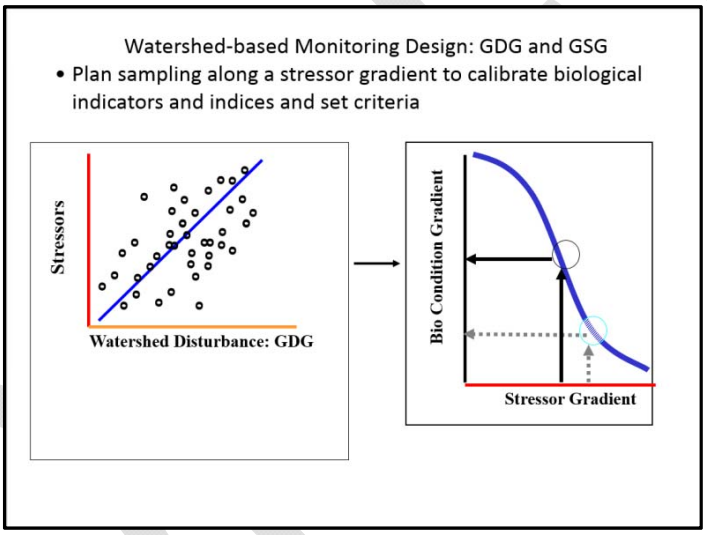

Figure 8. Watershed-based Monitoring Design.

Estimate of overall water quality: The ADEM 2005 and 2012 Monitoring Strategies were designed to estimate overall water quality in wadeable streams. The design included a network of approximately 990 monitoring units representing all wadeable, flowing waters within Alabama. Data collected at a subset of these locations will be used to develop a model to predict stream health for all wadeable flowing streams and rivers statewide using ADEM biological indices and a measure of watershed conditions. A similar approach has been used by Connecticut (Bellucci et al. 2013).

WDG Calculations: The ADEM is currently testing different methods to improve the correlation between the WDG scores/categories with chemical, physical, and biological data. Data analysis include basing the WDG on percent high risk landuses within the full watershed versus only within the riparian corridors and converting the WDG scores to a 100-point scale. Additionally, the WDG was calculated using percent landuse from the 1993, 2001, 2006, and 2011 National Land cover Datasets to assist with interpretation of longterm and before/after datasets.

Reporting

RSMP Monitoring Summary Reports are generally completed within two years of data collection, and are available by year at:

http://www.adem.alabama.gov/programs/water/wqsurvey.cnt.

Data collected at each station are entered and QAed by the collectors to ensure that the dataset in ALAWADR is complete and correct. Once data entry is complete, the RSMP manager reviews the annual surface water quality monitoring dataset by water body type, sampling protocol, and ecoregion to ensure that the collected data are of the highest quality, and to evaluate conditions at each monitoring location. Draft reports are completed and reviewed by Field Operations and the Basin Teams prior to publication.

WETLANDS MONITORING PROGRAM (WMP)

In April of 2006, EPA developed the *Application of Elements of a State Water Monitoring and Assessment Program* (EPA 2006) to help States plan and implement a comprehensive water quality monitoring and assessment program to protect and restore water quality of all waters of the State as described in the Clean Water Act (CWA). The *Elements* document requires that each state develop a wetland monitoring program by 2014, and serves as a guideline to ensure that a State's Wetland Monitoring and Assessment Program not only meets the needs of the State's Monitoring Objective but also those required by the CWA Section 106(e)(1).

In 2011, ADEM began sampling wetland systems statewide as part of EPA's National Wetlands Condition Assessment (NWCA). In 2012, Piedmont and Coastal Plain wetland systems were sampled as part the two-year Southeast Wetlands Monitoring Intensification Survey. Wetland training in hydric soils, vegetation, and amphibians was provided to ADEM field staff. ADEM will analyze the protocols and data obtained during these surveys to develop a comprehensive wetland monitoring program that can be incorporated in Alabama's current Water Quality Monitoring Strategy.

Currently, ADEM is focusing efforts on identifying reference wetlands, defining wetland site classes, and developing methods and protocols for sampling these systems. These activities are based on EPA's 2008 *Core Elements of an Effective State or Tribal Wetland Program Framework* (Core Elements Framework) document to develop a WMP that will meet current and future monitoring needs, including monitoring and assessing Category 2B and 4A wetlands, wetland restoration projects, mitigated wetlands, and protected wetland areas. In 2014, a workgroup made up of representatives from key state and federal agencies was established to ensure full participation of each of the programs in the development of the WMP. Below is a summary of the 5-year WMP goals, objectives, and activities.

Year One (2015):

Goals and Objectives: Organize a WMP workgroup meeting. Identify and document the objectives of Alabama's long term wetlands monitoring program. Identify the data needed to achieve these goals and objectives for all reference wetlands statewide. Determine the objectives, methods, and

indicators for the first 5-yr Wetland Monitoring Strategy Design to include in Alabama's overall Surface Water Monitoring Strategy.

Activities

1. Coordinate a three day WMP Workgroup meeting to establish long term wetland monitoring objectives to satisfy program needs and incorporate the elements of the Core Elements Framework.
2. Train field staff to delineate/determine wetlands for identification and categorizing wetland types based on vegetation, hydrology, and hydric soil indicators and begin recons of wetlands identified in existing wetland inventory.
3. Gather and compile existing wetland inventory maps and location information such as: watershed, ecoregion size, landuse, and wetland types from available resources to categorize wetlands of the state.
4. Research and develop a wetland delineation/determination method for wetland identification and verification, review methods used during the 2011 NWCA Survey and the multi-state Piedmont and Coastal Wetland Assessment Study to select the best indicators and sampling methods to meet ADEM monitoring objectives as described in the 2015-2019 Surface Water Monitoring Strategy.
5. Integrate the 5-yr WMP into Alabama's 2015-2019 Surface Water Monitoring Strategy. It will include a process for revising the WMP annually, based in part on data needs of and input from program partners.
6. Report progress updates and program design modification to EPA for comments.

Year Two (2016):

Goals and Objectives: Complete an updated, accurate wetland inventory for the State of Alabama. Research and develop core and supplemental indicators to assess the condition and function of the wetlands to establish and compare "quality standards" and potential stressors that may impact wetland quality for long term monitoring and assessment to protect and restore water quality as described in the CWA as well as the ADEM Monitoring Strategy Objectives.

Activities

1. Research and identify a listing of potential reference wetlands in the State of Alabama.
2. Continue to research and develop field methods and parameters to collect biological and water quality samples for further analysis to provide a measurement for evaluating water quality of wetlands.
3. Adopt a list of indicators and stressors to measure wetland condition and function that are best suited to reach ADEM monitoring objectives.
4. Sample and monitor eight potential reference wetland locations within the 65 ecoregion.
5. Train staff in ArcMap and GIS Mapping programs for the interpretation of wetland inventory data, evaluation of potential stressors within the watershed to monitor and protect water quality standards, and provide conditional information to be used in future project planning and reporting condition to public.
6. Compile wetland inventory data collected and verified into an ArcMap GIS program to create an accurate and updated wetland inventory for the State of Alabama to include level 1 assessment of the watershed indicators such as landuse information, population density, and potential disturbances.
7. Report progress updates and program design modification to EPA for comments.

Years Three (2017) and Four (2018):

Goals and Objectives: Research and develop a Quality Assurance Plan to be approved by EPA that ensures the validity and accuracy of data gathered. Research and develop a monitoring design to meet the State of Alabama's Monitoring and Assessment goals and objectives. Process data collected using selected methodologies and indicators to determine the effectiveness of the strategy in meeting ADEM monitoring objectives. Test the ability of the ADEM surface water database (ALAWADR) to manage all WMP data and to identify gaps that need to be addressed.

Activities:

Develop and revise existing SOPs, QAPPs, etc. as needed, based on data analysis and workgroup input, to incorporate wetlands monitoring and assessment into state's current monitoring plans.

Continue to sample, monitor and compile data of potential reference wetland locations within the state of Alabama.

1. Develop a design that relies on a combination of stratified random sampling (probabilistic sampling along a gradient of wetland watershed conditions) and targeted sampling to support specific management decisions and needs. This approach mirrors the ADEM current Monitoring Strategy.
2. Test ability of ALAWADR to manage all data used to identify, delineate, and classify wetlands, as well as all data and information collected as part of the WMP.
3. Analyze and process wetlands data collected to establish baseline for reference conditions based on wetland types for future sampling activities and comparison of similar wetland types to determine and characterize wetland quality to protect and restore wetlands water quality.
4. Report progress updates and program design modification to EPA for comments.

Year Five (2019):

Goals and Objectives: Evaluate monitoring program. Modify the wetlands monitoring strategy as needed to better meet the goals and objectives for the State of Alabama and to allow the future incorporation of other elements outlined in the "Core Elements Framework" into the WMP as needed. Research and modify SOPs and QAPPs to ensure the validity and accuracy of data gathered after any changes in strategy. Implement necessary changes to ALAWADR to manage all WMP data. Migrate WMP data into ALAWADR.

Activities:

1. Develop a schedule to re-evaluate the monitoring program.
2. Continue to research other wetlands program elements for future development.

3. Update documents as needed to reflect changes in the program i.e., SOPs, QAPPs, and reporting documents.
4. Identify and prioritize wetlands selected for reference reach monitoring to capture wetland quality over a variety of wetland types, conditions, and functions such as protected and least-impacted wetlands to establish background or reference conditions statewide, restored or mitigated wetlands to document project effectiveness, and Category 2B and 4A wetlands as well as other wetlands as requested to meet the needs of other programs to document current water quality conditions.
5. Revise ALAWADR as needed to manage all WMP data.
6. Migrate 2015-2019 WMP data into ALAWADR.
7. Provide a final Wetland Program Development summary to EPA.
8. Update WMP Strategy based on program evaluation.

FISH TISSUE MONITORING PROGRAM (FTMP)

Background

The Alabama Department of Environmental Management (ADEM) and its predecessor, the Alabama Water Improvement Commission (AWIC), have collected fish for analysis of contaminant levels since 1970. For the 20 years that followed, fish collections focused on areas of known or suspected contamination. In 1991, ADEM instituted and expanded the Fish Tissue Monitoring Program (FTMP) to provide statewide screening of bioaccumulative contaminants in fish tissue, and to provide the ADPH with data needed for determination of potential risk to those who consume fish from Alabama waters. The expanded program historically exists as a cooperative effort between the ADEM, ADPH, ADCNR, and TVA.

Following expansion of the program to statewide screening, fish from all of Alabama's major reservoirs, rivers, streams and state-managed public fishing lakes were collected over a five-year period. Data from these locations were provided to the ADPH for issuance, modification or removal of fish consumption advisories.

In 1997, the FTMP was incorporated into the ADEM Watershed Management Approach. With this approach, water quality of each major drainage basin in the state was assessed by ADEM on a five-year rotating basis. In addition to the basin locations sampled each year, the ADEM continued to sample areas of concern outside the focus basin as needed or requested by cooperating agencies and as resources allowed.

Because of the variability in contaminant concentrations observed in fish collected from locations over several years, and the need for additional monitoring at a number of locations, the approach to annual monitoring was refined in 2002. Annual fish tissue monitoring became multi-faceted and directed toward accomplishing three objectives:

1. sampling locations throughout the focus basin (Tier I basin screening),
2. repetitive sampling of sites where the ADPH determined that EPA/FDA action levels have been exceeded (Tier II known impact) and
3. sampling remaining areas across Alabama where fish have not been collected for the FTMP (Tier I screening).

Repetitive sampling of sites where EPA/FDA action levels have been exceeded proceeds as follows:

1. sites that exceed EPA/FDA action levels for the first time will be sampled for a minimum of two concurrent years to provide verification of contaminant concentrations, as requested by the ADPH;
2. sites where ADPH consumption advisories currently exist will be sampled at a minimum of every three years to provide data for analysis of trends in contaminant concentrations.

The frequency of sampling for these sites is dependent on available resources. The Program also monitors sites outside the focus basin as needed or when requested by cooperating agencies.

In June 2006 the ADPH adopted the EPA guidance level for mercury in fish of 0.33 ug/g for issuance of public consumption advisories, replacing the FDA guidance level of 1.0 ug/g previously used. In March 2014, the FTMP discontinued dioxin monitoring below paper mills. Dioxin monitoring was discontinued because levels in fish have been below method detection levels since 2004 and below levels requiring consumption advisories since the early 1990's.

The program was further modified to its current form in 2015 to not only provide the data neede by the ADPH for consumption advisories but to also meet the data needs of the ADEM water quality assessment and listing process. In order to meet these needs, fish tissue samples will be collected within each major river basin in the state on a three-year rotating basis, providing two repetitions of sampling within the six-year period required for monitoring data in the assessment and listing methodology. The initial regional rotation will be as follows:

a) Alabama, Cahaba, Tallapoosa, and Tennessee Rivers (2015)

b) Coosa and Tombigbee Rivers (2016)

c) Black Warrior, Perdido-Escambia, Choctawhatchee, Pea, and Chattahoochee Rivers (2017)

In addition to the major river basin schedule, coastal sample locations (locations south of the I-65 Mobile River bridge) will be divided into three geographic regions, eastern, central, and western, and sampled on a three-year rotation as well.

Within the river basins and coastal zone, site selection will be directed toward accomplishing three goals:

1. Repetitive sampling of sites where the ADPH has determined that EPA/FDA limits have been exceeded,
2. Repetitive sampling of sites within each major Alabama reservoir in support of Alabama's Assessment and Listing Methodology,
3. Sampling remaining areas in Alabama where fish have not been collected for the FTMP or other areas of concern as they arise.

The extent to which the above goals are accomplished each year continues to be dependent upon available resources.

To date, several thousand fish have been collected and processed from more than 350 locations and analyzed for the FTMP.

Objectives

The objectives of the FTMP are to:

1. Provide the ADPH with the data needed for determination of potential risk to those who consume fish from Alabama waters,
2. Provide the ADEM WQB required data to meet the needs of Alabama's Assessment and Listing Methodology,
3. Provide a statewide screening of bioaccumulative contaminants in fish tissue,
4. Monitor trends in contaminant concentrations in fish tissues.

Design

The number of sampling locations each year typically varies from forty to fifty stations, consisting of a mix of Tier I stations (screening and basin assessment) and Tier II stations (EPA/FDA limit exceedance sites). The number of fish collected each year typically ranges from 480-600. Stations sampled and numbers of fish collected vary according to the size of the basin, number of Tier II sites, and resources available in a given year.

Sampling is typically conducted in the fall of the year, generally October-December. These months are preferred in fish tissue monitoring programs because:

a) organic pollutants, primarily stored in fatty (lipid) tissue, would be at the greatest concentration as fat content of fish is highest at this time of year,

b) target species are more easily collected while water levels are low and as water temperatures cool,

c) Fall collections do not interfere with spawning seasons of target species.

Collection methods may include electrofishing and/or gillnets as needed. At each location, six individuals of the same species are collected from each of two primary feeding groups, predators and bottom-feeders. Where mercury contamination is the primary concern, only predator species may be collected if resources are limited. Collected fish are within a size range identified in SOP#2300, with the additional requirement that catfish weigh a minimum of one pound as requested by the ADPH.

Fish collected at each location may be analyzed as species-specific composite samples (Tier I screening), or as individuals (Tier II known impact) when more definitive contaminant concentration data in fish is needed from an impacted site. Following completion of analyses, all data are compiled and provided to the ADPH for modification of Alabama's Fish Consumption Advisories and distributed to cooperating agencies.

Core and Supplemental Water Quality Indicators

Core Indicators: Arsenic, cadmium, lead, mercury, selenium, chlordane, chlorpyrifos, 4,4-DDD, 4,4-DDE, 4,4-DDT, 2,4-DDD, 2,4-DDE, 2,4-DDT, dieldrin, endosulfan I, endosulfan II, endrin, heptachlor, heptachlor epoxide, hexachlorobenzene, lindane, mirex, toxaphene, PCBs, dioxin, relative weight. The physical condition of important sport and/or commercial fish species collected for tissue monitoring is evaluated using relative weight. Relative weight is a condition indicator used by fishery biologists to compare individual fish or a group of fish with a standardized norm. Using this system a fish that scores 80 to 100 would be considered in good-to-excellent condition while a fish that scores 79 or below would be considered fair-to-poor. These same fish are also examined for any external anomalies such as lesions (sores), tumors, parasites, and deformities.

This relative weight condition indicator is used to evaluate the trends in the health of a fish community.

Supplemental Indicators: As needed for Tier II assessments.

Reporting

ADPH fish consumption advisories can be found at: http://www.adph.org/tox/index.asp?id=1360

FTMP summary reports can be found at:

http://www.adem.state.al.us/programs/water/wqsurvey.cnt

PERMIT COMPLIANCE MONITORING PROGRAM

Background

Congress passed the Federal Water Pollution Control Act (1965) requiring state development of water quality standards for all interstate waters. Thereafter, the law was amended to include revisions outlined in the Clean Water Act (1972) which further delineated water quality standards on an intrastate level and required discharging facilities to comply with set-forth permits in order to achieve these water quality standards. The Act was further amended by the Water Quality Act of 1987 which, in part, brought about the regulation of industrial and municipal stormwater.

ADEM has developed a comprehensive monitoring strategy that includes, as a component, the compliance monitoring of National Pollution Discharge Elimination System (NPDES), State Indirect Discharge (SID), and Underground Injection Control (UIC) permits issued by the Department.

Objectives

Determination of a facility's compliance with the Departmental issued NPDES, SID or UIC permit(s).

Design

ADEM implements various compliance sampling techniques to assure the implementation of state and federal laws and the protection of overall environmental quality. One of the compliance monitoring programs conducted by ADEM consists of Compliance Sampling Inspections (CSI) of permitted facilities. During the CSI, an extensive review of the permitted facility's records and reports is conducted. Facilities are required to maintain all records and reports for a minimum of three years. Reviewed records include: Departmental issued permits, discharge monitoring reports, chain of custody forms, laboratory analytical data, laboratory standard operating procedures, calibration records, Best Management Practice (BMP) and Spill Prevention Control and Countermeasure (SPCC) plans along with any associated inspections.

Compliance inspectors also conduct a facility walk-through to gauge the effectiveness and operation of the treatment or pretreatment processes utilized by the permitted facility. Along with the records review and treatment plant inspection, representative samples required for monitoring parameters listed in the facilities' permit are obtained. ADEM also conducts Compliance Bioassay

Inspections (CBI), which includes collection of effluent samples to evaluate the biological effect of a permittee's effluent on test organisms (i.e., bioassays).

The Department has agreed with EPA to conduct inspections at varying frequencies for permitted entities. Generally, a commitment list is developed at the beginning of each inspection year based upon factors such as the classification of the discharger (e.g. major or minor source), the status of the receiving waterbody (e.g., TMDL or impaired water), facilities with the longest period between inspections, citizen complaints, federal request and proximity of locations.

A compliance sampling inspection may include (but is not limited to) collection of samples by grab or composite (flow or timed) sampling techniques. Composite samples consist of equal volume aliquots being collected at equal time or flow intervals throughout the duration of discharge, not to exceed twenty-four hours. Samples are collected from permitted outfalls at influent, effluent, receiving waterbody, or overland flow sampling locations. Samples of the receiving waterbody may be collected both upstream and downstream of the permitted outfall/discharge point. Samples may be collected for field measurements, chemical laboratory analysis, microbiological analysis, and/or bioassay. The sample results are then used to interpret the degree of potential impact to the receiving water and assess permit compliance.

For those facilities that have intermittent discharges, on an unannounced inspection, samples are only collected if a discharge is present during the time of the facility visit. Inspectors are required to return on an announced visit to ensure a sample is collected for every facility on the commitment list unless a special circumstance exists (i.e. facility does not discharge). Chemical and bacteriological analyses are performed, as applicable, and the results are reviewed by the appropriate regulatory entity, where they may be used to verify the accuracy of the permittee's self-monitoring program and reports, determine compliance with discharge limitations, determine the quantity and quality of effluents, develop permits, and/or provide evidence for enforcement proceedings where appropriate.

A core set of environmental indicator parameters may also be analyzed from effluent samples collected during CSIs. These data are forwarded to the Water Division for use in TMDL development and other water quality assessments. Each indicator parameter is evaluated on a systematic basis to determine its usefulness for assessing NPDES, SID, and UIC compliance status.

Core and Supplemental Water Quality Indicators

As applicable on a programmatic basis:

Core Indicators: Total alkalinity, aluminum, antimony, arsenic, atrazine, alachlor, metolachor, aldicarb, cadmium, total organic carbon, chemical oxygen demand, chlorine, chlorophyll *a*, chromium, copper, cyanide, dissolved oxygen, E-coli, Enterococci, carbonaceous biochemical oxygen demand, hardness, iron, lead, manganese, mercury, nickel, ammonia, nitrate+nitrite, total Kjeldahl nitrogen, organo-chlorine pesticides, oil and grease, organo-phosphorus pesticides, pH, zinc, selenium, semi-volatiles, silver, total dissolved solids, total suspended solids, specific conductance, temperature, thallium, total phosphorus, dissolved reactive phosphorus, toxicity, turbidity.

Supplemental Indicators: As required by permit.

GROUND WATER MONITORING PROGRAM

Background

Many of the elements of Alabama's ground water programs are managed by subdivisions within the Alabama Department of Environmental Management (ADEM), including the Land, Field Operations, and Water Divisions. The Groundwater Branch in the Land Division provides the hydrogeological support for these programs. Other programs related to ground water management and protection are managed by other state and federal agencies. The on-site sewage program is managed by the Alabama Department of Public Health and the Class II Underground Injection Control Program is managed by the State of Alabama Oil and Gas Board. Ground water quantity issues are addressed by the Alabama Department of Economic and Community Affairs Office of Water Resources. Other ground water monitoring and regulatory programs are managed by the Geological Survey of Alabama and the Alabama Surface Mining Commission (ASMC). The U.S. Environmental Protection Agency (EPA) provides oversight on all federally funded and delegated ground water programs, except for the ASMC, which is overseen by the U.S. Department of Interior, Office of Surface Mining.

The State of Alabama recognized that there was a need to coordinate management of groundwater programs and as a result set up the Ground Water Programs Advisory Committee (GWPAC) in 1994 to aid in completing the requirements for EPA's Core Comprehensive State Ground Water Protection Program (CSGWPP). This committee met for several years but is not active at the present time.

The Groundwater Assessment Program (GAP) at the Geological Survey of Alabama (GSA) is responsible for storage and maintenance of Alabama water well data, state wide monitoring of groundwater levels, and applied hydrogeologic research related to Alabama's water resources. The GSA has maintained a program to collect water levels from all of the major aquifers in the state for more than 40 years. The GAP manually measures water levels in about 400 water wells each year and maintains a system of 18 continuously monitored wells outfitted with electronic monitoring equipment that require periodic manual data downloads. In order to upgrade this program with the latest technology, the GAP has initiated implementation of the first phase of a real time groundwater level monitoring system. Phase 1 consists of 30 wells distributed throughout the state. Water levels, measured every 30 minutes, are transmitted to GSA where the data are

stored. The GAP is currently developing the capability to post real-time groundwater levels along with interpretations of the data on the GSA web site. These data will indicate current aquifer conditions and climatic and production impacts. GSA is completing a state-wide groundwater resource assessment in 2016. A future component of the assessment will be a systematic evaluation of groundwater quality over several years throughout the state.

The following items summarize some of the other significant ground water developments that have occurred within the last several years in Alabama:

- Initiation of a ground water quality database for reporting.
- Regulations have been developed by ADEM and implemented to deal with Animal Feeding Operations and Concentrated Animal Feeding Operations (AFOs and CAFOs). Hydrogeologic site evaluations and ground water monitoring requirements have been included in the regulations as part of siting and operation requirements for AFO/CAFO lagoons and land application sites.
- The U.S. Geological Survey has also conducted National Water Quality Assessment for two study units that include significant parts of Alabama's Mobile River and Lower Tennessee River Basins.
- The Non-Point Source Program has provided funding for pesticide sampling of residential wells in vulnerable areas in the southernmost half of the Coastal Plain Ground Water Province. Sampling, analysis, and reporting have been completed.
- The state Groundwater Program has provided funding for pesticide sampling of residential wells in vulnerable areas in the northernmost half of the Coastal Plain Ground Water Province. Sampling, analysis, and reporting have been completed.
- ADEM has implemented an ambient ground water monitoring program in the Piedmont District for radionuclides. Sampling was completed and a report was developed in December 2003.
- ADEM has implemented an ambient ground water monitoring program for nutrients in watersheds with heavy poultry industry.
- The Alabama Department of Agriculture and Industries (ADAI) provided funding for pesticide and metals sampling of residential wells in vulnerable areas in the Valley and

Ridge and the Cumberland Plateau Provinces of Central and North Alabama. Sampling was completed and a report developed. The ADAI also provided funding for sampling of residential wells in vulnerable areas of the Tennessee River Watershed. Sampling was completed and a report developed.

- ADEM has completed a statewide ambient ground water quality monitoring effort using the probabilistic monitoring grid approach.

Information that follows pertains to this statewide monitoring effort. Available funding allowed only one year of monitoring. If funding and necessary resources are available in the future the effort will be repeated.

In support of the State Pesticides in Groundwater Plan, ADEM and the Alabama Department of Agriculture and Industries have worked cooperatively to determine ambient groundwater quality in Alabama. Monitoring of selected private residential wells in targeted counties began in 1989 using conventional techniques for analysis. In 1992 ADEM began using immunoassay analyses for county-wide studies and in 2000 began a systematic study of the state.

Funding for the immunoassay monitoring program was through the Clean Water Act Section 106 and 104(b)(3) Grant programs, the Alabama Department of Agriculture and Industries, EPA Nonpoint Source Section 319 grant, and a Special Appropriation for the Tennessee Valley Area.

Objectives

Objectives for this statewide ambient ground water quality monitoring effort were as follows:

1) Characterize the ambient groundwater quality in the state; and,
2) Focus monitoring efforts in key agricultural counties with vulnerable aquifers.

Design

Random Sampling: County-wide studies were developed based on aquifer specific characteristics such as vulnerability and use. Use was defined as drinking water, agricultural use such as field products or poultry, and the ratio of residential homes to on-site sewage systems. Private residential wells were sampled and field parameters logged, with 30-100 wells sampled per county. Wells were randomly selected and located in rural areas (see map).

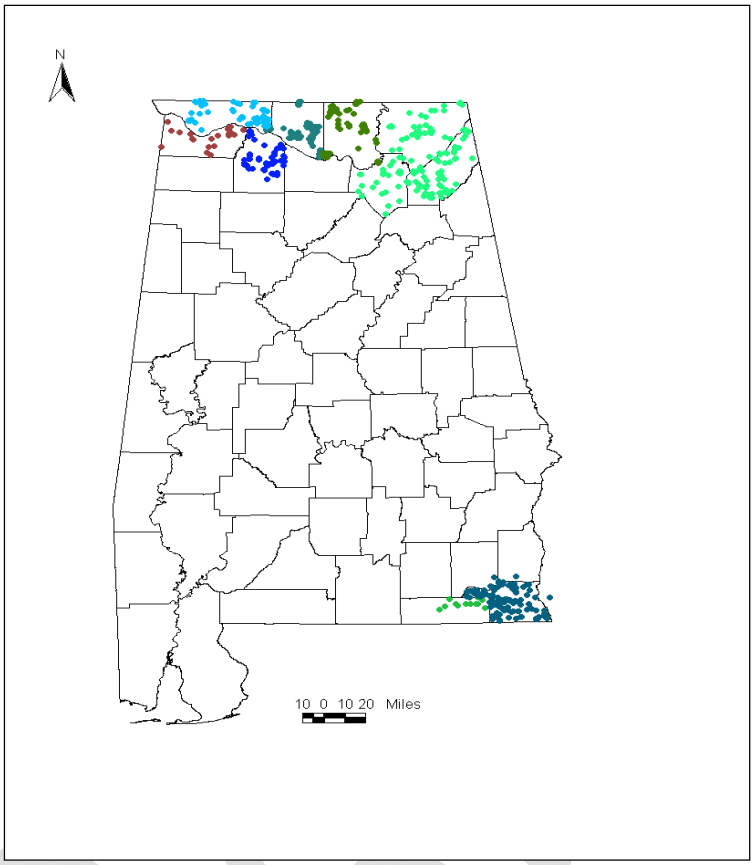

Figure 9. Counties and locations where random sampling procedures were used.

Spatial Sampling: The state-wide study was designed similarly to two previous studies by the Center for Disease Control (CDC) and state health departments. The studies were conducted in 1994 in nine Midwestern states and a similar study conducted in 1995 for Alabama, Georgia and Florida. The CDC study developed an equal-area sampling design by laying a ten-mile grid over Alabama, Georgia and Florida. The CDC monitoring program was used to estimate the extent of bacterial contamination in private wells. Samples were collected from wells at or within a 3-mile radius of the intersections of the grid lines. If a suitable well was not located within the 3-mile radius the closest well to the nodal point was sampled.

The sampling grid in Alabama was divided into 3 areas based on hydrologically distinct physiographic provinces. The provinces included the Lower Coastal Plain, the Upper Coastal Plain, and the Valley and Ridge. In 2000, 140 wells were sampled in the Upper Coastal Plain, 190 wells were sampled in 2001 from the Lower Coastal Plain and 147 samples were collected in 2002 from the Valley and Ridge province (see map).

Core and Supplemental Water Quality Indicators

Core Indicators/Random Sampling: pH, conductivity, temperature, nitrates, atrazine, aldicarb, alachlor, and metolachlor

Core Indicators/Spatial Sampling: fecal coliform bacteria, atrazine, aldicarb, alachlor, and metolachlor, total organic carbon, sulfate, silicate, phosphate, nitrate, bromide, flouride, chloride, and 61 metals.

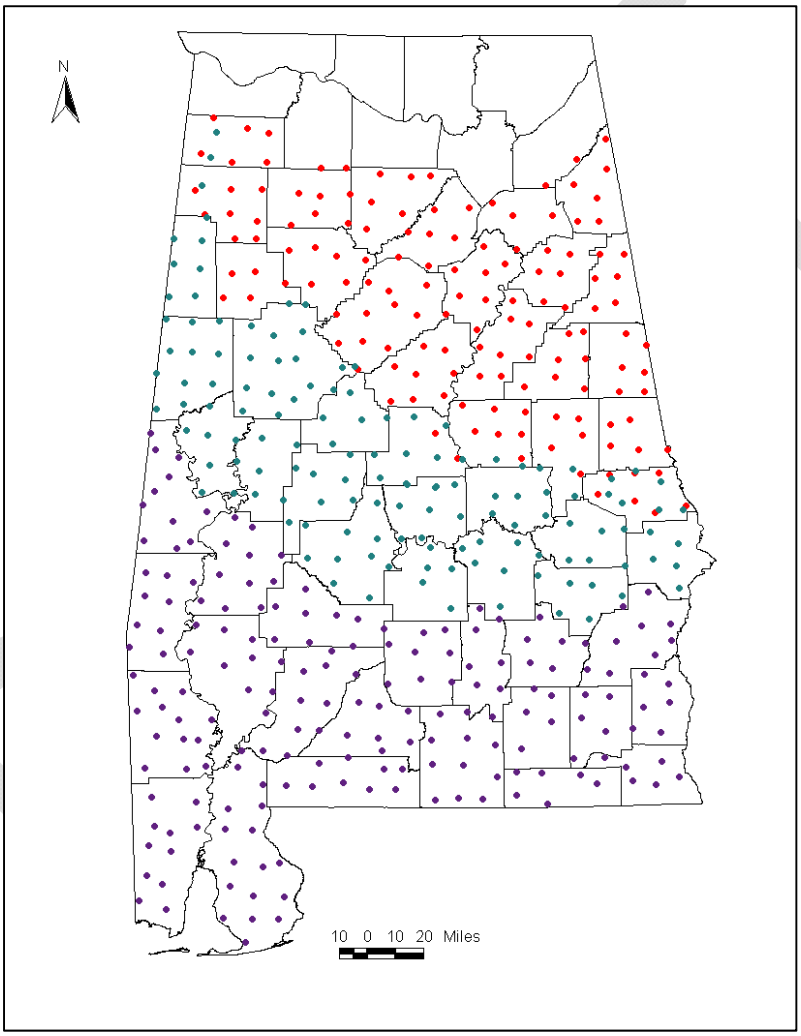

Figure 10. Spatial sampling grid. Red nodes are sampling locations for the Valley and Ridge Province, green nodes are locations in the Upper Coastal Plain and purple nodes are locations in the Lower Coastal Plain.

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APPENDIX A.

Long term Ambient Trend Network

The ADEM Ambient Monitoring Network, which includes stations sampled as part of the RSMP, the RRMP, and the CWMP, has expanded over the years to meet new and emerging data needs. A summary is provided to assist with future report generation and programmatic reviews.

Background

The ADEM has maintained an Ambient Monitoring Network since 1974. In 2005, the network was expanded to include 94 monitoring stations statewide to provide data for long-term trend analysis for the NPDES program. In addition, these data would be used for development of water quality criteria and standards, particularly for nutrient and sediment in mid- and large rivers systems for which ecoregional reference reaches are difficult to establish. Fifty-seven of the 94 monitoring locations were established at USGS gaging stations to provide continuous flow data to help in the development of pollutant loading models. Sampling at ambient monitoring network stations was designed to meet the requirements of The ADEM 2004 CALM, based on waterbody type and use classification, over a 5-year basin rotation. Core and supplemental indicators at each location were determined by waterbody type. Metals were collected at all stations once in June.

Sampling frequency also varied among reaches. Monthly (January-December) sampling was requested at stations where data were limited, or where additional data were needed for TMDL development. June/August/October sampling was selected as the minimum sampling frequency for all ambient monitoring stations that would be representative of a water body under critical conditions and that would, over a 5-year monitoring cycle, provide the minimum data for categorizing each station in Alabama's Integrated Assessment Report. To assist with field efforts and lab loading, monitoring of some 3X stations was re-scheduled to May/July/September. To the extent possible, these changes were made within an entire basin. A more in-depth summary is provided in the 2005 Monitoring Strategy document.

2015 Ambient Monitoring Network

An extensive review of the upland portion of the network was conducted in 2014. Based on this review, the network was expanded to 109 monitoring locations to support current data needs and priorities. In 2015, the Ambient Monitoring Network was reduced to 88 stations statewide, when 21 stations were removed from the network to increase CWMP sampling to a 3-year coastal monitoring rotation for nutrient criteria development.

The objectives of the network are to identify long-term trends in water quality and collect data to develop criteria, standards, and TMDLs. The selected stations are distributed relatively evenly throughout each of Alabama's 14 major drainage basins to provide overall coverage throughout the state. Site selection focused on USGS gaging stations, to provide valuable real-time flow data. Fifty-nine of the 88 monitoring locations were established at USGS gaging stations. In addition, sites were also located at state lines to monitor water quality within each basin as it enters and leaves Alabama.

The monitoring, assessment, and listing methodologies differ between wadeable and non-wadeable waterbodies, as well as between freshwater and estuarine waterbodies. Fifty-one wadeable and 37 non-wadeable sampling reaches are monitored statewide.

Monthly (January-December) sampling is conducted at 25 stations where data were limited, where additional data were needed for TMDL development, or to monitor water quality as it enters or leaves the state. Sampling three times during the growing season was selected as the minimum sampling frequency that would provide data representative of a water body under critical conditions and provide the minimum data needed for categorizing water bodies in Alabama's Integrated Assessment Report. To increase the number of stations that can be monitored, and to level out field and laboratory resource needs, twenty-five locations are sampled May/July/September and 34 are sampled June/August/October.

Station descriptions and data summaries are included in the Biennial Integrated Report, available at: http://www.adem.alabama.gov/programs/water/waterquality.cnt.

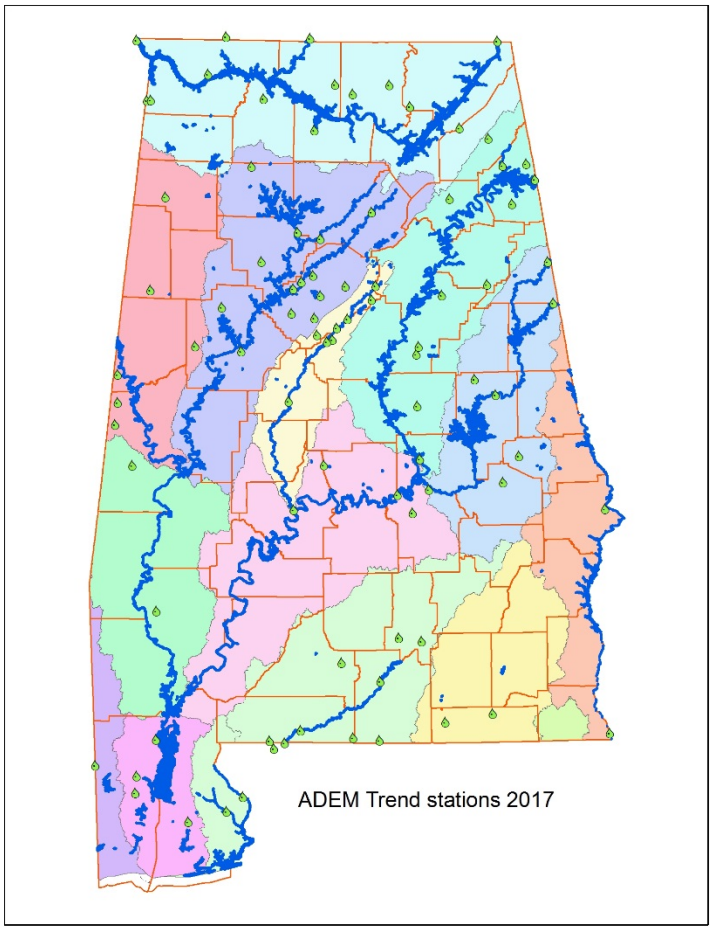

Figure 11. Ambient trend monitoring locations.

Core and Supplemental Water Quality Indicators

Collection methods varied between wadeable and nonwadeable sampling reaches. At wadeable stream reaches, *in situ* measurements and water samples are collected at mid-depth. The protocol used to collect field parameters and water samples at nonwadeable stations depends on accessibility. At nonwadeable stations that are accessible by boat, samples are collected as photic zone composites. Full vertical profiles of depth, temperature, dissolved oxygen, pH, and conductivity are measured at inaccessible stations ≥ 3 m in depth. A minimum of 3 measurements are collected at the surface, mid-depth, and bottom at stations <3 m in depth. At stations not accessible by boat, surface grab samples are collected. Full vertical profiles of depth, temperature, dissolved oxygen, pH, and conductivity are measured at inaccessible stations ≥ 3 m in depth. A minimum of 3 measurements are collected at the surface, mid-depth, and bottom at stations <3 m in depth.

Sampling frequency for the majority of physical and chemical parameters was set at either monthly (Jan-Dec) or three times per year (May/July/September of June/August/October). Metals samples are collected once in May or June at all stations. Habitat and aquatic community assessments (periphyton, macroinvertebrate, and fish) are conducted at 71 non-navigable stations. Stations to be sampled are determined annually by the Basin Teams.

Core Indicators: Flow (where appropriate), Total stream depth, Sampling depth, Water temperature, Dissolved oxygen, pH, Specific conductance, Turbidity, Total suspended solids, Total dissolved solids, Hardness, Alkalinity, Ammonia-nitrogen, Nitrate+nitrite-nitrogen, Total Kjeldahl nitrogen, Total phosphorus, Dissolved reactive phosphorus, Chlorophyll *a*, Total organic carbon, Five-day carbonaceous biochemical oxygen demand, Chlorides, Total and dissolved Aluminum, Total and dissolved Iron, Total and dissolved Manganese, Dissolved Antimony, Dissolved Arsenic^{+3}, Dissolved Cadmium, Dissolved Chromium^{+3}, Dissolved Copper, Dissolved Lead, Dissolved Mercury, Dissolved Nickel, Dissolved Selenium, Dissolved Silver, Dissolved Thallium, Dissolved Zinc

Supplemental Indicators: Habitat Assessment, Macroinvertebrate Assessment, Periphyton Bioassessment, Fish IBI Assessment

APPENDIX B.

Ecoregional Reference Reach Network

Background

Innate regional differences exist in climate, landform, soil, natural vegetation, and hydrology. These factors, in turn, affect nutrient regime, substrate characteristics, and the composition of biological communities within aquatic ecosystems. By defining relatively homogeneous ecological areas, ecoregions provide a geographic framework for more efficient management of aquatic ecosystems and their components (Hughes 1985, Hughes et al. 1986, and Hughes and Larsen 1988). The EPA has recommended the development of ecoregional reference conditions as a scientifically defensible method of defining expected habitat, biotic, and chemical conditions within streams, rivers, reservoirs, and wetlands. Level IV ecoregions have been developed or are under development in 37 states nationwide. Griffith et al. (2001) delineated six Level III ecoregions in Alabama: Piedmont, Southeastern Plains, Ridge and Valley, Southwestern Appalachians, Interior Plateau, and the Southern Coastal Plain. Within these, they delineated 29 Level IV ecoregions.

ADEM uses ecoregions as an a priori classification of streams to assist in the development of a dataset representing least impaired background conditions for site classification analysis, development of biological, chemical, and physical reference conditions, and comparison with other streams. Since 1991, ADEM has selected and monitored least-impaired wadeable, flowing reference sites within each sub-ecoregion to be representative of "best attainable" conditions within that subecoregion (ADEM 2001).

The ADEM Ecoregional Reference Reach Project: 1991-2004: Specific selection criteria were used to ensure that reference reaches were typical of the subecoregion and relatively unimpaired. Watersheds containing the highest percentage of natural vegetation were first located using topographic maps and land use information compiled by EPA and local Soil and Water Conservation Districts. Departmental databases were used to ensure that potential reference watersheds did not contain any point source discharges, mining, or urban runoff, and minimal agricultural sources. Field reconnaissance was then conducted to ground truth land use estimates. In situ field parameters were collected and visual macroinvertebrate surveys were conducted to screen for obvious impacts to chemical and biological conditions. Substrate composition, gradient, canopy cover, sinuosity, and habitat quality and availability were estimated to assess stream condition and comparability to other streams in the subecoregion. Intensive site assessments were then conducted to verify that the reaches were in relatively good condition.

From 1991-1995, the Ecoregional Reference Reach Project was conducted annually, statewide by ecoregion. In 1996, the ADEM went to a 5-year basin rotation. Reference reaches and candidate reference reaches were sampled within the target basin, or as needed to support specific projects. Through this process, a total of 594 locations were investigated as potential reference reaches statewide. Sixty-five ecoregional reference reaches were established within Alabama. Data from these sites were used to develop assessment guidelines for The ADEM habitat assessments, screening-level macroinvertebrate assessments, and chemical parameters, including nutrient concentrations for 10 of the 29 subecoregions.

The ADEM Ecoregional Reference Reach Project: 2005-2014: In 2005, ADEM used its WDG and Departmental databases to identify candidate reference reaches in least-disturbed watersheds. Habitat and biological assessments (macroinvertebrates, fish, and periphyton), and monthly water quality data were used to verify that the sites were representative of least-impaired conditions within a subecoregion. Between 2005 and 2014, two hundred and sixty-nine locations were sampled as candidate reference reaches. Although the project concentrated on wadeable streams and rivers, for which the EPA and ADEM have developed rapid bioassessment protocols (Plafkin et al. 1989, Barbour et al. 1999, ADEM 2009, ADEM 2010a, ADEM 2012d, ADEM 2012e), large river ecoregional reference reaches have been established on Sipsey Fork and Hatchet Creek to assess specific impacts to Locust Fork, Mulberry Fork, and the Cahaba River.

In 2008, data from established ecoregional reference reaches were used to define macroinvertebrate site classes, and update reference guidelines for the ADEM habitat assessments and macroinvertebrate assessments, and chemical parameters (ADEM 2008a). In 2010, guidelines for chemical parameters were revised using additional data (ADEM 2011a).

In 2012, watershed information from 1,292 sites were used to identify potential ecoregional reference reaches statewide. Sites were classified by level 4 ecoregion and stream size (<5 square miles, 5-75 square miles, >75<1,000 square miles). For each site class, sites in the top 25th percentile of watershed condition, based on the ADEM WDG scores were selected as potential reference reaches.

Data collected at each candidate reference reach, including habitat assessment information, reach and watershed characteristics and observations, and the absence of permitted discharges within the watershed were used to validate reference reach status. Water quality data were used as a tertiary filter to exclude sites that may have been impacted by unknown sources. Google Earth

was also used to evaluate disturbances not reflected in the WDG score (silviculture, poultry, etc.). For sites >5 square miles, all watersheds within the lowest WDG category were selected as candidate reference reaches if at least five sites meeting this criterion could not be identified.

Current Initiatives

Without a centralized location for decisions concerning reference reach status, it has been difficult for users to be certain that they are using the most up-to-date list of potential reference reaches and ecoregional reference reach guidelines. As part of the 2015 Monitoring Strategy, the ADEM is implementing a more formalized process to review, identify and track ecoregional reference reach status and guidelines.

Identifying population of potential reference reaches: At a minimum, potential reference reaches are identified through desktop screening level surveys every five years. Analyses may be conducted more frequently if additional information is obtained. Recommendations and information from outside agencies and stakeholders are also considered. Multiple sources of information are used to evaluate and rank current watershed conditions, including ADEM's WDG, Departmental databases, Google Earth, EPA's 2012 HWI Assessment of Alabama, and EPA's 2016 station-specific RPS information. Each set of potential reference reaches is stored as a project in ALAWADR.

Selecting candidate reference reaches: Candidate reference reaches are selected from the population of potential reference reaches for intensive monitoring. They are monitored intensively for one year. Candidate reference reaches are selected as study-specific reference reaches to support current monitoring efforts, or to provide additional data for development or revision of ecoregional guidelines. As part of the 2015 Monitoring Strategy, the ADEM is currently expanding its efforts to establish ecoregional reference reaches in non-wadeable flowing waterbodies, as well as braided, blackwater and swamp systems to determine if these waters constitute distinct site classes, with distinct background conditions.

Candidate reference reaches are selected from the current list of active candidate, verified, or potential reference reaches. Within each site class, highest priority is given to waterbodies within protected areas, such as state parks and national forests.

Reviewing and verifying reference reach status: Candidate reference reach data is intensively reviewed. As with all stations, data are entered and QAed by the collectors to ensure that the dataset in ALAWADR is complete and correct. The collectors can also add notes concerning

status of a candidate reference during a station visit or suggest a current sampling station as a candidate reference reach.

Once data entry is complete, the program managers review the annual surface water quality monitoring dataset by waterbody type, sampling protocol, ecoregion, and drainage area to ensure that the data is of the highest quality, and to evaluate conditions at each monitoring location. Draft reports are completed and reviewed by Field Operations and Basin Teams.

Candidate ecoregional reference reach data are reviewed by reference reach project managers and Basin Teams, and a decision is made whether to reject or verify the site as a reference reach, or to continue monitoring. In 2015, the ADEM added functionality to ALAWADR to track reference reach status decisions and the reference reach dataset at the station level.

Calculating ecoregional reference guidelines: Data from verified ecoregional reference reaches are used to document "best attainable" baseline conditions. The methods used to calculate these guidelines are outlined in ADEM 2008a, 2011a, and 2015. The data are reviewed to ensure that the collected data meet the criteria set for use in the dataset. Verified ecoregional reference data are also reviewed to ensure that the data still represent "best attainable" conditions, or if the status of some of these data should be revised. For example, minimum detection limits of older data may be much higher than what is currently used; using these data could skew guidelines to higher concentrations. In other instances, data from "least-impaired" stations were used because they were the best available at the time; if data from watersheds in better conditions becomes available, the dataset should be reviewed to determine if the lower quality data are needed, or if they can be dropped as verified reference reaches.

Ecoregional reference reach guidelines are updated every five years, when a complete 5-year cycle becomes available. However, where verified reference reach data are limited, or no longer representative of "best attainable" conditions, or current methodologies, guidelines are updated more frequently on an as-needed basis.

Core and Supplemental Indicators

Core Indicators: Flow (where appropriate), Total stream depth, Sampling depth, Water temperature, Dissolved oxygen, pH, Specific conductance, Turbidity, Total suspended solids, Total dissolved solids, Hardness, Alkalinity, Ammonia-nitrogen, Nitrate+nitrite-nitrogen, Total Kjeldahl nitrogen, Total phosphorus, Dissolved reactive phosphorus, Chlorophyll *a*, Total organic

carbon, Five-day carbonaceous biochemical oxygen demand, Chlorides, color, Dissolved organic carbon

Supplemental Indicators: Supplemental indicators are determined by the data needs at each targeted site and may include: Total and dissolved Aluminum, Total and dissolved Iron, Total and dissolved Manganese, Total Mercury, Dissolved Antimony, Dissolved Arsenic^{+3}, Dissolved Cadmium, Dissolved Chromium^{+3}, Dissolved Copper, Dissolved Lead, Dissolved Nickel, Dissolved Selenium, Dissolved Silver, Dissolved Thallium, Dissolved Zinc, Habitat assessment/physical characterization, Macroinvertebrate Assessment, Periphyton Bioassessment, Fish IBI Assessment, Diurnal dissolved oxygen surveys, Intensive bacteriological studies, Pesticides, Herbicides, Atrazine