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ADEM

TECHNICAL REPORT

Methodology
For
Coastal Watershed Assessments

Coastal Programs
April 2001

Alabama Department of Environmental Management
Mobile Branch
2204 Perimeter Road, Mobile, AL 36615

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List of Abbreviations

ADEM.....Alabama Department of Environmental Management
ALAMAP..... Alabama Monitoring and Assessment Program
ASWCC..... Alabama Soil and Water Conservation Committee
CACWP..... Coastal Alabama Clean Water Partnership
EPA..... United States Environmental Protection Agency
GIS..... Geographic Information Systems
HUC..... Hydrologic Unit Code
NEP.....National Estuary Program
NPDES.....National Pollutant Discharge Elimination System
NPS..... Non-Point Source
PCS..... Permit Compliance System
SWCD.....Soil and Water Conservation District
TMDL..... Total Maximum Daily Loading
TN..... Total Nitrogen
TP.....Total Phosphorus
TSS..... Total Suspended Solids
USGS..... United States Geological Survey

Introduction

In 1996, the Alabama Department of Environmental Management (ADEM) adopted the statewide watershed management approach to nonpoint source (NPS) pollution monitoring and management. This approach is an integrated holistic strategy for more effectively restoring and protecting aquatic ecosystems and encompasses not only the water resources but all the land from which water drains to that resource. It is becoming widely recognized that to protect water resources, it is increasingly important to address the condition of the land areas within the watershed because as water drains off the land it carries with it the effects of human activities throughout the watershed (EPA 1993).

As part of its " Water Quality and Natural Resource Monitoring Strategy for Coastal Alabama"(1993), the ADEM began conducting watershed surveys in the coastal areas of Mobile and Baldwin Counties. Successive watershed surveys have been conducted in Dog River, Bon Secour River, Chickasaw Creek, and Little Lagoon. While these surveys have identified problems and documented overall water quality in these areas, they were not designed to address the broader objectives and aspects of the watershed management approach. As numerous state, federal and local environmental programs have evolved in coastal Alabama, there is an increasing need for watershed based environmental studies to provide the data and information needed for management decisions. The purpose of this proposed methodology is to provide a framework for future watershed studies that would help meet these needs and lead to more effective implementation of future pollution control strategies and management practices. The methodology would also provide consistency among the different studies conducted while remaining flexible enough to address different coastal watersheds and their varying priority issues.

Specific objectives of studies conducted through this methodology would include:

1. assess water quality within the subject watershed area
2. identify stream segments most impaired by pollution
3. identify causes of impairment in the subject watershed/stream segment
4. provide support and information for more effective implementation of pollution control strategies and NPS management practices

Specific ADEM programs that could utilize the data and information produced through this methodology include the 6217 Coastal Nonpoint Pollution Control Program, the Alabama Monitoring and Assessment Program (ALAMAP), and the Department's §303(d) and TMDL programs. There are also a number of other organizations that may find this information useful including the Mobile Bay National Estuary Program (NEP), the Coastal Alabama Clean Water Partnership, the South Alabama Regional Planning Commission, and the Alabama Department of Conservation and Natural Resources Coastal Programs.

Listed below is an outline for the watershed study process. The study components are in a loose chronological order. For example, field study site selection will depend on the findings of the "research and review of available data". However, because of time and funding constraints generally associated with such surveys, much of the work must also be done concurrently.

Process of a Watershed Assessment Study

1.) Select and Delineate Study Area
- What sub-watershed and how much of it

2.) Research and Review Available Data
- Historical water quality data
- Historical macroinvertebrate data
- Historical or ongoing projects
- Land use and impervious surfaces

3.) Select Field Study Sites
- Nutrient and sediment loading sites
- Macroinvertebrate sampling sites
- Chemical parameter sampling sites

4.) Conduct Field Studies
- Macroinvertebrate and habitat assessments
- Nutrient and sediment loading
- Chemical/Field parameters

5.) Compile and Analyze Data

6.) Write and Disseminate Report

This outline has been developed based on the review of numerous "watershed" efforts around the country and ongoing efforts within Alabama. The reasons supporting each component are discussed in the subsequent sections of this report.

Study Area Selection and Delineation

Watershed or Study Area Size

The watersheds or basins of the state are defined by the U.S. Geological Survey (USGS) and labeled using an 8 digit code known as a hydrologic unit code (HUC). These 8 digit watersheds are further broken down into 11 digit sub-watersheds. Mobile and Baldwin Counties contain 8 basins (or parts thereof) and 44 sub-watersheds (see figure 1 and table 1).

The ideal unit of study or area covered in a study would be an 11 digit sub-watershed. However, given limited resources and the size and complexity of some sub-watersheds, it may be necessary to limit the study area to a particular group of tributaries within an 11 digit sub-watershed. A good example of this would likely be the Halls Mill Creek (Dog River) sub-watershed (HUC: 03160205 020). Because of this sub-watershed's size, complexity, extensive urbanization, and its potential for impairment, it would be better to conduct a series of smaller studies allowing for an overall more detailed and useful assessment of the water quality and causes of impairments. This would also allow for more effective implementation of management practices and restoration strategies.

Watershed Selection

There are a number of considerations to be made when selecting a sub-watershed for study. Fortunately, there is already considerable effort underway to identify those sub-watersheds most threatened or impaired. The Statewide Nonpoint Source Watershed Assessment Project which is being conducted by the Alabama Soil and Water Conservation Committee (ASWCC) and local Soil and Water Conservation Districts (SWCD) (see "Supporting Programs and Resources") has ranked the sub-watersheds of each county to come up with a county based prioritized listing. This was done using a numeric NPS rating system with input from the public as to perceived priority for conducting water quality improvement projects (see table 2). Similarly, for coastal Alabama, the Coastal Alabama Clean Water Partnership (CACWP) is currently in the process of compiling its own prioritized list using the ASWCC rankings along with input from stakeholders representing a variety of public and private interests. The Water Quality Branch of the ADEM Water Division also maintains the §303(d) impaired waterbody listing. This is a list of waterbodies that are not supporting or are only partially supporting their designated water use classification. The Department is required to address these listings and implement corrective management practices. A draft version of the 2000 §303(d) list specific to coastal Alabama appears in the appendix. The CACWP is also including the §303(d) impaired waterbody listings in its prioritization process.

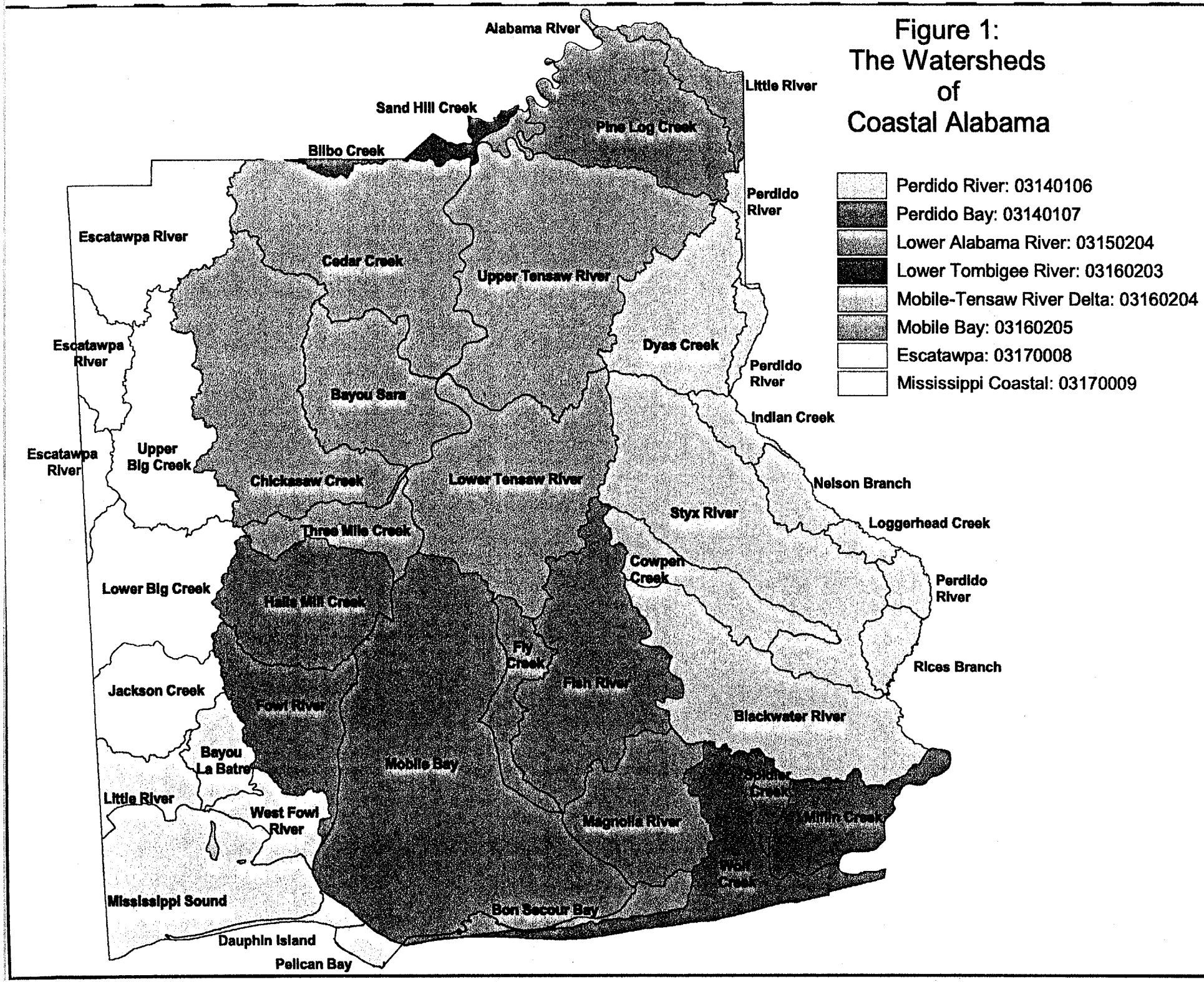


Figure 1:
The Watersheds
of
Coastal Alabama
Perdido River: 03140106
Perdido Bay: 03140107
Lower Alabama River: 03150204
Lower Tombigee River: 03160203
Mobile-Tensaw River Delta: 03160204
Mobile Bay: 03160205
Escatawpa: 03170008
Mississippi Coastal: 03170009
Alabama River
Little River
Sand Hill Creek
Pine Log Creek
Bilbo Creek
Perdido River
Escatawpa River
Cedar Creek
Upper Tensaw River
Escatawpa River
Dyas Creek
Perdido River
Bayou Sara
Indian Creek
Escatawpa River
Upper Big Creek
Chickasaw Creek
Lower Tensaw River
Nelson Branch
Styx River
Loggerhead Creek
Three Mile Creek
Cowpen Creek
Perdido River
Lower Big Creek
Halls Mill Creek
Fly Creek
Rices Branch
Fish River
Jackson Creek
Fowl River
Blackwater River
Bayou La Batre
Mobile Bay
Little River
West Fowl River
Magnolia River
Mississippi Sound
Bon Secour Bay
Dauphin Island
Pelican Bay

Table 1. **Watersheds and Sub-Watersheds of Coastal Alabama**

Watershed	Sub-Watershed	Hydrologic Unit Code
Perdido River		03140106
	Perdido River	010
	Perdido River	020
	Dyas Creek	040
	Indian Creek	050
	Nelson Branch	100
	Loggerhead Creek	110
	Perdido River	140
	Rices Branch	150
	Styx River	170
	Cowpen Creek	180
	Blackwater River	190
Perdido Bay		03140107
	Soldier Creek	020
	Miflin Creek	030
	Wolf Creek	040
Lower Alabama River		03150204
	Little River	110
	Pine Log Creek	120
	Alabama River	130
Lower Tombigbee River		03160203
	Bilbo Creek	130
	Sand Hill Creek	140
Mobile/Tensaw River		03160204
	Upper Tensaw River	010
	Cedar Creek	020
	Bayou Sara	030
	Lower Tensaw River	040
	Chickasaw Creek	050
	Three Mile Creek	060

Watershed	Sub-Watershed	Hydrologic Unit Code
Mobile Bay		03160205
	Mobile Bay	010
	Halls Mill Creek	020
	Fowl River	030
	Fly Creek	040
	Fish River	050
	Magnolia River	060
	Bon Secour Bay	070
Escatawpa River		03170008
	Escatawpa River	030
	Escatawpa River	050
	Escatawpa River	070
	Upper Big Creek	090
	Lower Big Creek	100
	Jackson Creek	120
Mississippi Coastal		03170009
	Pelican Bay	010
	Dauphin Island	020
	Miss. Sound	030
	West Fowl River	040
	Bayou La Batre	050
	Little River	060

Table 2.

Top Five Sub-Watershed Rankings* as Listed by the Baldwin and Mobile County Soil and Water Conservation Districts

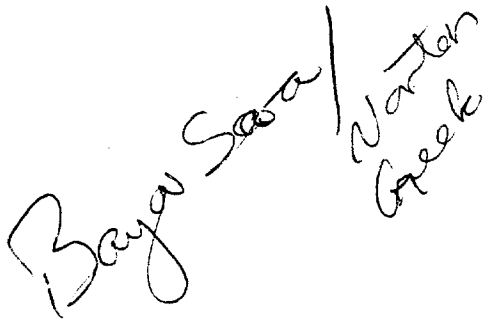
Baldwin County

Ranking	Sub-Watershed	HUC
1st	Fly Creek	03160205 040
2nd	Fish River	03160205 050
3rd	Mobile Bay	03160205 010
4th	Wolf Creek	03140107 040
5th	Lower Tensaw R.	03160204 040

Mobile County

Ranking	Sub-Watershed	HUC
1st	Chickasaw Creek	03160204 050
2nd	Upper Big Creek	03170008 090
3rd	Halls Mill Creek (Dog R.)	03160205 020
4th	Lower Big Creek Lake	03170008 100
5th	Cedar Creek	03160204 020

* The 1st ranking is applied to the sub-watershed most in need of attention



In coastal watershed studies to be conducted, the major consideration in selecting the subject watershed should be the current extent of NPS impairment or the potential for impairment. The processes used by the ASWCC and the CACWP take this into consideration and their prioritized listings should be weighed heavily. Other important considerations would include the number of §303(d) listings within the sub-watershed, rapid development or anticipated rapid development (or other landscape changes), number of point source discharges, and public interest/concern. It should be noted that the ASWCC prioritized list, the CACWP prioritized list, and the §303(d) list are all likely to change over time. Ultimately, the watershed study schedule should move to a loose rotational basis so that eventually all of the coastal watersheds will be targeted for study.

Research and Review of Available Data

After the area of study has been selected and defined, the details of the study design (e.g. sample site selection, number of sites, and parameters) will depend on the findings of a research and review of available data. The investigator should come away from this process with the following information:

- Geographic knowledge of the sub-watershed and all its waterbodies/tributaries
- Identified water quality impairments of known and unknown origin
- Predominant land uses and their generalized locations
- Potential water quality impacts associated with those land uses
- Streams that are known to, or would likely, demonstrate impacts from the various land uses
- Inventory of Point Source Discharges
- Public Concerns

Supporting Programs and Resources

ADEM Programs

Water quality data is available from a number of Departmental programs. The Ambient Monitoring program includes 18 current sites and 11 historical (inactive) sites in coastal Alabama. These stations are known as "trend sites". Data from some of these sites goes back to 1978. Sampling frequency for much of this time has been monthly and is now conducted three times per year. Two other relevant Departmental programs are the Alabama Monitoring and Assessment Program (ALAMAP) and the Coastal 2000 program. Combined, these two programs sample 80 sites per year in coastal Alabama. Parameters available from these programs would include temperature, pH, conductivity, salinity, dissolved oxygen, alkalinity, hardness, total suspended solids, total dissolved solids, fecal coliform, total phosphorus, nitrate/nitrite, ammonia, chlorides, biochemical oxygen demand, turbidity, chlorophyll-a, sediment organics (pesticides), sediment metals, benthic macroinvertebrates, fish tissue (organics and metals). The Coastal Alabama Recreational Water Quality Monitoring Program can provide bacteriological

data (fecal coliform and enterococci) from 11 high use public beach or swimming areas around Mobile Bay and the Gulf Beaches. The §303(d) and TMDL programs will be sampling 54 sites in coastal Alabama during 2001 on roughly a monthly basis with intensive surveys to be conducted on Rabbit Creek, Puppy Creek, Bayou Sara, and Bayou La Batre. Also, as part of the Watershed Assessment Strategy, the Department will be conducting basin-wide NPS screening assessments on the Mobile, Lower Tombigbee, and the Escatawpa basins during 2001. The other coastal basins were assessed in 1999. This work includes macroinvertebrate and fish bioassessments, habitat assessments, and chemical water analyses for non-tidally influenced areas. Data from these screening assessments is available from the Environmental Indicators Section of the Field Operations Division.

Point Source Discharge Records

In assessing and identifying impairment, it is important to be able to separate potential NPS impairment from point source impairment. The location of point-source discharges will also greatly influence the design of the field studies. All discharges of pollution to waters of the state are required to be permitted. The ADEM maintains records on these permitted discharges. The records include a variety of information including receiving waters, discharge locations, and rate of discharge flow, as well as relative data on analytical parameters (e.g. biochemical oxygen demand, total suspended solids, pH, dissolved oxygen content). These discharge records may be accessed through a physical file search or through various electronic databases. The ADEM maintains a number of databases in support of the National Pollutant Discharge Elimination System (NPDES). These databases include major and minor municipal and industrial discharges as well as stormwater discharges for construction, mining, industrial and municipal facilities. All can be queried by various methods to obtain information on discharges within the subject watershed. One of these, known as DataEase, is accessible through the Water Division's Municipal Branch. This database is a maintained record of facility discharge monitoring reports, as well as any accompanying, pertinent information (i.e. facility location, receiving waters, parameters, etc.) relative to a facility's discharge. Another useful database is the U.S. EPA's Permit Compliance System (PCS) program. It is located on the internet at www.epa.gov/enviro/html/pcs/pcs_query_java.html. This program contains a substantial amount of data and metadata which should aid in assessing existing impacts to the study area. Other sources of information such as directories of area commercial sites should be available through local municipal government and would include up to date estimates of the number of businesses within the study area. If resources allow, a cross check should be made with this list against those appearing in the ADEM database. It is possible that un-permitted discharges may be found in this manner. Area ADEM inspectors might also provide relevant information on potential impacts to the watershed from other point sources. When possible, watershed studies should be coordinated with personnel responsible for compliance evaluation inspections at discharging facilities within the subject watershed study area. These inspections provide 24 hour composite sampling of selected discharges. Such data, in conjunction with associated temporal data sets, would aid significantly in assessing water body impacts from point source discharges.

Other Sources of data and information

Other possible sources of water quality data and information would include:

Agencies and Organizations

Coastal Alabama Clean Water Partnership
Mobile Bay National Estuary Program
Weeks Bay National Estuarine Research Reserve and Watershed Project
Alabama Coastal Foundation
South Alabama Regional Planning Commission
Dauphin Island Sea Lab
The Alabama Geological Survey
U.S. Geological Survey
U.S. Fish and Wildlife Service
Alabama Department of Economic and Community Affairs
Alabama Department of Conservation and Natural Resources
Auburn University Marine Extension and Research Center

Technical Papers and Projects

A Survey of the Dog River Watershed I&II ADEM 1994, 1995
A Survey of the Bon Secour River Watershed ADEM 1996
A Survey of the Chickasaw Creek Watershed ADEM 1997
A Survey of the Little Lagoon Watershed ADEM 2000
Management Plan for the Weeks Bay Watershed Weeks Bay Watershed Project
Surface Water Quality Screening Assessment of the Tennessee River Basin-1998 ADEM 2000
Perdido Bay Interstate Study Florida Department of Environmental Regulation & ADEM 1989
Alabama /Mississippi Pilot Reference Site Project 1990-1994 ADEM and Mississippi Department of Environmental Quality 1995
Eutrophication Processes in Coastal Systems Florida State University 2000
Perdido Bay Ecosystem Management Plan Florida Department of Environmental Protection 1996

Perdido Ecosystem Management Strategies Perdido Ecosystem Restoration Group and Florida Department of Environmental Protection 1998
Preliminary Characterization of Water Quality of the Mobile Bay National Estuary Program Study Area Thompson Engineering 1998

For additional reference materials please see "References Cited"

Land Use and Impervious Surfaces

SWCD Watershed Assessments

A fundamental resource to be used throughout this methodology is the Statewide Nonpoint Source Watershed Assessment Project which was conducted by the Alabama Soil and Water Conservation Committee (ASWCC) and local Soil and Water Conservation Districts (SWCD) (FY97 CWA § 319 Workplan Project #4). The purpose of that project was to evaluate each watershed of the state with regard to potential surface and ground water problems from NPS pollution and to establish an ongoing process for water quality protection that involves the general public. This program is based on information provided through Conservation Assessment Worksheets completed in 1998 by the individual SWCDs. These worksheets provide valuable watershed and NPS information such as:

- Estimated land uses by acres and percentage of total watershed
- Sediment delivery to streams from various categories
- Estimated number of animals by type and density
- Predominate pesticides used and characteristics related to water quality
- Number of households on septic tanks/field line systems
- Estimated percentage of household with contaminated wells
- Potential for pollution of surface waters from:
  - Animal wastes
  - Pesticides
  - Sediment (by source)
  - Domestic onsite wastewater systems
  - Urban runoff
- Potential for pollution of groundwater from:
  - Animal wastes
  - Pesticides
  - Domestic onsite wastewater systems
- Wildlife resource evaluation
- Endangered species potentially present

All of this information has been compiled in an ACCESS database by the Environmental Indicators Section of the ADEM Field Operations Division in Montgomery. Much of the information was also obtained on CD-ROM from the Coastal Alabama Clean Water Partnership coordinator and is on file at the Mobile Branch of the ADEM Field Operations Division.

EPA Land Use Estimates

Additional land use information can be obtained from EPA published estimates of percent land cover for the entire southeast U.S. (EPA 1997). These estimates are based on leaves-off Landsat TM data acquired in 1988, 1990, 1991, 1992, and 1993. It is

recommended that these estimates be used to supplement information collected in the local SWCD watershed assessments.

Impervious Surface Estimates

Imperviousness can be defined as the sum of roads, parking lots, sidewalks, rooftops and other impermeable surfaces of the urban landscape. Stream degradation has been shown to occur at relatively low levels of imperviousness (10 – 20 %) thus making imperviousness a very useful indicator to measure the potential impacts of land development on aquatic systems (Importance of Imperviousness 1994). Land use and land cover, including impervious surfaces, can be determined using aerial photography or digital satellite imagery. Digital satellite imagery (LANDSAT TM) was used in a study of the Fish River sub-watershed conducted by Auburn University, School of Forestry (Basnyat et al. 1996). This is a highly technical process using remote sensing and geographical information systems (GIS) with various other computer analysis programs. An excerpt from the methods section of the Fish River study appears in the Appendix . It is also possible to produce rough estimates of impervious surface coverage from infrared digital aerial photography using an English Area Grid. Infrared aerial photography of Baldwin County is currently being conducted and should be available to ADEM Coastal Programs by FY 2002. Infrared aerial photography of Mobile County is expected to be flown in FY 2002 and available in FY 2003.

Field Studies

Field Study Design

The field study portion of the watershed assessment consists of the following components:

- Watershed Reconnaissance and Sample Site Selection
- Nutrient and Sediment Loading Estimates
- Macroinvertebrate and Habitat Assessments
- Chemical/Field Parameter Assessment

As mentioned previously, much of the detail of the field study design will depend on the findings of the "Research and Review of Available Data". For example, site selection and parameters will depend on land uses, location of point source discharges and known or suspected impairments. Proper sample site selection must be emphasized. The sites selected for the various components of the field study must be representative of particular land uses or other potential causes of impairment. The field study should be designed so that the study investigator will be able to draw conclusions and make comparisons from these results.

Sediment and Nutrient Loading Estimates

Nutrient concentrations in rivers and streams depend on a variety of natural variables (e.g. soil type, topography, land cover, rainfall, and stream discharge) as well as man-made alterations in the watershed. Nutrient concentrations may also demonstrate seasonal fluctuations in response to cyclical climatic conditions and biological utilization. Increased nutrient transport in the watershed and resulting accumulation (loading) in the surface waterbodies can lead to eutrophication and drastic changes to the biological communities. Similarly, the transport and accumulation of suspended sediments also depend on many of the same variables. Increases in suspended sediment loading also can have a drastic effect on the aquatic environment including habitat destruction and shading through increased turbidity (FDER 1988).

To estimate the sediment and nutrient loading for a particular flowing waterbody, nutrient and suspended sediment samples and flow data must be collected under a variety of stream flow conditions and preferably over a year's time. Special attention must be given to high rainfall events with more frequent data collection during the winter and spring months. Once stream discharge and chemical data have been acquired, sediment and nutrient loading can be estimated using the computer-modeling program described in "Total Nutrient and Sediment Loading Estimates" below.

Site selection

Site selection for nutrient and sediment loading estimations should be above tidal influence and should maintain flow throughout the year. Ideally, they should be wadeable even during high discharge events. They should be located at points of hydrologic convergence. However, the sites should be high enough in the watershed (e.g. 2nd or 3rd order streams) to target particular land uses or defined areas within the watershed. Data from these sites should allow the investigator to make comparisons of sediment and nutrient loading rates and define areas most in need of corrective management practices. Sites downstream of major point source discharges should be avoided unless they are a suspected source of nutrients and discharge information is unavailable.

Monitoring Frequency

Flow measurements and sampling should be conducted on a monthly basis June through November and twice per month December through May. Effort should also be made to sample during or just after heavy rainfall events. This sampling and flow measurement regime will yield the necessary information to estimate stream discharge as well as provide the necessary data for the nutrient and sediment loading computer model.

Stream Discharge Estimates

If there is no USGS continuous flow gauge at the sample site, mean daily discharge for the subject station can be estimated using instantaneous flow measurements taken throughout the study period. Using a linear regression ($y = a + bx$), these measurements can be regressed against a USGS discharge gauge for another stream in the area. Ideally this other stream should be of similar size and watershed characteristics and should be close enough that it would experience simultaneous rainfall (ADEM 1999). Current streamflow conditions and rainfall data can be found on the USGS internet site at http://AL.WATER.USGS.GOV\. This site also has historical water quality data and drought conditions.

Total Nutrient and Sediment Loading Estimates

Total loading for total phosphorus (TP), total nitrogen (TN), and total suspended solids (TSS) can be estimated using a computer modeling program known as FLUX. FLUX is an interactive data reduction program for estimating nutrient loading from grab sample analyses, with associated instantaneous flow measurements, and continuous flow (mean daily discharge) data (ADEM 1999). This method has been used by ADEM in the Brushy Creek Watershed Water Quality Assessment Study conducted in 1996 – 1997. The FLUX program is available via the inter-net from the Corps of Engineers Waterways Experiment Station and has been downloaded by ADEM's Mobile Branch of the Field Operations Division.

Macroinvertebrate Assessments

Macroinvertebrate assessments are a form of biosurvey that have become a widely accepted tool for evaluating a stream's water quality and detecting the sometimes subtle effects of NPS as well as point source impairment. Some of the advantages of using biosurveys for this type of monitoring are (ADEM 1996):

a) Biological communities reflect overall ecological integrity (i.e., chemical, physical, and biological integrity). Therefore, biosurvey results directly assess the status of the waterbody relative to the primary goal of the Clean Water Act.

b) Biological communities integrate the effects of different pollutant stressors and thus provide a holistic measure of their aggregate impact. The analysis of changes in the makeup of a macroinvertebrate community is one way to detect water quality problems.

c) Because of their limited mobility and often relatively long life cycles (one year or more), communities integrate stresses over time and provide an ecological measure of fluctuating environmental conditions. Assessing the integrated response of biological communities to highly variable pollutant inputs offers a particularly useful approach for monitoring non-point source impacts and the effectiveness of certain Best Management Practices.

d) Routine monitoring of biological communities can be relatively inexpensive, particularly when compared to the cost of assessing toxic pollutants, either chemically or with toxicity tests. Benthic macroinvertebrates are found in most aquatic habitats and their size makes them easily collected.

e) The status of biological communities is of direct interest to the public as a measure of a pollution free environment, while reductions in chemical pollutant loadings are not as readily understood by the layman as positive environmental results.

f) Where criteria for specific ambient impacts do not exist (e.g. non-point source impacts that degrade habitat), biological communities may be the only means of evaluation.

When conducting studies of macroinvertebrate communities there are several sampling approaches that may be utilized. Appropriate accommodations should be made for stream size, ecoregion, seasonality, and flow conditions. The conclusions drawn from analyses of macroinvertebrate samples are ideally based on a comparison with a control site or ecoregion reference. When such references are not available, this data can be evaluated based on basic biological community parameters such as diversity, evenness and richness. The entire macroinvertebrate assessment process including site selection, field methods, laboratory methods, and data analysis is explained in detail in the ADEM Standard Operating Procedures and Quality Assurance Manual, Volume II (1999). (As

stated previously, ADEM will be conducting basin-wide NPS screening assessments on the Mobile, Lower Tombigbee, and the Escatawpa basins during 2001. The other coastal basins were assessed in 1999. This work includes macroinvertebrate and fish bioassessments, habitat assessments, and chemical water analyses. Data from these screening assessments is available from the Environmental Indicators Section of the Field Operations Division and, depending on site locations, may be incorporated into a sub-watershed study.

Habitat Assessments and Physical Characterization

At a minimum, Habitat Assessments and Physical Characterization should be conducted at all macroinvertebrate assessment sites. The biological condition of the macroinvertebrate community is generally correlated with the quality of available habitat (without considering influences of water quality). The presence of stable and diverse habitat usually will support a diverse and healthy aquatic fauna (ADEM 2000). Habitat quality should therefore be assessed at each assessment site in order to evaluate stream condition and to assist in the interpretation of the biological data. Three habitat characteristics are evaluated at each site. These are divided into primary, secondary, and tertiary parameters. Primary habitat parameters evaluate the availability and quality of the substrate and instream cover. They include those characteristics that directly support aquatic communities, such as substrate type, stability, and availability. Secondary habitat parameters evaluate channel morphology, which is determined by flow regime, local geology, land surface form, soil, and human activities. Channel morphology indirectly affects the biological communities by affecting sediment movement through a stream (ADEM 2000). Secondary habitat parameters include an evaluation of flow regime, sinuosity/instream geomorphology, and sediment deposition and scouring. Tertiary habitat characteristics evaluate bank structure and riparian vegetation. Bank and riparian vegetation prevent bank erosion and filter out some of the pollutants associated with stormwater runoff. The presence of overhanging riparian vegetation also influences primary productivity in the stream by regulating light intensity, temperature, and the organic biomass (leaves and wood) available to the system. Tertiary parameters would also include riparian width.

The EPA published revised habitat assessment forms which evaluate riffle/run and glide pool streams separately (EPA 1997b). These forms appear in the Appendix. In coastal Alabama, the glide/ pool stream morphology is much more prevalent and the primary parameters of the assessments place more emphasis on pool structure and variability. The scores for these habitat assessments are converted into percent maximum and allow for comparison between stream types. Because these forms are somewhat subjective in nature, at least two trained observers should complete the form independently and then discuss the results to come to a consensus. The physical characterization worksheet also appears in the Appendix. The physical characterization and habitat assessment process, including form instructions and analysis, is explained in detail in section 6 of the ADEM Standard Operating Procedures and Quality Assurance Manual, Volume II (1999).

Chemical/Field Parameter Assessment

Water chemistry and hydrographic data should also be used as indicators of impairment from both non-point and point-source discharges. They should be collected at all sites. Basic chemical parameters will vary depending on suspected causes/sources of potential impairment but may include nutrients (ammonia, total phosphorus, nitrate/nitrite), sediments (total suspended solids and turbidity), and fecal coliform. Other parameters such as sediment metals and pesticides may also be added based on other potential impairments from land uses and/or point-source discharges. Basic hydrographic data for all sites would include temperature (air and water), specific conductivity, salinity, pH, and dissolved oxygen. These data should be collected throughout the water column profile (surface, mid-depth/5ft, and bottom) when total depth permits. A list of impairment concerns and associated study parameters appears in table 3.

While the purpose of this section of the field study is to compare water quality among the various land uses and areas of the watershed, the chemical and field parameter data should also be compared to established state standards or, in the absence of such standards, to criteria used in other studies and popular literature. Many of the state standards are based on the waterbody's designated "use classification". State water quality standards and waterbody use classifications appear in the Department's Administrative Code: Chapter 335-6-10 and 335-6-11 (2000). Other applicable comparative data are used in the ALAMAP Coastal program and can be found in the ALAMAP Coastal report: *A Report on the Condition of the Estuaries of Alabama in 1993-1995, A Program in Progress* (1997). Sediment contaminate data can also be assessed based on "Ecological Response Levels" developed by Long et al. (1995) or compared to the various NOAA, EPA and COE publications on the subject.

Bacterial Assessment

Pathogens (i.e. bacterial contamination) is one of the most common pollutants and is the listed cause of impairment for 16 of the 33 Mobile and Baldwin County waterbodies on the draft 2000 §303(d) list. Fecal bacteria occur naturally in the environment and it is not uncommon for levels to increase immediately after a heavy rain event. However, consistently elevated levels may indicate a continuous source of contamination from point or non-point sources. Potential sources for this contamination include failing septic systems, leaking or overflowing sewage collection lines, and runoff from residential, agricultural, or wild areas with large domestic or wild animal populations. ADEM uses fecal coliform bacteria as an indicator species to indicate the possible presence of sewage or animal waste. Although not harmful themselves, fecal coliforms are commonly used as an indicator of other potential human pathogens. EPA recommends using Enterococci bacteria as an indicator species because there is a stronger correlation with incidents of human illness. Currently ADEM does not conduct

Enterococci analyses and they must be done by the Alabama Department of Public Health.

For the purpose of comparison among land uses and areas within the subject watershed, it is recommended that representative sites are sampled simultaneously (within same day or ½ day) and that sampling frequency is sufficient to calculate a geometric mean at least once during the study period. A geometric mean requires at least 5 samples within a 30 day period at intervals not less than 24 hours. State standards for fecal coliform contamination depend on the waterbody's use classification and can be found in the Department's Administrative Code: Chapter 335-6-10 (2000). As mentioned previously, ADEM's Coastal Alabama Recreational Water Quality Monitoring Program can provide bacteriological data (fecal coliform and enterococci) from 11 high use public beach or swimming areas around Mobile Bay and the Gulf Beaches. During the months May – September, sampling for this program is sufficient to maintain a geometric mean.

Tidally Influenced Waterbodies

Many of the coastal watersheds that border or include Mobile Bay, Mississippi Sound and the Gulf of Mexico have large areas that are tidally influenced. Much of this prescribed methodology is not applicable to these areas. When assessing tidally influenced waterbodies it is recommended that the investigator use data from, or coordinate with, one of the Department's probabilistic based monitoring programs designed for this purpose (i.e. ALAMAP Coastal or Coastal 2000).

A probabilistic sampling study can be designed especially for the subject area as was done in the case of the Little Lagoon watershed survey (2000). This approach uses a systematic hexagonal grid which is placed over a map of the area to be sampled. Sites are then randomly selected within this grid matrix. This design, while having a random component ensures a more representative distribution of sample sites throughout the area of interest. This sample design also ensures strict adherence to requirements for probabilistic sampling and allows the proportion of the area that is affected by a certain condition to be estimated within given confidence limits. This affected area can then be graphically depicted and mapped for analysis allowing the scientist to make statements as to the overall ecological health of the study area (Carlton et al 1997). This approach requires at least 30 sampling sites or an equivalent number of replicates from fewer sites to meet acceptable confidence limits and can be used for any parametric regime. Analytical parameters should be chosen based on the issues to be assessed (Table 3). If there are no specific pre-identified issues or concerns to guide sample design, the probabilistic approach may also be applied to the non-tidally influenced areas, using protocols from the Departmental ALAMAP upland program.

Quality Control/Quality Assurance

All field determinations, sample collection and handling, and chain of custody procedures conducted during coastal watershed assessments shall be in accordance with the ADEM Field Operations Standard Operating Procedures and Quality Control Assurance Manual, Volumes I and II (2000, 1999). Five percent of all sampling will be field duplicated. Ten percent of all field determinations such as temperature, pH, specific conductivity, and dissolved oxygen will be replicated at sites where duplicate sampling occurs. Blank samples should also be collected at the same frequency as field duplicates.

Table 3.
Impairment Concerns and Associated Study Parameters

Concern: Organic Enrichment/Nutrients

Parameter	Frequency and Timing		Special Target Conditions	Analytical Method
Ammonia	monthly June-Nov	2x/month Dec-May	Heavy rain/high flow	EPA 350.1
Nitrate+Nitrite	monthly June-Nov	2x/month Dec-May	Heavy rain/high flow	EPA 353.2
Total Phosphorus	monthly June-Nov	2x/month Dec-May	Heavy rain/high flow	EPA 365.4
Total Kjeldahl Nitrogen	monthly June-Nov	2x/month Dec-May	Heavy rain/high flow	EPA 351.2
Biochemical Oxygen Demand (5day)	monthly June-Nov	2x/month Dec-May	Heavy rain/high flow	EPA 405.1
Visibility	monthly May-Sept			Photometer/Secchi disk
Chlorophyll-a	monthly May-Sept			Standard Methods 10200H
Fecal coliform	monthly to include at least one geo. mean		Heavy rain/high flow	Standard Methods 9222D
Dissolved Oxygen	monthly			Membrane Electrode
pH	monthly			Glass Electrode
Temperature	monthly			Thermistor
Specific Conductivity	monthly			Wheatstone Bridge
Salinity	monthly			Derived from conductivity
Flow	monthly June-Nov	2x/month Dec-May	Heavy rain/high flow	USGS approved flow meter

Concern: Pathogens

Fecal coliform	monthly to include at least one geo. mean		Heavy rain/high flow	Standard Methods 9222D
Enterococci	monthly to include at least one geo. mean		Heavy rain/high flow	Standard Methods 1600

Concern: Sediment Loading

TSS	monthly June-Nov	2x/month Dec-May	Heavy rain/high flow	EPA 160.2
Turbidity	monthly June-Nov	2x/month Dec-May	Heavy rain/high flow	EPA 180.1
Visibility	monthly June-Nov	2x/month Dec-May	Heavy rain/high flow	Photometer/Secchi disk
Grain size	one time			
Flow	monthly June-Nov	2x/month Dec-May	Heavy rain/high flow	USGS approved flow meter

Table 3 cont.

Concern: Metals (Water Column and/or Sediments)

Water samples for metals analysis should be collected one time in proximity of potential source and removed from potential source. If potential source is a point source, sampling should be conducted during discharge. Sediment samples for metals analysis should be collected one time in proximity to potential source and removed from potential source.

Parameter	Analytical Method
Aluminum	EPA 202.1
Arsenic	EPA 200.9
Cadmium	EPA 200.9
Chromium	EPA 218.1
Copper	EPA 220.1
Lead	EPA 200.9
Mercury	EPA 245.2/245.5
Nickel	EPA 200.9
Silver	EPA 200.9
Tin	EPA 200.9
Zinc	EPA 289.2
Barium	EPA 208.1
Iron	EPA 236.1
Hardness	EPA 130.2
Alkalinity	EPA 310.1

Table 3 cont.

Concern: Pesticide: sediment and/or water (insecticides, herbicides, nematocides etc.)

Target pesticides, frequency, and timing of sampling will depend on land use issues.
Consult county extention agent for information pertaining to specific agricultural practices in the subject area (i.e. pesticides used, application rates, timing frequency of application etc.)

Parameter	Analytical Method
Chlordane	SW8081A
4,4'-DDD	SW8081A
4,4'-DDE	SW8081A
4,4'-DDT	SW8081A
Aldrin	SW8081A
alpha-BHC	SW8081A
beta-BHC	SW8081A
delta-BHC	SW8081A
gamma-BHC (Lindane)	SW8081A
Dieldrin	SW8081A
Endosulfan-I	SW8081A
Endosulfan-II	SW8081A
Endosulfan Sulfate	SW8081A
Endrin	SW8081A
Endrin Aldehyde	SW8081A
Endrin Keytone	SW8081A
Heptachlor	SW8081A
Heptachlor Epoxide	SW8081A
Methoxychlor	SW8081A
Toxaphene in solids	SW8081A

Concern: Petroleum and other issue specific contamination

Water samples should be collected one time in proximity of potential source and removed from potential source. If potential source is a point source, sampling should be conducted during discharge. Sediment samples should be collected one time in proximity to potential source and removed from potential source.

Poly aromatic hydrocarbons (PAH)	SW 8270b
Polychlorinated biphenyls (PCBs)	SW 8082
Volatile Organic Compounds	SW8260b
Oil and Grease	EPA 1664
Pentachlorophenol	SW 8270b

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Appendix

Appendix Table of Contents

Draft 2000 §303(d) List for Coastal Alabama

WaterbodyID	Waterbody Name	Support Status	WBTYPE	Rank	River Basin	County	Uses	Causes	Sources	Size	Downstream / Upstream Locations	Final TMDL Date
AL/03170008-030_01	Puppy Creek	Non	R	L	Escatawpa	Mobile	Fish & Wildlife	Pathogens Nutrients	Urban runoff/Storm sewers	10 0 miles	AL Hwy 217 / Its Source	Oct-01
AL/03170008-090_01	Boggy Branch	Partial	R	M	Escatawpa	Mobile	Fish & Wildlife	Metals (Fe)	Natural sources	3.6 miles	Big Creek Lake / Its Source	Oct-02
AL/03170008-090_03	Juniper Creek	Non	R	H	Escatawpa	Mobile	Fish & Wildlife	Pathogens	Pasture Grazing	6 6 miles	Big Creek / Its Source	Oct-01
AL/03170008-090_04	Collins Creek	Partial	R	H	Escatawpa	Mobile	Fish & Wildlife	Pathogens	Pasture Grazing Onsite wastewater systems	8.1 miles	Big Creek / Its Source	Oct-01
AL/03170009-030_01	Mississippi Sound	Partial	E	M	Escatawpa	Mobile	Shellfish Harvesting Fish & Wildlife Swimming	Pathogens	Urban runoff/Storm sewers	146.5 mi2	Segment classified for shellfish harvsting	Oct-04
AL/03170009-030_02	Portersville Bay	Non	E	L	Escatawpa	Mobile	Shellfish Harvesting Fish & Wildlife Swimming	Pathogens	Municipal Industrial	23.2 mi2	1000 ft. W. of outfall / Bayou La Batre Utilities Outfall	Oct-04
AL/03170009-050_01	Bayou La Batre	Non	R	L	Escatawpa	Mobile	Fish & Wildlife	OE/DO Pathogens	Urban runoff/Storm sewers	4.0 miles	Portersville Bay / Its Source	Oct-02
AL/03160204-020_01	Cold Creek Swamp	Partial	E	L	Mobile	Mobile	Fish & Wildlife	Metals (Hg)	Contaminated sediments Flow reg/mod	1 0 mi2	Cold Creek with Mobile R / West through swamp	Oct-03
AL/03160204-030_01	Bayou Sara/ Norton Creek	Partial	R	H	Mobile	Mobile	Swimming Fish & Wildlife	Nutrients	Unknown source	3 7 miles	Saraland WWTP / Gunnison Creek	Oct-02
AL/03160204-050_01	Eightmile Creek	Partial	R	M	Mobile	Mobile	Public Water Supply Fish & Wildlife	Pathogens	Urban runoff/Storm sewers Collection system failure	3.2 miles	AL Hwy 45 / Highpoint Blvd	Oct-01
AL/03160204-050_02	Gum Tree Branch	Non	R	H	Mobile	Mobile	Fish & Wildlife	Pathogens	Collection system failure Urban runoff/Storm sewers	2.2 miles	Eightmile Creek / Its Source	Oct-01
AL/03160204-060_02	Threemile Creek	Non	R	L	Mobile	Mobile	Agri. & Ind.	OE/DO Mercury	Municipal Collection system failure Hwy/road/bridge construc Land development Unknown source	1.1 miles	Mobile River / 1.1 mile upstream	Mar-05
AL/03160204-060_01	Threemile Creek	Non	R	L	Mobile	Mobile	Agri. & Ind.	OE/DO	Municipal Collection system failure Hwy/road/bridge construc Land development	16.3 miles	1.1 mile upstream of mouth/ Its Source	Mar-02
AL/03160204-050_04	Chickasaw Creek	Non	R	L	Mobile	Mobile	Agri. & Ind. Fish & Wildlife	Mercury	Unknown source	35.7 miles	Mobile River/ Its Source	Oct-04
AL/03160205-040_01	Bay Minette Creek	Non	R	L	Mobile	Baldwin	Fish & Wildlife	Mercury	Unknown source	16.6 miles	Bay Minette/ Its Source	Oct-04
AL/Mobile R_01	Mobile River	Partial	R	L	Mobile	Mobile	Agri. & Ind Fish & Wildlife	Mercury	Unknown source	29 5 miles	Mobile Bay/ Cold Creek	Oct-04
AL/03160205-030_01	Fowl River	Non	R	L	Mobile	Mobile	Swimming Fish & Wildlife	Mercury	Unknown source	16.9 miles	Mobile Bay/ Its Source	Oct-04

Draft 2000 §303(d) List for Coastal Alabama

WaterbodyID	Waterbody Name	Support Status	WBTYPE	Rank	River Basin	County	Uses	Causes	Sources	Size	Downstream / Upstream Locations	Final TMDL Date
AL/03160205-010_01	Mobile Bay	Partial	E	L	Mobile	Mobile	Shellfish Harvesting Fish & Wildlife Swimming	OE/DO	Urban runoff/Storm sewers	50.0 mi2	Southwest bay	Oct-03
AL/03160205-010_02	Mobile Bay	Partial	E	M	Mobile	Mobile	Shellfish Harvesting Fish & Wildlife	Pathogens	Urban runoff/Storm sewers	198.5 mi2	Segment classified for shellfish harvsting	Oct-05
AL/03160205-020_01	Rabbit Creek	Non	R	L	Mobile	Mobile	Fish & Wildlife	OE/DO Pathogens	Urban runoff/Storm sewers Onsite wastewater systems	3.0 miles	Dog River / AL Hwy. 163	Oct-01
AL/03160205-020_02	Dog River	Non	R	L	Mobile	Mobile	Fish & Wildlife Swimming	OE/DO Pathogens	Land development Urban runoff/Storm sewers Onsite wastewater systems	4.0 miles	Mobile River / 4 miles upstream	Oct-01
AL/03160205-050_01	Caney Branch	Partial	R	M	Mobile	Baldwin	Fish & Wildlife	Pathogens	Pasture grazing - riparian	5 0 miles	Fish River / Its Source	Mar-01
AL/03160205-050_02	Fish River	Non	R	L	Mobile	Baldwin	Fish & Wildlife Swimming	Mercury Pathogens	Unknown source Pasture grazing	31.5 miles	Weeks Bay / Its Source	Oct-04
AL/03160205-060_01	Magnolia River	Partial	R	M	Mobile	Baldwin	Fish & Wildlife Swimming	OE/DO	Land development Onsite wastewater systems	6.3 miles	Baldwin Co. Rd. 49 / Baldwin Co. Rd 24	Mar-02
AL/03160205-060_02	UT to Magnolia River	Partial	R	M	Mobile	Baldwin	Fish & Wildlife	Pathogens	Agriculture	3.0 miles	Baldwin Co. Rd. 24 / Its Source	Oct-01
AL/03160205-060_03	UT to Bon Secour R.	Non	R	H	Mobile	Baldwin	Fish & Wildlife	Pathogens	Urban runoff/Storm sewers Pasture grazing	2.3 miles	Baldwin Co. Rd. 65 / Its Source	Oct-01
AL/03160205-070_01	Intracoastal Waterway	Non	R	L	Mobile	Baldwin	Fish & Wildlife	OE/DO	Urban runoff/Storm sewers Natural sources	2.2 miles	Oyster Bay / Alabama Hwy. 59	Oct-03
AL/03160205-070_02	Bon Secour Bay	Partial	E	M	Mobile	Baldwin	Shellfish Harvesting Swimming Fish & Wildlife	Pathogens	Urban runoff/Storm sewers Onsite wastewater systems	121.3 mi2	Segment classified for shellfish harvsting	Oct-05
AL/Gulf of Mexico_01	Gulf of Mexico	Non	E	L	Mobile	Mobile	Shellfish Harvesting Swimming Fish & Wildlife	Mercury	Unknown source	238 mi2	Mississippi / Florida	Oct-08
AL/03140106-070_01	Boggy Branch	Partial	R	L	Perdido-Escambia	Escambia	Fish & Wildlife	OE/DO Zinc Chlorides	Industrial	0.2 miles	Atmore WWTP / Masland Carpets WWTP	Mar-03
AL/03140106-070_02	Brushy Creek	Non	R	H	Perdido-Escambia	Escambia	Fish & Wildlife	OE/DO	Industrial Municipal Urban runoff/Storm sewers	0.2 miles	Al/Fla State Line/ Boggy Branch	Mar-03
AL/03140107-040_01	Intracoastal Waterway	Non	E	L	Perdido-Escambia	Baldwin	Fish & Wildlife	OE/DO	Urban runoff/Storm sewers Natural sources	5 miles	AL Hwy 59 / Wolf Bay	Oct-03
AL/03160203-130_01	Olin Basin	Non	L	L	L Tombigbee	Washington	Fish & Wildlife	Pesticides Metals (Hg)	Contaminated sediments	65 acres	All of Olin Basin	Oct-03

ADEM-FIELD OPERATIONS DIVISION
PHYSICAL CHARACTERIZATION / WATER QUALITY FIELD DATA SHEET

Station # _____ Date: _____ Collector Names _____

Reach Description: _____

WATERSHED CHARACTERISTICS

Watershed Land Use: Forest Pasture Ag. Residential Commercial Ind. Other: _____

Local Watershed Erosion: None Slight Moderate Heavy

Local Watershed NPS Pollution: No Evidence Potential sources Obvious Sources

REACH CHARACTERISTICS

Land Use at Reach: Pasture Crops Residential Forest Commercial Ind. Other: _____

Length of Reach: _____ ft *Est. Stream Width:* _____ ft

Est. Stream Depth: Riffle: _____ ft Run: _____ ft Pool: _____ ft

Channelized: Y N *Bank Height:* _____ ft *High Water Mark:* _____ ft *Dam Present:* Y N

Prev. 7 day precip: Fl. Flood Heavy Mod. light none *Macrophytes:* None Rare Common Abundant

Canopy Cover: Open 0-20% Mostly Open 20-40% Est. 50/50 40-60% Mostly Shaded 60-80% Shaded 80-100% *Canopy Type:* _____

SEDIMENT / SUBSTRATE CHARACTERISTICS

Odors: Normal Sewage Petroleum Chemical Anaerobic Other: _____

Oils: Absent Slight Moderate Profuse

Deposits: Sludge Sawdust Paper-Fiber Sand Relict Shells Other: _____

Are the undersides of stones not deeply embedded, black? Y N N/A

WATER QUALITY CHARACTERISTICS

Water Odors: Normal Sewage Petroleum Chemical Other: _____

Water Surface Oils: None Slick Sheen Globs Flecks

Water Color: Clear Sl. Tannic Mod. Tannic Dk Tannic Green Gray Other: _____

Weather Conditions: Clear P/C Mostly Cloudy Cloudy Raining

Biological Indicators: Periphyton Macrophytes Fish Filamentous Slimes Others

PHOTOS - Roll # _____

Picture # _____ Description _____ Picture # _____ Description _____

EST. % COMP. IN SAMPLING AREA

Inorganic + Organic = 100%

Type	Diameter	Percent	*Stable?
Bedrock		_____ %	S
Boulder	>10 in.	_____ %	Y
Cobble	2.5 - 10 inches	_____ %	Y
Gravel	0.1 - 2.5 inches	_____ %	Y
Sand	gritty	_____ %	
Silt		_____ %	
Clay	slick	_____ %	
Detritus	Stick, Wood	_____ %	Y
	CPOM	_____ %	
Mud-Muck	fine organic	_____ %	
Marl	Gray Shell Frag.	_____ %	

FIELD NOTES

* Those with "Y" are considered stable for purposed of the Habitat Assessment. "S" = sometimes

Bedrock is only considered stable habitat if it has plants growing on it or if it has numerous cracks

ADEM-FIELD OPERATIONS DIVISION
GLIDE/POOL HABITAT ASSESSMENT FIELD DATA SHEET

Name of Waterbody _____ Date: _____

Station Number _____ Investigators _____

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
1 **Instream Cover**	> 50% mix of snags, submerged logs, undercut banks, or other stable habitat; rubble, gravel may be present.	50-30% mix of stable habitat; adequate habitat for maintenance of populations.	30-10% mix of stable habitat; habitat availability less than desirable.	<10% stable habitat; lack of habitat is obvious.
Score _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2 **Pool Substrate Characterization**	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
Score _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3 **Pool Variability**	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
Score _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4 **Man-made Channel Alteration**	No Channelization or dredging present.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization (>20 years) may be present, but not recent.	New embankments present on both banks; channelization may be extensive, usually in urban or agriculture lands; and > 80% of stream reach is channelized and disrupted.	Extensive channelization; banks shored with gabion or cement; heavily urbanized areas; instream habitat greatly altered or removed entirely.
Score _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5 **Sediment Deposition**	<20% of bottom affected; minor accumulation of fine and coarse material at snags and submerged vegetation; little or no enlargement of islands or point bars.	20-50% affected; moderate accumulation; substantial sediment movement only during major storm event; some new increase in bar formation.	50-80% affected; major deposition; pools shallow, heavily silted; embankments may be present on both banks; frequent and substantial sediment movement during storm events.	Channelized; mud, silt, and/or sand in braided or non-braided channels; pools almost absent due to deposition.
Score _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6 **Channel Sinuosity**	Bends in stream increase stream length 3 to 4 times longer than if it was in a straight line.	Bends in stream increase stream length 2 to 3 times longer than if it was in a straight line.	Bends in stream increase the stream length 2 to 1 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
Score _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7 **Channel flow Status**	Water reaches base of both lower banks and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel.	Water fills 25-75% of the available channel and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
Score _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8 **Condition of Banks**	Banks stable; no evidence of erosion or bank failure; <5% affected.	Moderately stable; infrequent, small areas of erosion mostly healed over; 5-30% affected.	Moderately unstable; 30-60% of banks in reach have areas of erosion.	Unstable; many eroded areas; "raw" areas frequent along straight section and bends; on side slopes, 60-100% of bank has erosional scars.
Score _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
9 **Bank Vegetative Protection (each bank)**	> 90% of the stream bank surfaces covered by vegetation.	90-70% of the streambank surfaces covered by vegetation.	70-50% of the stream bank surfaces covered by vegetation.	<50% of the streambank surfaces covered by vegetation.
Score (LB) _____	10 9 8	7 6	5 4 3	2 1 0
Score (RB) _____	10 9 8	7 6	5 4 3	2 1 0
10 **Grazing or other disruptive pressure (each bank)**	Vegetative disruption, through grazing or mowing, minimal or not evident; almost all plants allowed to grow naturally.	Disruption evident but not affecting full plant growth potential to any great extent; >1/2 of the potential plant stubble height remaining.	Disruption obvious; patches of bare soil or closely cropped vegetation common; <1/2 of the potential plant stubble height remaining.	Disruption of stream bank vegetation is very high; vegetation has been removed to ≤ 2 inches average stubble height.
Score (LB) _____	10 9 8	7 6	5 4 3	2 1 0
Score (RB) _____	10 9 8	7 6	5 4 3	2 1 0
11 **Riparian vegetative zone Width (each bank)**	Width of riparian zone >60 feet; human activities (i.e., parking lots, roadbeds, clearcuts, lawns, or crops) have not impacted zone.	Width of riparian zone 60 - 40 feet; human activities have impacted zone only minimally.	Width of riparian zone 40 - 20 feet; human activities have impacted zone a great deal.	Width of riparian zone <20 feet; little or no riparian vegetation due to human activities.
Score (LB) _____	10 9 8	7 6	5 4 3	2 1 0
Score (RB) _____	10 9 8	7 6	5 4 3	2 1 0

ADEM-FIELD OPERATIONS DIVISION
RIFFLE/RUN HABITAT ASSESSMENT FIELD DATA SHEET

Name of Waterbody _____ Date: _____

Station Number _____ Investigators _____

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
1 **Instream Cover**	>50% mix of boulder, cobble, submerged logs, undercut banks, or other stable habitat.	50-30% mix of boulder, cobble, or other stable habitat; adequate habitat.	30-10% mix of boulder, cobble, or other stable habitat; habitat availability less than desirable.	<10% mix of boulder, cobble, or other stable habitat; lack of habitat is obvious.
Score _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2 **Epifaunal surface**	Well developed riffle and run; riffles as wide as stream and length is 2x the width of stream; abundance of cobble.	Riffle is as wide as stream, but length is <2 times width; abundance of cobble; boulders and gravel common.	Run area may be lacking; riffle not as wide as stream and its length is <2 times the stream width; gravel or large boulders and bedrock prevalent; some cobble present.	Riffles or run virtually non existent; large boulders and bedrock prevalent; cobble lacking.
Score _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3 **Embeddedness**	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble and boulder particles are >75% surrounded by fine sediment.
Score _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4 **Velocity/Depth Regimes**	All 4 velocity/depth regimes present (slow-deep, slow-shallow, fast-shallow, fast-deep).	Only 3 of 4 regimes present. (if fast-shallow is missing, score lower.)	Only 2 of 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/depth regime (usually slow-deep).
Score _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5 **Man-made Channel Alteration**	No Channelization or dredging present.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization (>20 years) may be present, but not recent.	New embankments present on both banks; and 40 - 80% of stream reach is channelized and disrupted.	Banks shored with gabion or cement; >80% of the stream reach channelized and disrupted.
Score _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6 **Sediment Deposition**	Little or no enlargement of islands or point bars and less than 5 % of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from coarse gravel; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel coarse sand on old and new bars; 30 50% of the bottom affected; sediment deposits at obstruction, constriction, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; > 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
Score _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7 **Frequency of Riffles** (Distance between riffles/ stream width)	<5 5 6 7	8 9 11 13 15	16 18 21 23 25	26 28 30 32 34 ≥ 35
Score _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8 **Channel flow Status**	Water reaches base of both lower banks.	Water fills >75% of the available channel.	Water fills 75 - 25% of the available channel and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
Score _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
9 **Condition of Banks**	Banks stable; no evidence (<5%) of erosion or bank failure.	Moderately stable; infrequent, small areas (5-30%) of erosion mostly healed over.	Moderately unstable; 30-60% of banks in reach have areas of erosion.	Unstable; many eroded areas; "raw" areas frequent Along straight section and bends; on side slopes, 60-100% of bank has erosional scars.
Score _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
10 **Bank Vegetative Protection**	>90% of the stream bank surfaces covered by vegetation.	90-70% of the streambank surfaces covered by vegetation.	70-50% of the stream bank surfaces covered by vegetation.	<50% of the streambank surfaces covered by vegetation.
Score (LB) _____	10 9	8 7 6	5 4 3	2 1 0
Score (RB) _____	10 9	8 7 6	5 4 3	2 1 0
11 **Grazing or other disruptive pressure**	Vegetative disruption, through grazing or mowing, minimal or not evident; almost all plants allowed to grow naturally.	Disruption evident but not affecting full plant growth potential to any great extent; >1/2 of the potential plant stubble height remaining.	Disruption obvious; patches of bare soil or closely cropped vegetation common; < 1/2 of the potential plant stubble height remaining.	Disruption of stream bank vegetation is very high; vegetation has been removed to ≤ 2 inches average stubble height.
Score (LB) _____	10 9	8 7 6	5 4 3	2 1 0
Score (RB) _____	10 9	8 7 6	5 4 3	2 1 0
12 **Riparian vegetative zone (each bank)**	Width of riparian zone >60 feet; human activities (i.e., parking lots, roadbeds, clearcuts, lawns, or crops) have not impacted zone.	Width of riparian zone 60 - 40 feet; human activities have impacted zone only minimally.	Width of riparian zone 40 - 20 feet; human activities have impacted zone a great deal.	Width of riparian zone <20 feet; little or no riparian vegetation due to human activities.
Score (LB) _____	10 9	8 7 6	5 4 3	2 1 0
Score (RB) _____	10 9	8 7 6	5 4 3	2 1 0

Excerpt from *"Relationships Between Landscape Characteristics and Non-Point Source Pollution Inputs to Coastal Estuaries"* by Basnyat et al. Auburn University, School of Forestry.

Land Use / Land Cover (LULC)

LULC patterns for the study area were determined by interpreting digital imagery (LANDSAT Thematic Mapper (T.M.) and SPOT panchromatic data). The SPOT image was used as a reference in the rectification and classification of TM images. All processing and analyses were performed using the Geographic Resource Analysis Support System (GRASS) developed by the US Army Corps of Engineers, ARC-INFO, developed by the Environmental Systems Research Institute (ESRI), and MAP-X, developed by Delta Data Systems, Inc.

The LANDSAT TM scene containing the watershed was taken by the LANDSAT V satellite on March 15, 1994. The scene was relatively cloud free. The LANDSAT TM information came with seven separate recorded spectral bands, each band representing different spectral wavelengths that are radiating from various LULC back into space. The first three bands represent visible spectrums blue, green, and red respectively. Band 4 represents near infrared, band 5 and 7 represent mid-infrared, and band 6 represents thermal infrared. Except for the thermal infrared band, the bands have resolutions of 30 meters and were resampled by Earth Observation Satellite Company (EOSAT) to 25 meters. The data was map oriented (i.e. georeferenced) to a UTM projection for map zone 16.

A supervised classification was performed on the sub-scene of the image which belongs to the study area. In supervised classification, the analyst selects areas of known cover type in the image and specifies these to the computer as training areas. Statistical measures are generated for the training areas and input to the classifier, which then determines other areas in the image that have similar spectral characteristics. A combination of bands 4, 3 and 2 were used in this process. The TM image combines near-infrared band 4 with visible bands 3 and 2. Using band 4 results in more clearly defined water boundaries than in the 3, 2, 1 image, yet the two visible bands still reveal some water detail and vegetational discrimination. By displaying the band that senses peak chlorophyll reflectance (band 4) as red, strong hues result. The human eye easily discriminates subtle tonal variations in this color, and information can be gleaned about the conditions and variety of vegetation. Generally deep red hues indicate broad leaf and / or healthier vegetation while lighter reds signify grasslands or sparsely vegetated areas. Densely populated urban areas are shown in light blue.

This TM band combination gives results similar to traditional color infrared aerial photography. Due to the nature of the study, the optimal classification system includes both use and cover categories. For this study, "use" refers to man's activities which are directly related to the land while "cover" describes the vegetation and artificial construction covering the land's surface. The classification system followed a modified version of the "LUDA" system (Anderson and others 1976) which is resource oriented. In an attempt to make the results as widely applicable as possible, the modified classification system initially employed eight general categories: urban and residential land, active agricultural land; inactive agricultural land; forest land; wetlands/grasslands; orchards/tree crops; barren land and water. Once the image was classified, areas under each land use/land cover were extracted within the study area and for each sub-watershed.