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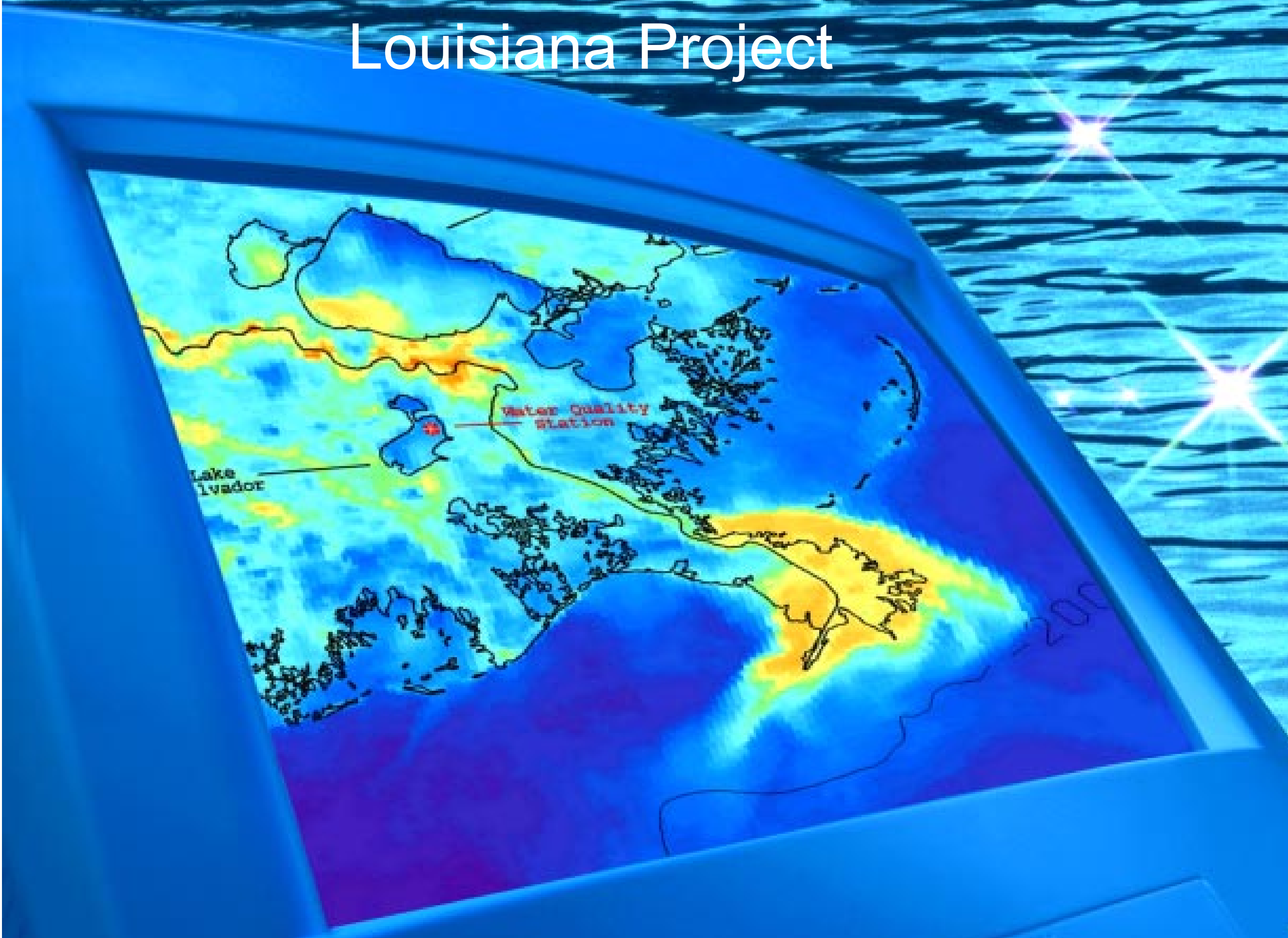
Delivering Timely Water Quality Information to Your Community

The Jefferson Parish - Louisiana Project



E M P A C T

Environmental Monitoring for Public Access
& Community Tracking

Disclaimer

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1. INTRODUCTION

1.1 Background

Wetland loss along the Louisiana coastal zone is one of the state's most pressing environmental problems. Although numerous factors have contributed to this loss, perhaps the leveeing of the Mississippi River for flood control has had the most far-reaching impact. Construction of the levy has blocked the river's historic spring overflows and thus impeded the rush of marsh-supporting fresh water, nutrients, and sediment to the coastal zone. [Source: **http://www.mvn.usace.army. mil/pao/dpond/davispond.htm**]

Coastal Louisiana is losing, on average, between 25 and 35 square miles of land annually -- that's more than one football field every 30 minutes. Louisiana has 40 percent of the Lower 48 states' coastal wetlands and 80 percent of the nation's total wetland loss. These valuable wetlands are nursery grounds for fisheries, a buffer that protects developed areas from storm surges, and a filtering system for pollutants carried in urban runoff. [Source: Video News Release **http://gmpo.gov/pubinfo/empact. html**]

One of the strategies for reversing this wetland loss in coastal Louisiana is to partially restore some of the natural flow into the ecosystem. Diversion of freshwater and sediments from the Mississippi River is expected to conserve and restore coastal wetlands. One such project is the Davis Pond Freshwater Diversion Project. The construction for this project began in January 1997. Freshwater diversions to the Barataria Basin are scheduled for 2001. In order to establish a baseline prior to any freshwater diversions, the EMPACT (**E**nvironmental **M**onitoring for **P**ublic **A**ccess and **C**ommunity **T**racking) project team began monitoring the water quality in Lake Salvador and Lake Cataouche (both are downstream of the diversion) in August 1999. After freshwater diversions occur, the water quality monitoring will continue. Analyses of pre-and post diversion water quality data will be used to determine the effects of river water diversion on the estuary.

The Davis Pond Freshwater Diversion into the Barataria Estuary will be the largest freshwater diversion project built to date, capable of diverting up to 10,650 cubic feet (approximately 80,000 gallons) per second of river water. The freshwater diversion will imitate historic spring floods by providing a controlled flow of freshwater and nutrients into the Barataria Bay estuary. It is expected that this diversion will restore former ecological conditions by combating land loss, enhancing vegetation and improving fish and wildlife habitat.

However, there are many concerns that the freshwater diversion will have a negative impact on the estuary. Some citizens are concerned about the impact that nutrient rich river water may have on water quality and growths (blooms) of phytoplankton. Commercial fishermen are concerned that massive amounts of river water may deteriorate the water quality in the lakes and bays where they make their living.

Communities south of the diversion site are concerned that water levels will increase and cause flooding during high wind driven tides. Scientists debate the wisdom of introducing more nutrients into an already eutrophic system. Also all stakeholders are interested in the changes that will occur as salinity levels are altered in the upper estuary.

Partners in the project hope that monitoring conducted through the EMPACT project will provide valuable before and after data of the effects of diverting freshwater from Mississippi river into coastal areas encroached by saltwater. These data will assist scientists and coastal managers in making informed decisions on how to best manage freshwater flow from the diversion to diminish the likelihood of algal blooms, which can be toxic, can contaminate seafood, and can have human health impacts.

1.2 EMPACT Overview

This handbook offers step-by-step instructions about how to provide time-relevant water quality data to your community. It was developed by the U.S. Environmental Protection Agency's (EPA's) EMPACT program. The EMPACT program was created by EPA's Office of Research and Development (ORD) to introduce new technologies that make it possible to provide time-relevant environmental information to the public. EMPACT is working with the 150 largest metropolitan areas and Native American Tribes in the country to help communities in these areas:

- Collect, manage, and distribute time-relevant environmental information.

- Provide residents with easy-to-understand information they can use in making informed, day-to-day decisions.

To make this and some other EMPACT projects more effective, partnerships with the National Oceanic and Atmospheric Administration (NOAA) and the United States Geological Survey (USGS) were developed. EPA will work closely with these federal agencies to help achieve nationwide consistency in measuring environmental data, managing the information, and delivering it to the public.

To date, environmental information projects have been initiated in 84 of the 150 EMPACT- designated metropolitan areas and Native American Tribes. These projects cover a wide range of environmental issues, including water quality, groundwater contamination, smog, ultraviolet radiation, and overall ecosystem quality. Some of these projects were initiated directly by EPA.

Others were launched by EMPACT communities themselves. Local governments from any of the 150 EMPACT metropolitan areas and Native American Tribes are eligible to apply for EPA-funded Metro Grants to develop their own EMPACT projects. The 150 EMPACT metropolitan areas and Native American Tribes are listed in the table at the end of this chapter.

Communities selected for Metro Grant awards are responsible for building their own time- relevant environmental monitoring and information delivery systems. To find out how to apply for a Metro Grant, visit the EMPACT Web site at **http://www.epa.gov/empact/apply.htm**.

One such Metro Grant recipient is the Jefferson Parish - New Orleans Project. The project provides the public with time-relevant water quality monitoring data and impacts of water quality management activities (i.e., river water diversions) in the New Orleans Standard Metropolitan Statistical Area (SMSA).

1.3 Jefferson Parish EMPACT Project

1.3.1 Sampling Techniques

The Jefferson Parish - New Orleans Project Team utilizes time-series water sampling data, remote sensing/satellite data, and water quality field sampling data to monitor impacts of freshwater diversions, such as harmful algal blooms, in the New Orleans SMSA. The resulting information is communicated to the community during public meetings and events and by using Internet technology, audiovisual tools, and print media.

The time-series water sampling data are collected by an automated system, in which a sampling unit collects hourly data and then transmits the data via Geostationary Operational Environmental Satellites (GOES) to the USGS District Office every four hours for storage, retrieval, and analysis. Near-real time stream flow data available on the USGS's Louisiana District Home Page are PROVISIONAL data that have not been reviewed or edited. Each station record is considered PROVISIONAL until the data are reviewed, edited, and published. The data are usually published within 6 months of the end of the year, which runs from October through September. Coordinated water temperature, dissolved oxygen, turbidity, salinity, water level, and fluorescence are taken to confirm remote sensing data. The sampling unit is located in Lake Salvador, a key outfall area of the Davis Pond Freshwater Diversion Project.

Satellite data collected by the NOAA Advanced Very High Resolution Radiometer (AVHRR) and the Orbview-2 SeaWiFS ocean color sensor are received and processed at the Earth Scan Lab (ESL), Coastal Studies Institute at Louisiana State University (LSU) using SeaSpace's Terascan™ system. This software package receives the data from the satellites, performs calibration, geometric correction, and more specialized processing for the determination of temperature, reflectance (turbidity), and chlorophyll *a* concentrations. Field water samples, obtained close in time to the satellite data, are used to "surface truth" the satellite measurements for temperature, concentration of suspended solids and chlorophyll *a*. Ground truthing is the process of comparing satellite data to actual field measurements.

Water quality field sampling is conducted weekly from eight stations in Lake Salvador and Lake Cataouche (a smaller lake north of Lake Salvador) to ground-truth remote sensing (satellite) data and validate time-series water sampling data. The LSU-Coastal Ecology Institute (CEI) analyzes the samples for chlorophyll *a*, nutrients, and suspended solids. The Louisiana University Marine Observatory Consortium (LUMCON) provides data on phytoplankton speciation including identification of harmful algal species. The field sampling data are interpreted and made available via the Internet (**http://its2.ocs.lsu.edu/guests/ceilc**).

1.3.2 EMPACT Project Team

The Jefferson Parish Project team consists of the following members and key partners:

- Drew Puffer of the Gulf of Mexico Program (GMP) is serving as EPA project manager. His role is to provide technical support and administrative advice, to coordinate communications with the EPA, and to identify potential sources of funding to extend the life of the project.

- Terry Hines-Smith, GMP's public affairs specialist, works with the project partners and stakeholders to identify and maximize their information and public outreach resources.

- Marnie Winter, Director of the Jefferson Parish Environmental and Development Control Department, is the local project manager. Her role is to administer grant funds and to coordinate with parish officials to secure approval of contracts and other legal documents required for the project. She also interacts directly with other partners on the project team, serves as the point of contact for communications, and acts as official parish spokesperson at media and other public outreach events. She has secured additional support for the project through the Jefferson Parish Government and was instrumental in leveraging chlorophyll *a* and silicate monitoring from the U.S. Army Corps of Engineers (USACE).

- Ms. Winter is being assisted by Vickie Duffourc, an environmental specialist for a consulting firm under standing contract with the parish. Ms. Duffourc is responsible for coordinating the various aspects of the project, including project communications, and works under the direct supervision of Ms. Winter.

- The USGS collects water quality field samples and services the time-series sampling unit. Jefferson Parish provides a trained environmental technician and the parish's boat to assist the USGS with collecting water samples and servicing the sampling unit. Dr. Chris Swarzenski and the staff of the USGS District Office in Baton Rouge, Louisiana, provide weekly maintenance and calibration of the data collection station, QA/QC of near-real time data, technical services required to received, transfer, and store the near-real time data set, and scientific interpretation of data received. Jake Peters, at the USGS office in Atlanta, also contributes through his association with the EPA Water Data and Tools Projects. While many persons at the USGS Baton Rouge office contribute to this project, Dr. Swarzenski is the lead investigator and Paul Ensminger is the field service technician.

- Dr. Nan Walker, LSU Coastal Studies Institute and Earth Scan Laboratory, is responsible for acquiring, processing, and interpreting satellite data collected by the NOAA and Orbview-2 satellites. These data are used to assess the regional distribution of water temperature, water quality and chlorophyll *a* content and changes over space and time. She uses field measurements of suspended solids, suspended sediments, chlorophyll *a* and temperature to investigate the relationships between satellite and in-situ data for different regions in the study area. Dr. Walker posts the satellite images and interpretive text on the Earth Scan Laboratory LSU Web page, which is linked to the Jefferson Parish EMPACT home page.

- Dr. Eugene Turner, LSU-CEI, is responsible for analysis of water samples and providing the resulting data in tabular and graphic form. LSU-CEI conducts chlorophyll *a* and nutrient analysis on water samples taken weekly from the project area to ground-truth satellite images. LSU-CEI scientists interpret the water quality data and post it to LSU Web page, which will be linked to the Jefferson Parish EMPACT home page.

- Dr. Quay Dortch, LUMCON, receives weekly water samples from the project area and identifies harmful algal species contained in each sample. She provides the resulting data in tabular and graphic form and coordinates with the Louisiana Department of Health and Hospitals regarding possible threats to human health.

As shown above, this project team consists of several distinguished coastal scientists. The collected and analyzed data are being used to understand the physical and biological conditions of water bodies that may be impacted by the Davis Pond river diversion project in the future.

The project provides near-real time regional physical and biological measurements from satellites and a monitoring station in Lake Salvador to the agencies and organizations involved with public health, fisheries, and habitat related issues. This information allows these entities to respond quickly to adverse environmental conditions, make appropriate decisions to ensure economic and environmental sustainability of the affected environment, and protect the health of commercial and recreational users. During the first year, the chlorophyll *a* measurements (from field and satellite sensors) were not being reported in real time.

The addition of a pressure sensor to detect water level changes in near-real time provides early warning of increased water levels and allows diversion managers to make appropriate decisions to minimize the introduction of more water when flooding is likely.

1.3.3 Project Costs

To keep costs low, Jefferson Parish used nearby existing sampling stations to collect data, used Parish personnel for data collection (when possible), and developed strategic partnerships with members of the project team. Figure 1.1 provides the initial budget for the Jefferson Parish's monitoring project [Source: Water Data and Tools: Tracking Freshwater Diversions & Algal Bloom Impacting the New Orleans Standard Metropolitan Statistical Area Gulf of Mexico, New Orleans, LA].

The costs to conduct a water quality monitoring project similar to the Jefferson Parish Project can vary significantly. Factors affecting the cost include, but are not limited to, the size and location of your study area, the number and types of parameters you want to measure, the number of personnel needed to collect and analyze the data, the number of samples to collect, the amount of new equipment which will need to be purchased, etc. For example, the Parish purchased only one additional sampling station for their study because they were able to obtain data from seven existing sampling stations located nearby. Monitoring costs for a proposed project would be much higher if additional sampling stations are needed.

Figure 1.2 provides some typical costs for equipment and services you could expect to incur when implementing a project similar to that of Jefferson Parish. Please note that these costs can vary significantly for a project depending upon the number of sampling stations required for the project and the types of services contracts that you are able to negotiate.

Figure 1.1. Initial EMPACT Project Budget for Jefferson Parish

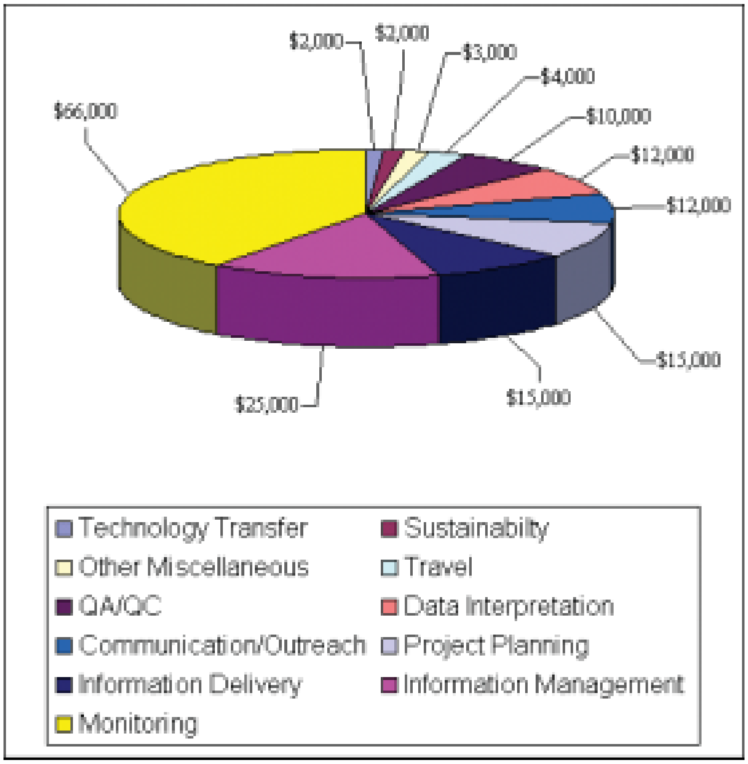
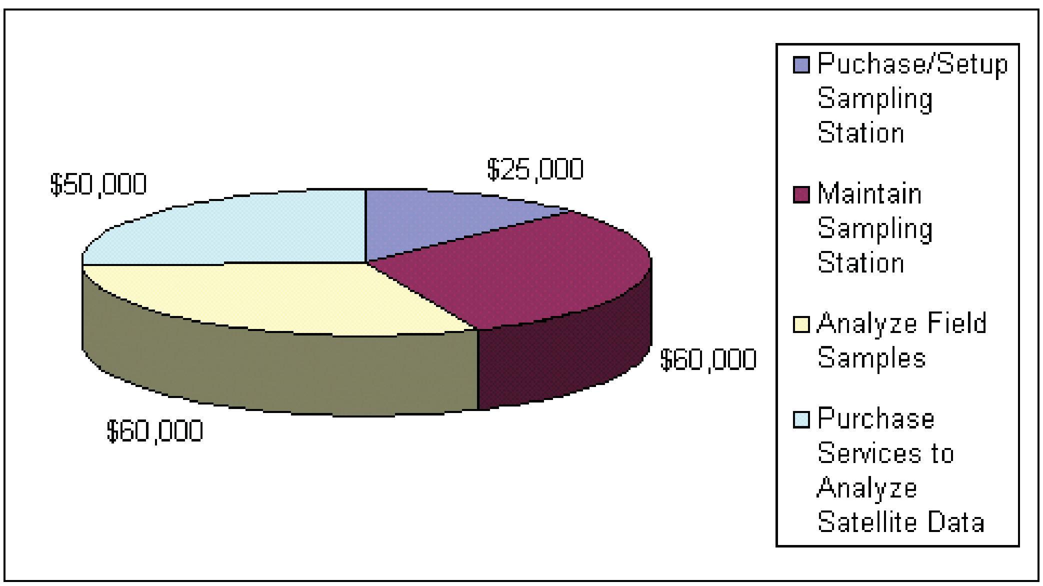


Figure 1.2. Typical Costs For Equipment and Services



1.3.4 Jefferson Parish EMPACT Project Objectives

Overall project objectives include the following:

- To provide the public with information on the physical and biological characteristics and components of Lake Salvador and adjacent regions as close to real time as possible.

- To gather baseline data in the Davis Pond Diversion outfall area to assist coastal scientists and managers in distinguishing the effects of river water from other stressors.

- To use the field data collected to investigate the satellite-derived parameters including water temperature, water reflectance (suspended solids) and chlororphyll *a* .

- To provide reliable data on water quality and phytoplankton blooms to the agencies and organizations involved with public health, fisheries, and habitat related issues.

1.3.5 Technology Transfer Handbook

The Technology Transfer and Support Division of the EPA's ORD National Risk Management Research Laboratory initiated development of this handbook to help interested communities learn more about the Jefferson Parish Project. The handbook also provides technical information communities need to develop and manage their own time-relevant water monitoring, data visualization, and information dissemination programs. ORD, working with the Jefferson Parish Project team, produced this handbook to leverage EMPACT's investment in the project and minimize the resources needed to implement similar projects in other communities.

Both print and CD-ROM versions of the handbook are available for direct on-line ordering from EPA's Office of Research and Development Technology Transfer Web site at **http://www.epa.gov/ttbnrmrl**. You can also order a copy of the handbook (print or CD-ROM version) by contacting ORD Publications by telephone or mail at:

EPA ORD Publications
US EPA-NCEPI
P.O. Box 42419
Cincinnati, OH 45242
Phone: (800) 490-9198 or (513) 489-8190

Note!

Please make sure you include the title of the handbook and the EPA document number in your request.

We hope you find the handbook worthwhile, informative, and easy to use. We welcome your comments, and you can send them by e-mail from EMPACT's Web site at **http://www.epa.gov/empact/comment.htm**.

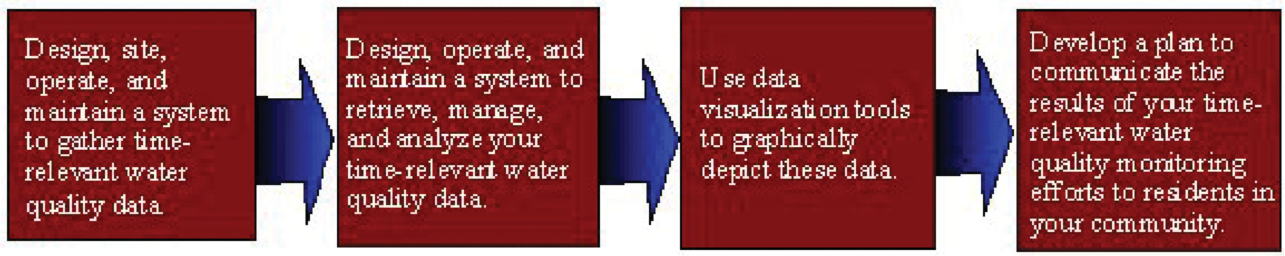
1.4 EMPACT Metropolitan Areas

Albany-Schenectady-Troy, NY
Albuquerque, NM
Allentown-Bethlehem-Easton, PA
Anchorage, AK
Appelton-Oshkosh-Neeha, WI
Atlanta, GA
Augusta-Aiken, GA-SC
Austin-San Marcos, TX
Bakersfield, CA
Baton Rouge, LA
Beaumont-Port Arthur, TX
Billings, MT
Biloxi-Gulfport-Pascagoula, MS
Binghamton, NY
Birmingham, AL
Boise City, ID
Boston-Worcester-Lawrence-MA-NH-ME-CT
Brownsville-Harlingen-San Benito, TX
Buffalo-Niagara Falls, NY
Burlington, VT
Canton-Massillon, OH
Charleston-North Charleston, SC
Charleston, WV
Charlotte-Gatsonia-Rock Hill, NC-SC
Chattanooga, TN-GA
Cheyenne, WY
Chicago-Gary-Kenosha, IL-IN-WI
Cincinnati-Hamilton, OH-KY-IN
Cleveland, Akron, OH
Colorado Springs, CO
Columbia, SC
Columbus, GA-AL
Columbus, OH
Corpus, Christie, TX
Dallas-Fort Worth, TX
Davenport-Moline-Rock Island, IA-IL
Dayton-Springfield, OH
Daytona Beach, FL
Denver-Boulder-Greeley, CO
Des Moines, IA
Detroit-Ann Arbor-Flint, MI
Duluth-Superior, MN-WI
El Paso, TX
Erie, PA
Eugene-Springfield, OR
Evansville-Henderson, IN-KY
Fargo-Moorhead, ND-MN
Fayetteville, NC
Fayetteville-Springfield-Rogers, AR
Fort Collins-Loveland, CO
Fort Myers-Cape Coral, FL
Fort Pierce-Port St. Lucie, FL
Fort Wayne, IN
Fresno, CA
Grand Rapids-Muskegon-Holland, MI
Greensboro-Winston-Salem-High Point, NC
Greenville-Spartanburg-Anderson, SC
Harrisburg-Lebanon-Carlisle, PA
Hartford, CT
Hickory-Morganton-Lenoir, NC
Honolulu, HI
Houston-Galveston-Brazoria, TX
Huntington-Ahsland, WV-KY-OH
Huntsville, AL
Indianapolis, IN
Jackson, MS
Jacksonville, FL
Johnson City-Kingsport-Bristol, TN-VA
Johnston, PA
Kalamazoo-Battle Creek, MI
Kansas City, MO-KS
Killeen-Temple, TX
Knoxville, TN
Lafayette, LA
Lakeland-Winter Haven, FL
Lancaster, PA
Lansing- East Lansing, MI
Las Vegas, NV-AZ
Lexington, KY
Lincoln, NE
Little Rock-North Little Rock, AR
Los Angeles-Riverside-Orange County, CA
Louisville, KY-IN
Lubbock, TX
Macon, GA
Madison, WI
McAllen-Edinburg-Mission, TX
Melbourne-Titusville-Palm Bay, FL
Memphis, TN-AR-MS
Miami-Fort Lauderdale, FL
Milwaukee-Racine, WI
Minneapolis-St. Paul, MN-WI
Mobile, AL
Modesto, CA
Montgomery, AL
Nashville, TN
New London-Norwich, CT-RI
New Orleans, LA
New York-Northern New Jersey-Long Island, NY-NJ-CT-PA
Norfolk-Virginia Beach-Newport News, VA-NC
Ocala, FL
Odessa-Midland, TXOklahoma City, OK
Omaha, NE-IA
Orlando, FL
Pensacola, FL
Peoria-Pekin, IL
Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD
Phoenix-Mesa, AZ
Pittsburgh, PA
Portland, ME
Portland-Salem, OR-WA
Providence-Fall River-Warwick, RI-MA
Provo-Orem, UT
Raleigh-Durham-Chapel Hill, NC
Reading, PA
Reno, NV
Richmond-Petersburg, VA
Roanoke, VA
Rochester, NY
Rockford, IL
Sacramento-Yolo, CA
Saginaw-Bay City-Midland, MI
St. Louis, MO-IL
Salinas, CA
Salt Lake City-Ogden, UT
San Antonio, TX
San Diego, CA
San Francisco-Oakland-San Jose, CA
San Juan-Caguas-Arecibo, PR
San Luis Obispo-Atascadero-Paso Robles, CA
Santa Barbara-Santa Maria-Lompoc, CA
Sarasota-Bradenton, FL
Savannah, GA
Scranton-Wilkes Barre-Hazleton, PA
Seattle-Tacoma-Bremerton, WA
Shreveport-Bossier City, LA
Sioux Falls, SD
South Bend, IN
Spokane, WA
Springfield, MA
Springfield, MO
Stockton-Lodi, CA
Syracuse, NY
Tallahassee, FL
Tampa-St. Petersburg-Clearwater, FL
Toledo, OH
Tucson, AZ
Tulsa, OK Visalia-Tulare-Porterville, CA
Utica-Rome, NY
Washington-Baltimore, DC-MD-VA-WV
West Palm Beach-Boca Raton, FL
Wichita, KS
York, PA
Youngstown-Warren, OH

In addition, federally recognized Native American Tribes - regardless of location in the United States - are eligible to apply.

2. HOW TO USE THIS HANDBOOK

This handbook provides you with step-by-step information on how to develop a program to provide time-relevant water quality data to your community, using the Jefferson Parish Project in the New Orleans, Louisiana area as a model. It contains detailed guidance on how to:



- **Chapter 3** provides information about water quality monitoring - the first step in the process of generating time-relevant information about water quality and making it available to residents in your area. The chapter begins with an overview of water quality monitoring in estuariane systems and then focuses on the three monitoring components that are part of the Jefferson Parish Project: (1) collection of time-series physical and biological measurements at a fixed location in Lake Salvador; (2) satellite/remote sensing technology; and (3) water quality field sampling. The chapter also provides instructions on how to install, operate, and maintain the time-series sampling system, how to obtain satellite data and use these data for water quality monitoring, and how to set up the field sampling program.

- **Chapter 4** provides step-by-step instructions on how to collect, transfer, and manage time-relevant water quality data. This chapter discusses time-series sampling equipment calibration, transferring sampling data to the base station, managing sampling data at the base station, and checking sampling data for quality. This chapter also provides detailed information on satellite data acquisition, processing, interpretation, ground-truthing, and data transfer and management. In addition, this chapter presents details on water quality field sampling including details on sampling, water quality parameter analyses, phytoplankton speciation, and data transfer and management.

- **Chapter 5** provides information about using data visualization tools to graphically depict the time-relevant water quality data you have gathered. The chapter begins with a brief overview of data visualization. It then provides a more detailed introduction to selected data visualization tools utilized by the Jefferson Parish team. You might want to use these software tools to help analyze your data and in your efforts to provide time-relevant water quality information to your community.

- **Chapter 6** outlines the steps involved in developing an outreach plan to communicate information about water quality in your community. It also provides information about the Jefferson Parish Project's outreach efforts. The chapter includes a list of resources to help you develop easily understandable materials to communicate information about your time-relevant water quality monitoring program to a variety of audiences.

This handbook is designed for decision-makers considering whether to implement a time-relevant water quality monitoring program in their communities and for technicians responsible for implementing these programs. Managers and decision-makers likely will find the initial sections of **Chapters 3**, **4,** and **5** most helpful. The latter sections of these chapters are targeted primarily at professionals and technicians and provide detailed "how to" information. **Chapter 6** is designed for managers and communication specialists.

The handbook also refers you to supplementary sources of information, such as Web sites and guidance documents, where you can find additional guidance with a greater level of technical detail. The handbook also describes some of the lessons learned by the Jefferson Parish team in developing and implementing its time-relevant water quality monitoring, data management, and outreach program.

3. WATER QUALITY MONITORING

This chapter provides information about water quality monitoring the first step in the process of generating time-relevant information about water quality and making it available to residents in your area.

The chapter begins with a broad overview of water quality monitoring and then focuses on the three monitoring components that are part of the Jefferson Parish Project: (1) time-series water quality sampling (Section 3.1); (2) satellite/remote sensing technology (Section 3.2); and (3) water quality field sampling (Section 3.3). The chapter also provides instructions on how to install, operate, and maintain the sampling equipment, how to obtain satellite data and use these data for water quality monitoring, and how to set up the field sampling program.

Readers primarily interested in an overview of water quality monitoring might want to focus on information presented in this introductory section and the introductory parts of Sections 3.1, 3.2, and 3.3. If you are responsible for the actual design and implementation of a water quality sampling project, you should review Subsections 3.1.1 through 3.1.8. They provide an introduction to the specific steps involved in developing and operating a time-relevant water quality monitoring project and information on where to find additional guidance. If you are responsible for the designing and implementing a water quality monitoring program using satellite/remote sensing technology, you should review Subsections 3.2.1 through 3.2.2. They provide information on available satellite data and information on how to use satellite data for water quality monitoring. If you are responsible for the actual design and implementation of a water quality field sampling project, you should review Subsections 3.3.1 through 3.3.2. They provide information on setting up a field sampling program.

Water Quality Monitoring: An Overview

Water quality monitoring provides information about the condition of streams, lakes, ponds, estuaries, and coastal waters. It can also tell us if these waters are safe for swimming, fishing, or drinking. The Web site of the EPA Office of Water (http://www.epa.gov/owow/monitoring) is a good source of background information on water quality monitoring. (The information presented in the following paragraphs, which is taken from the Lake Access - Minneapolis EMPACT Manual - EPA/625/R-00/012, is summarized from the Web site listed above.)

Water quality monitoring can consist of the following types of measurements:

- Chemical measurements of constituents such as dissolved oxygen, nutrients, metals, and oils in water, sediment, or fish tissue.

- *Physical* measurements of general conditions such as temperature, conductivity/salinity, current speed/direction, water level, water clarity.

- *Biological* measurements of the abundance, variety, and growth rates of aquatic plant and animal life in a water body or the ability of aquatic organisms to survive in a water sample.

You can conduct several kinds of the following water quality monitoring projects:

- At fixed locations on a continuous basis

- At selected locations on an as-needed basis or to answer specific questions

- On a temporary or seasonal basis (such as during the summer at swimming beaches)

- On an emergency basis (such as after a spill)

Many agencies and organizations conduct water quality monitoring, including state pollution control agencies, Indian tribes, city and county environmental offices, the EPA and other federal agencies, and private entities, such as universities, watershed organizations, environmental groups, and industries. Volunteer monitors - private citizens who voluntarily collect and analyze water quality samples, conduct visual assessments of physical conditions, and measure the biological health of waters - also provide increasingly important water quality information. The EPA provides specific information about volunteer monitoring at http://www.epa.gov/owow/monitoring/vol.html.

Water quality monitoring is conducted for many reasons, including:

- Characterizing waters and identifying trends or changes in water quality over time.

- Identifying existing or emerging water quality problems.

- Gathering information for the design of pollution prevention or restoration programs.

- Determining if the goals of specific programs (such as river diversions) are being met.

- Complying with local, state, and Federal regulations.

- Responding to emergencies such as spills or floods.

EPA helps administer grants for water quality monitoring projects and provides technical guidance on how to monitor and report monitoring results. You can find a number of EPA's water quality monitoring technical guidance documents on the Web at: http://www.epa.gov/owow/monitoring/techmon.html.

In addition to the EPA resources listed above, you can obtain information about lake and reservoir water quality monitoring from the North American Lake Management Society (NALMS). NALMS has published many technical documents, including a guidance manual entitled *Monitoring Lake and Reservoir Restoration*. For more information, visit the NALMS Web site at http://www.nalms.org. State and local agencies also publish and recommend documents to help organizations and communities conduct and understand water quality monitoring. For example, the Gulf of Mexico Program maintains a Web site (http://www.gmpo.gov/mmrc/mmrc.html) that lists resources for water quality monitoring and management. State and local organizations in your community might maintain similar listings. The Louisiana State University's Coastal Studies Institute Web site also maintains a list of links for water quality information and resources at http://www.csi.lsu.edu/.

In some cases, special water quality monitoring methods, such as remote monitoring, or special types of water quality data, such as time-relevant data, are needed to meet a water quality monitoring program's objectives. *Time-relevant* environmental data are collected and communicated to the public in a time frame that is useful to their day-to-day decision-making about their health and the environment, and relevant to the temporal variability of the parameter measured. Monitoring is called *remote* when the operator can collect and analyze data from a site other than the monitoring location itself.

3.1 Time-Series Water Quality Sampling

The Jefferson Parish Project provides much needed baseline data on nutrient and chlorophyll levels in the upper Barataria basin. Evaluation of historical data sets indicate a lack of comprehensive water quality data especially in relation to chlorophyll data. It also provides the only data from the Davis Pond Freshwater Diversion outfall that is near-real time and easily assessable to the public via the world wide Web. Diversions, and the possibility of diversion-related algal blooms, are a major concern to communities in the New Orleans area, as is the growing dead zone in the Gulf of Mexico. Using time-relevant monitoring of lake water quality for the early detection of an algal bloom is a useful tool in providing timely environmental information to natural resource and human health protection agencies in Louisiana.

The Jefferson Parish Project team conducts time-relevant monitoring at one location in Lake Salvador. At this location, the project team operates a sampling platform, which performs time-series water quality monitoring using commercially available monitoring sensors. The sensors transmit time-relevant water quality data to a data acquisition system contained on the platform.

Using wireless communication, the sampling system can both receive programming and transmit data to a land-base station.

The time-series sampling system is installed on an existing oil pumping platform. The data collection platform contains batteries; solar panels; telemetry equipment; a data acquisition system (Handar 555A); and a sensor package. The specially designed field computer provides a suite of water quality parameters from the water below the platform. The sensor package, produced by Yellow Springs Instruments© (YSI©), has multisensor probes that can be customized to meet virtually any sensor needs. The sensor package, connected to the data acquisition system, collects data from 4 feet below the water surface at preprogrammed times.

Each hour, the time-series sampling system unit equipped with a multiprobe water quality sensor manufactured by YSI© collects water quality data. The system measures the following parameters:

- Water level
- Precipitation
- Air temperature
- Water temperature
- Wind speed/direction
- Specific conductance/Salinity
- pH
- Dissolved oxygen
- Backscattter/Turbidity
- Chlorophyll *a*

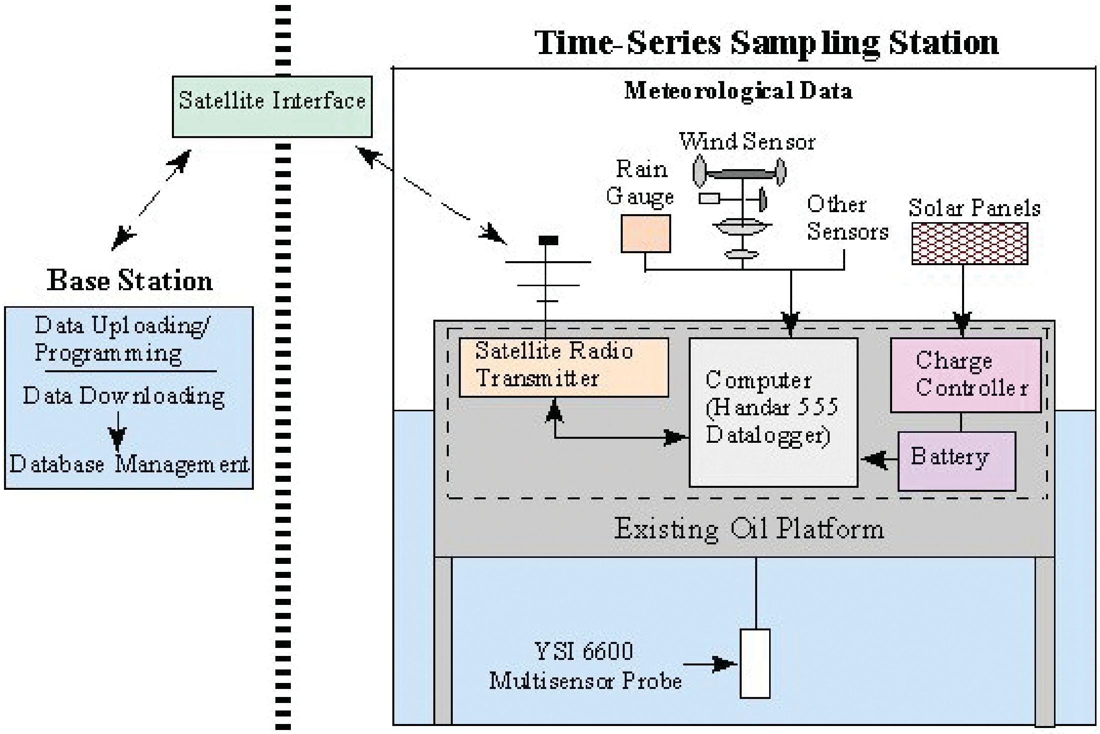
The Jefferson Parish Project team uses a land-base station to communicate with the sampling station via satellite interface. Time-relevant data are remotely downloaded from the station daily. Figure 3.1 illustrates some of the basic sampling station components and shows how the sampling system communicates with the land-base station.

The remainder of this chapter highlights the Jefferson Parish Project. The following subsection provides some background information on river diversion impacts and estuarine ecology and it introduces some important concepts relevant to the study of these topics.

3.1.1 Designing a Time-Relevant Water Quality Monitoring Project

The first step in developing a water quality monitoring project is to define your objectives. Keep in mind that time-relevant monitoring might not be

Figure 3.1 Diagram of Basic Sampling Station Components



the best method for your organization or community. For example, you would not likely need time-relevant monitoring capability to conduct monthly monitoring to comply with a state or federal regulation.

In order to clearly define the objectives of your particular water quality monitoring project, you need to understand the system you are planning to monitor. This means that you need to collect background information about the aquatic system, such as natural occurring processes, system interactions, system ecology, and human impacts on the system.

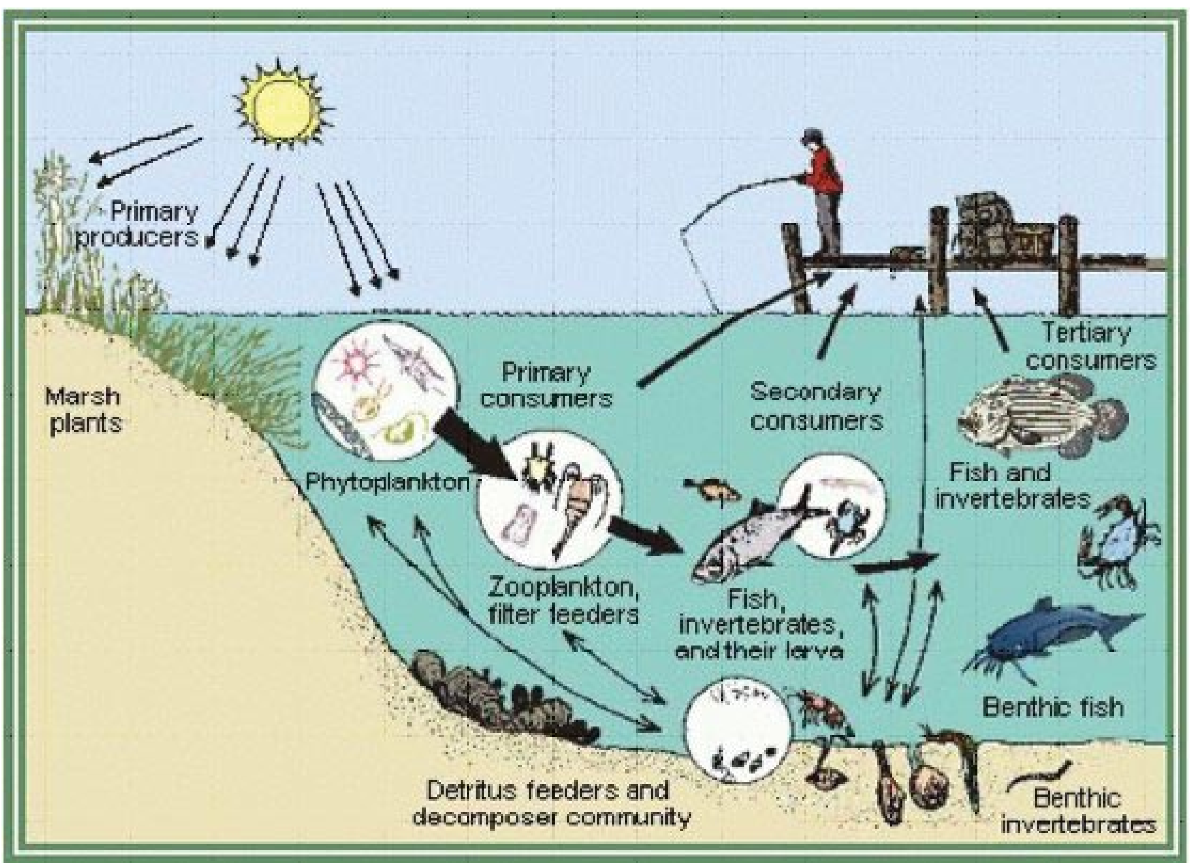
Since this particular monitoring project involves estuarine ecology and possible impacts of freshwater diversion into estuaries, the following text boxes provides some basic background information about these topics.

Estuarine Ecology

Estuaries are bodies of water that are balanced by freshwater and sediment influx from rivers and the tidal actions of the oceans, thus providing transition zones between the freshwater of a river and the saline environment of the sea. The result of this interaction is an environment where estuaries, along with their adjacent marshes and seagrasses, provide a highly productive ecosystem, that supports wildlife and fisheries and contributes substantially to the economy of coastal areas. As spawning, nursery, and feeding grounds, estuaries are invaluable to fish and shellfish. Estuarine-dependent species constitute more than 95 percent of the commercial fishery harvests from the Gulf of Mexico, and many important recreational fishery species depend on estuaries during some part of their life cycle. Estuaries are diverse and productive ecosystems that provide a variety of valuable resources, including fish and shellfish, recreation, transportation, and petroleum and minerals.

Estuaries and wetland environments are intertwined. Coastal emergent wetlands border estuaries and the coast and include tidal saltwater and freshwater marshes. Coastal wetlands serve as essential habitat for a diverse range of species. These wetlands are used by shorebirds, migratory waterfowl, fish, invertebrates, reptiles, and mammals. Migrating waterfowl and migratory birds utilize these coastal habitats. Mudflats, salt marshes, mangrove swamps, and barrier island habitats also provide year-round nesting and feeding grounds for abundant populations of gulls, terns, and other shorebirds. Estuaries, marshes and associated watersheds provide habitat for many threatened and endangered species. Estuaries and wetlands support complex food webs that provide an abundant food source for juvenile and adult fishes (see Figure 3.2 below). In addition to providing habitat, wetlands also improve water quality by filtering pollutants and sediment and offer a buffer zone to protect upland areas from flooding and erosion.

Figure 3.2. Conceptual diagram of the food web in estuarine ecosystems
[Source: http://www.epa.gov/ged/gulf.htm].



There are usually three overlapping zones in an estuary: an open connection with the sea where marine water dominates, a middle area where salt water and fresh water mix, and a tidal river zone where fresh water dominates. Tidal forces cause the estuarine characteristics to vary. Also variation in the seasonal discharge of rivers causes the limits of the zones to shift, thus increasing the overall ecological complexity of the estuaries. [Source: http://encarta.msn.com/find/Concise.asp?z=1&pg=2&ti=761570978#s1]

Most of the world's freshwater runoff encounters the oceans in estuaries. Tides or winds help mix the lighter, less dense fresh water from the rivers with the salt water from the ocean to form brackish water. The salinity of brackish water is typically 2 to 10 parts per thousand (ppt), while the salinity of salt water is about 35 ppt. Due mostly to changes in the river flow, the three main estuarine zones - saltwater, brackish, and freshwater - can shift seasonally and vary significantly from one area to another. [Source: http://encarta.msn.com/find/Concise.asp?z=1&pg =2&ti=761570978#s1]

The chemical components of fresh (or river) water can vary greatly and produce significant differences in estuarine nutrient cycles. Typically, the most important compounds for estuarine life that are supplied by river water are nitrogen, phosphorus, silicon, and iron. Seawater, which has fairly uniform chemical components, provides sulfate and bicarbonate. With adequate nutrients and light conditions, estuaries enable the production of phytoplankton which provides the basis for some of the most productive habitats on earth. [Source: http://encarta.msn.com/find/Concise.asp?z=1&pg=2&ti =761570978#s1]

River Diversion Impacts

Leveeing of the rivers for flood control has impacted the estuarine ecology by blocking the rivers' historic spring overflows and thus impeding the rush of marsh-supporting fresh water, nutrients, and sediment to the coastal zone. This resulted in wetland loss along coastal zones and causes pressing environmental problems.

Diversion of freshwater and sediments from rivers is expected to conserve and restore coastal wetlands, but citizens are concerned about the impact that nutrient rich river water may have on water quality and growths (blooms) of phytoplankton. The freshwater diversions imitate historic spring floods by providing a controlled flow of freshwater and nutrients into estuaries. It is expected that this diversion will restore former ecological conditions by combating land loss, enhancing vegetation and improving fish and wildlife habitat.

However, there are concerns that the freshwater diversion may have a negative impact on estuaries. Commercial fishermen are concerned that massive amounts of river water may deteriorate the water quality in the lakes and bays where they make their living. Communities downstream of diversion sites are concerned that water levels will increase and cause flooding during high wind driven tides. Scientists debate the wisdom of introducing more nutrients into already eutrophic systems. Stakeholders are also interested in the changes that will occur as salinity levels are altered in the upper estuaries.

Diverting too much nutrients into estuaries, leads to excessive algae growth and eventually oxygen depletion. In many cases, fish kills are evidence of oxygen depleted water in the estuary. Sewage and other organic wastes that are discharged into rivers and estuaries can overload estuaries with nutrients. These conditions can contribute to the loss of animal and plant life, the decrease of a buffer zone from storm surges, salt water intrusion, and ultimately the decline of the estuary and loss of wetland. [Source: http://encarta.msn.com/find/Concise.asp?z=1&pg=2&ti=761570978#s1]

River water diversions from previously leveed rivers into estuaries have shown three potential impacts: (1) they may increase the water level in the estuary; (2) they may increase nutrient and sediment input into the estuary; and (3) they may decrease the salinity in the estuary. Figure 3.3 shows the possible beneficial and negative impacts of river water diversions.

Designing the Jefferson Parish Project

The Jefferson Parish Project team's decision to collect time-relevant water quality data was in response to the public's repeated request for publicly available real time water quality data. Wetland loss and decline of the estuarine ecosystem raised an interest to learn more about impacts of river water diversions from previously leveed rivers into estuaries. The project team determined that pre-and post diversion water quality data have to be collected in order to make assessments of river water diversion impacts.

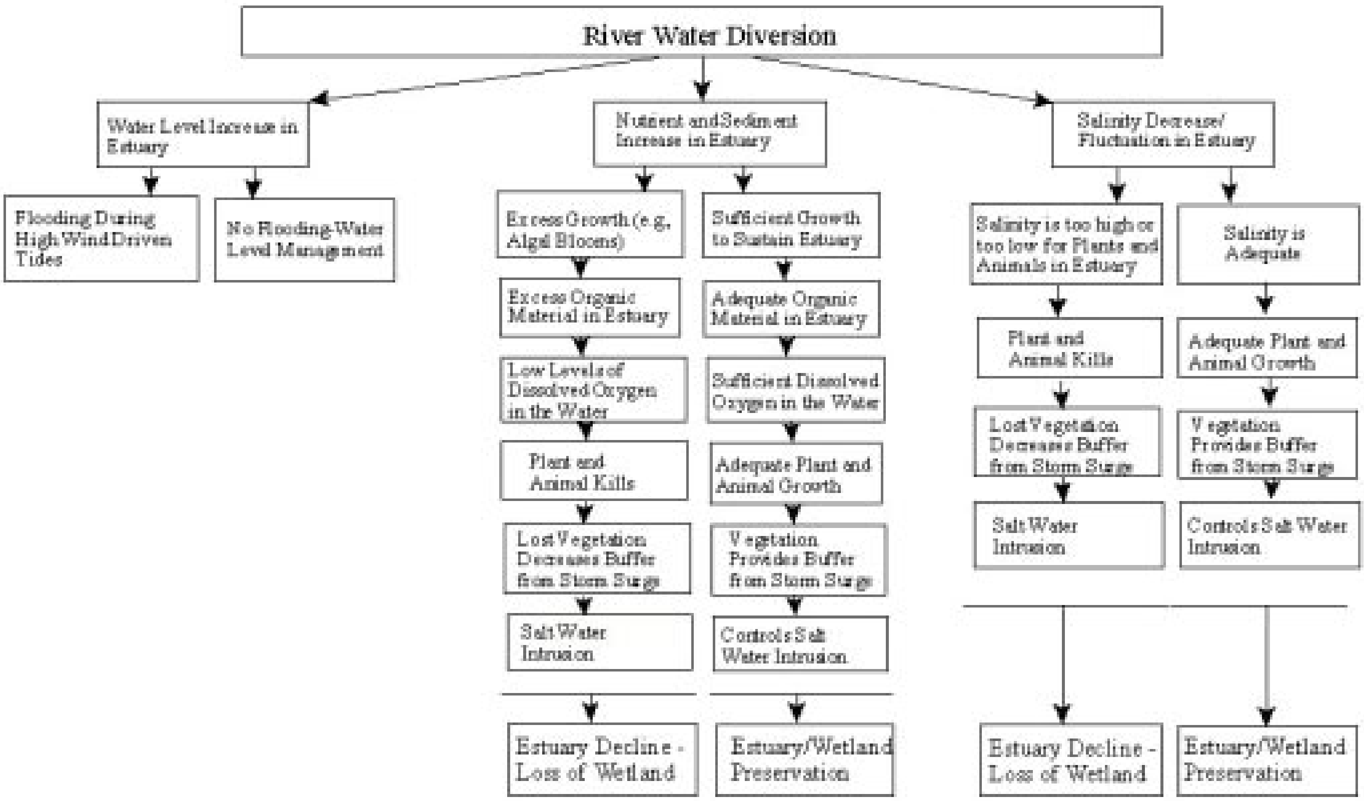
The project team decided to conduct time-relevant monitoring of lake water quality to be able to detect algal blooms early and to provide timely environmental information to natural resource and human health protection agencies. Having time-relevant data allows entities to respond quickly to adverse environmental conditions, make appropriate decisions to ensure economic and environmental sustainability of the affected environment, and protect the health of commercial and recreational users.

3.1.2 Selecting Your Sampling Frequency

The sampling frequency you select for your time-relevant water quality monitoring project depends on your project's objectives. For example:

- If you want to identify existing or emerging water quality problems such as algal blooms, you could tailor your monitoring frequency to

Figure 3.3. Possible Beneficial and Negative Impacts of River Water Diversion



collect data often enough to determine problems early to take measures to alleviate the problem and warn the public.

- If you want to study seasonal water quality problems, you may want to increase your monitoring frequency during seasons when water quality problems are more predominant (i.e., low dissolved oxygen levels and associated fish kills during summer months).

It is appropriate to experiment with different monitoring frequencies to optimize your ability to fulfill your project's objectives.

Jefferson Parish Project Monitoring Frequency

The Jefferson Parish Project team programed its time-series sampling system to collect water quality samples every hour. This monitoring frequency allows the team members to see short-term changes in water quality and allows them to detect problems early to respond quickly to adverse environmental conditions, make appropriate decisions to ensure economic and environmental sustainability of the affected environment, and protect the health of commercial and recreational users.

The data from the monitoring station in Lake Salvador are used to assess average conditions and variations from these average conditions. Ancillary measurement, including but not limited to river discharge/stage, are obtained to aid in the determination of the cause of the variability revealed by the time-series data. Previous studies in shallow estuarine systems of coastal Louisiana have shown that the physical and ecological variability is closely related to changes in wind speed/direction and river discharge.

3.1.3 Selecting Water Quality Parameters for Monitoring

The time-relevant monitoring parameters that you select depend on your project's objectives and the time-relevant technologies available to you. The Jefferson Parish project team chose to monitor the following eleven water quality parameters on a time-relevant basis to fulfill the project's objectives: water level, precipitation, air temperature, water temperature, wind speed/direction, specific conductance/salinity, pH, dissolved oxygen, reflectance/turbidity, and chlorophyll *a*.

The Jefferson Parish Project team uses time-relevant measurements of the above listed parameters as indicators for the health of the ecosystem (early detection of algal blooms, seagrass die-offs, and fish kills) and to monitor impacts of freshwater diversions.

Harmful Algal Blooms

Microscopic, single-celled plants (phytoplankton) serve as the primary producers of energy at the base of the estuarine food web. Some species of phytoplankton grow very fast, or "bloom," and accumulate into dense, visible patches near the surface of the water. Although the causes of algal blooms are not entirely known, scientists suspect that blooms occur as a result of a combination of high temperatures, a lack of wind, and, frequently, nutrient enrichment. Some algal blooms are called brown tides, and, while not harmful to humans, they cause serious ecosystem impacts due to decreases in light penetration and dissolved oxygen. Brown tides can cause seagrass die-offs and fish kills. Some algae produce potent neurotoxins that can be transferred through the food web, where they cause damage, even death, to organisms from zooplankton to humans.

The most well-known harmful algal bloom (HAB) events in the Gulf of Mexico involve blooms of *Gymnodinium breve* (also known as red tides). This organism discolors the water red (although other less harmful algae can also discolor the water red) and has been implicated in fish kills and the deaths of manatee and other marine mammals. *G. breve* produces brevetoxins that cause Neurotoxic Shellfish Poisoning (NSP). NSP induces gastrointestinal and neurological symptoms in humans that, although debilitating, are not fatal. In addition, toxic aerosols are formed by wave action and can produce asthma-like symptoms in humans. This often leads to beach closures [Source: http://www.epa.gov/ged/gulf.htm].

Jefferson Parish Time-Relevant Water Quality Monitoring Parameters

Water Level. The water level is monitored to ensure that freshwater diversions do not create or add to any local flooding problems. Early warning of an increased water level allows diversion managers to make appropriate decisions to minimize the introduction of more water when flooding is likely.

Precipitation. Precipitation is monitored because it affects the water level in the estuary. Increased water level may lead to flooding, which adversely impacts coastal communities. Both, the lack or excess, of precipitation can adversely affect vegetation and animal life and stress the ecosystem. In addition, precipitation increases urban runoff, which increases nutrient loads, decreases salinity, and influences dissolved oxygen levels in the estuary.

Air Temperature. Air temperature affects the water temperature and thus air temperature monitoring can be used to predict water temperature trends. Air temperature has a direct effect on biological activity and the growth of terrestrial organisms and vegetation. Extremely high or low air temperatures for extended periods of time can adversely affect vegetation and animal life and stress the ecosystem.

Water Temperature. Water temperature affects metabolic rates and thus has a direct effect on biological activity and the growth of aquatic animal life and aquatic vegetation. Generally, high temperatures (up to a certain limit) increase biological activity and growth, while low temperatures decrease biological activity and growth. For example, high temperatures in nutrient rich environments promote algal growth and may lead to algal blooms. Temperature also affects biological activity by influencing lake water chemistry, such as the oxygen content of the water. Warm water contains less dissolved oxygen than cold water. Low dissolved oxygen levels in the water might not be sufficient to support some types of aquatic life.

Wind speed/direction. Wind speed/direction is important for water mixing. High wind speeds promote mixing of water layers, whereas low wind speeds promote stratification of the water layers. Mixing of bottom and surface water creates relatively uniform temperature, dissolved oxygen, salinity, and reflectance/turbidity profiles. Algal blooms are less likely to occur at high wind speeds because higher turbidity in the surface water layer reduces light penetration and aquatic plant growth. In addition, wind speed and direction influence salinity and water levels through wind-driven tides. For example, a strong southerly wind can increase the water level in the project area by as much as 12 inches. Salinity levels in the project area also increase during periods with strong southernly wind.

Specific Conductance/Salinity or electrical conductivity. Electrical conductivity/salinity is an estimator of the amount of total dissolved salts or total dissolved ions in water. Many factors influence the electrical conductivity/salinity of lake water, including the watershed's geology, the watershed's size, wastewater from point sources, runoff from nonpoint sources, atmospheric inputs, evaporation rates, precipitation, fresh water diversion from rivers, tidal surges, and some types of bacterial metabolism. Electrical conductivity/salinity is also a function of temperature; therefore, time-series data are standardized to 25°C. High amounts of precipitation and fresh water diversion from rivers decreases electrical conductivity/salinity, while tidal surges increase electrical conductivity/salinity in the estuary. Estuaries are characterized by gradients in salinity from near fresh water at the mouths of the tributaries to near marine at the mouth of the estuary. Estuaries in the Gulf of Mexico are predominantly polyhaline (salinity more than 18 ppt) during the summer months. Electrical conductivity/salinity affects the distribution and health of benthic animals, fish, and vegetation. Both, excessively high or low salinities, can negatively impact the estuarine ecosystem.

pH. pH is a measure of the hydrogen ion concentration in the water. A pH of 7 is considered neutral. Values lower than 7 are considered acidic and higher than 7 are basic. Many important chemical and biological reactions are strongly affected by pH. In turn, chemical reactions and biological processes (e.g., photosynthesis and respiration) can affect pH. Lower pH values can increase the amount of dissolved metals in the water, increasing the toxicity of these metals. [Source: Lake Access - Minneapolis EMPACT Manual - EPA/625/R-00/012]

Dissolved Oxygen. Dissolved oxygen (DO) is an indicator of the habitability of estuarine waters for marine life and it is routinely measured by monitoring programs interested in characterizing the eutrophic state of estuaries. DO is recognized as an indicator of the extent of eutrophication because wide fluctuations in DO often result from increased primary productivity and may reflect prior nutrient loading. DO concentrations may also vary because of natural processes, such as stratification, depth, wind-induced mixing, and tidal fluxes. DO is necessary for respiration in most aquatic animals but different biota have different requirements for adequate DO. Hypoxia (condition where DO is less than 2 mg/L) increases stress from other factors (e.g., contaminants) on marine organisms, whereas anoxic conditions (DO < 0.1 mg/L) produce toxic hydrogen sulfide which can be lethal to marine biota. Many states require DO concentrations of 4-5 mg/L for estuaries to meet their designated use criteria. Sufficient evidence exists that DO < 2 mg/L is extremely stressful to most aquatic organisms. Low DO is usually observed from June through October and is primarily driven by stratification of the water column [Source: http://www.epa.gov/ged/gulf.htm]. Additional information about hypoxia can also be found on the following USGS Web site: http://wwwrcolka.cr.usgs.gov/midconherb/hypoxia.html.

Turbidity. Turbidity (or backscatter) describes the clarity of the water. Turbidity is a measurement of the amounts of total suspended solids in the water. The particles that make up the turbidity can range from mineral matter to organics. In combination with the chlorophyll measurements, it can be determined if mineral matter or organics dominate. Predominant orgaincs can be an indication of an algal bloom, which could mean that algae below the zone of light penetration are decaying and consuming oxygen, which in turn, can result in hypoxia that effects bottom dwelling organisms. Measurements of turbidity and backscatter are interrelated in that water with high turbidity measurements also yields high reflectance measurements. This is the case because the more particles are present, the more light can be scattered back to the sensor. Increased turbidity measurements might have several adverse effects on water quality, including the following:

- Turbidity reduces light penetration, which deceases the growth of aquatic plants and organisms. The reduced plant growth reduces photosynthesis, which results in decreased daytime releases of oxygen in the water.

- Suspended particles eventually settle to the bottom, suffocating eggs and/or newly hatched larva, and occupy potential areas of habitat for aquatic organisms.

- Turbidity can also negatively impact fish populations by reducing the ability of predators to locate prey - shifting fish populations to species that feed at the lake or ocean bottom.

- Fine particulate material can affect aquatic organisms by clogging or damaging their sensitive gill structures, decreasing their resistance to disease, preventing proper egg and larval development, and potentially interfering with particle feeding activities.

- Increased inputs of organic particles deplete oxygen as the organic particles decompose.

- Increased turbidity raises the cost of treating surface water for thedrinking water supply.

Chlorophyll *a*. Nutrient loading is just one indicator of the potential that an estuary has to become eutrophic. Chlorophyll *a* can be an indicator of the first level response to nutrient enrichment. Measurements of chlorophyll *a* (via fluorescence) in the water column represent the standing stock or biomass of phytoplankton. Blooms of phytoplankton often indicate that an estuary is undergoing eutrophication. In some estuaries, there is a good correlation between nitrogen loadings from various sources and concentrations of chlorophyll *a*. In other estuaries, however, the relationship does not hold and it is possible, in fact, for an estuary to receive heavy loads of nitrogen and yet not exhibit increases in phytoplankton biomass. Other factors such as light limitation, depth of the mixing zone, flushing rates, and contaminants may affect the growth of phytoplankton.

3.1.4 Selecting Monitoring Equipment

The time-relevant water quality monitoring equipment that you select depend on your project's objectives. When you select your monitoring equipment, you should carefully consider ease of use, equipment lifetime, reliability, and maintenance requirements. You also might consider to use equipment that has been used successfully for similar types of projects.

Jefferson Parish Equipment Components

The sampling system consists of a platform; data acquisition system (computer system); a battery; a solar panel; telemetry equipment; and a sensor package. The computer system allows for remote programming, data acquisition, and data retrieval. Information about the equipment components listed below was obtained from User's Manuals available from the Handar (now Vaisala Inc.) Web site at http://www.vaisala.com and from the Yellow Springs Instruments, Inc. (YSI) Web site at http://www.ysi.com. Even though the Jefferson Parish project team uses Handar and YSI instrumentation, other manufactures provide similar equipment. For example, satellite transmitters are also produced by Sutron (http://www.sutron.com) and sensor equipment is also supplied by Hydrolab (http://www.hydrolab.com).

Platform. The platform, which provides the structure for the sampling system, is an existing oil pumping platform in Lake Salvador. A picture of the platform with the sampling system is shown in Figure 3.4. For safety reasons, the platform is equipped with a light that is connected to a

battery, which gets charged by a solar panel. The floor of the platform has metal grating to which the equipment on the platform is secured. The grating also allows the Jefferson Parish team members to walk on the platform and access the equipment.

Data Acquisition System (DAS). The Handar Model 555A is a programable DAS that controls the sensors, data storage, telemetry, and data transmission. The 555 software governs all aspects of the DAS operation, which includes reading the sensors, analyzing and processing the data, storage and telemetry. The user creates its own unique program using an MS-DOS compatible computer by selecting commands and sensor parameters from pull down menus. The program is then stored in the nonvolatile memory of the DAS. The unit contains a data acquisition board, serial bus, and power supply enclosed in a corrosion-resistant fiberglass resin case. The Handar 555 unit enables the user to:

- Collect, process, and store data at user-specified intervals.
- Transmit data to the land-base station via wireless communication.
- Program the unit from the land-base station.
- Operate the unit in the field with a portable computer.

Figure 3.4. Picture of the sampling system platform taken during the January 9, 2001 site visit.

The structure on the left of picture is the light (A) below which you see the solar panel (B) and the box containing the battery (C). The structure to the right of the light is the fiberglass case (D) containing the DAS, the satellite radio transmitter, and the battery. The solar panel for the sampling system (E) is to the left of the DAS case. Above the DAS case is the rain gauge (F)

and the satellite transmission antenna (G). The wind speed/direction sensor, which is usually mounted above the DAS case, is not shown in the picture because it was damaged prior to the site visit and was in the process of being replaced. The right of the pictures shows pipes and structures (H) of the oil platform, which are not part of the sampling system.

Battery and Solar Panel. The Handar 555A DAS model has an internal lead-acid gel cell battery. This battery is sealed and rechargeable with a solar panel assembly. A variety of solar panels may be used for recharging the battery as long as the charging current is regulated not to exceed 0.3 A. Higher charging currents can damage the battery and even cause a hydrogen gas explosion.

Telemetry Equipment. The Handar Serial Bus allows the data acquisition board to communicate with the communications devices and the Programming Set. A variety of communications options are available for telemetry, including communication via telephone systems, radio, or satellite.

The Jefferson Parish project team uses a satellite radio transmitter for communications via GOES. The GOES are satellites operated by the National Environmental Satellite, Data and Information Service (NESDIS) of NOAA. The GOES Satellite Radio Module consists of a 10-watt transmitter that can be set to any of the allowable 199 domestic GOES and 33 international channels assigned by NESDIS. The normal configuration of GOES consists of the GOES East satellite stationed 21,700 miles above the equator at 75 degrees west longitude and the GOES West satellite is at 135 degrees west longitude.

Data are transmitted by the data acquisition system on an assigned ultra high frequency (UHF)-band frequency in the direction of the GOES. The GOES repeats the message in the S-band, which is received at the NESDIS ground station at Wallops Island, Virginia. The data are then re-broadcast to the DOMSAT satellite, which is a low orbiting communications satellite, and then retrieved on an eight-foot dish at the USGS office in Baton Rouge.

Sensor Package. The sensor package, YSI 6600, has multisensor probes to measure the various water quality parameters. A picture of the sensor package and probes is shown in Figure 3.5 below. The YSI 6600 is controlled by the Handar 555 unit. The sensors collect water quality and water level data beneath the platform. A special cable transmits power and protocols from the Handar 555 unit to the sensors and transmits data from the sensors to the Handar 555 unit.

Jefferson Parish Equipment Selection

When selecting the water quality sampling equipment, the Jefferson Parish project team worked with their local USGS office in Baton Rouge to find out which equipment they use. The USGS district office in Baton Rouge

Figure 3.5. Picture of the YSI 6600 sensor package with multisensor probes taken during the January 9, 2001 site visit.

already maintains and services a number of water quality sampling stations in that area and has extensive experience with the monitoring equipment used. Since the Jefferson Parish team contracted USGS to operate and maintain their time-series sampling unit, they wanted to use the same equipment the Baton Rouge USGS office is using for their other projects to facilitate the process and reduce costs. Since other USGS offices may be using different water quality monitoring equipment than the Baton Rouge office, you should contact your local USGS office and find out which equipment they use, if you are contracting USGS to operate and maintain your time-series sampling unit. The Jefferson Parish Project team selected the Handar 555A DAS with the YSI 6600 sensor package to collect time-relevant water quality data. This capability has provided the Jefferson Parish Project team with new opportunities for data collection and analysis and helps the project team to meet its objectives as described below:

- Multiple water quality parameters can be collected simultaneously.
- On demand water quality sampling can be conducted during significant environmental events or when humans are physically unable to test on-site.
- Multiple data points may be collected and received daily making water quality testing a more efficient and economical process.
- The frequent collection of water quality data enables personnel to provide timely environmental information to the community and natural resources and human health protection agencies.

The Jefferson Parish Project team also selected the time-series monitoring equipment for its ease of use, warranty and Customer Service, reliability, low maintenance requirements, and successful use for similar types of projects.

Ease of Use. Using the time-series monitoring equipment allows the project team to collect near-real time data without having to travel out into the field to view, upload, and process the data. This eliminates the need for frequent trips to a monitoring site and lets the project team respond to events as they occur.

Equipment Warranty and Customer Service. The Handar 555 DAS with its YSI 6600 multi-parameter monitoring systems is designed for long-term *in situ* monitoring.

The YSI sondes are warranted for two years; all cables are warranted for one year; and depth, dissolved oxygen, temperature/conductivity, pH, chloride, turbidity, and chlorophyll probes are warranted for one year. Handar warrants its data acquisition systems for five years and its telemetry systems for one year. Both YSI and Handar have customer service agreements providing repair services for their equipment.

Reliability. The Handar 555 DAS with its YSI 6600 multi-parameter monitoring systems is designed to work reliably even in extreme weather conditions.

Low Maintenance Requirements. The time-series sampling system has relatively low maintenance requirements. The YSI probes need some regular maintenance, such as periodic cleaning, membrane changes of the dissolved oxygen probe, and replacement of desiccant for the water level sensor. In addition, weekly calibration of the dissolved oxygen sensor is required. Users also need to check the batteries and the charging system of the DAS on a regular basis.

Successful Use in Similar Projects. The Jefferson Parish Project team also selected the time-series sampling system because of its proven track record. Other water quality monitoring projects (e.g., the Louisiana Lake Pontchartrain project and other local monitoring sites maintained by the USGS) use time-series sampling systems successfully for similar types of projects.

3.1.5 Siting Monitors

The time-relevant water quality monitoring location(s) that you select depend on your project's objectives. When you select your monitoring location(s), you should carefully consider the following factors:

- Will the data collected at this location(s) fulfill your project's objectives? For example, if you would like to study the impacts of freshwater diversions on water quality in estuaries, you need to make sure that the monitor to collect pre- and post-diversion data is located in a representative area downstream from the diversion structure.

- Is your community supportive of equipment installation for time-series monitoring in the location(s) you selected?

- Does the monitoring equipment at the selected location(s) present a danger to your community? For example, is the location(s) in an area with heavy boat, swimming, or personal water craft traffic?

- Is your monitoring equipment safe at the selected location(s)? For example, is the equipment protected from vandalism, tampering, or weather related damage?

- Are there any local, state, or federal regulations that you need to consider in siting the monitor(s)?

- Is the access to the monitor location(s) adequate?

Siting the Jefferson Parish Monitoring Location

The Jefferson Parish Project team decided to locate the time-relevant monitoring system on an existing structure, an old oil pumping platform, located in Lake Salvador, a key outfall area of the Davis Pond Diversion. Key project members determined that this site met project locality needs during field reconnaissance.

3.1.6 Installing the Time-Series Sampling System

This section discusses some of the basic installation procedures for the sampling system. The detailed installation procedures for the time-series sampling equipment are available from the user's manuals of the individual pieces of equipment. The user's manual for the YSI 6600 sensor package can be downloaded from the Yellow Springs Instruments, Inc. Web site at http://www.ysi.com. The user's manual for the data acquisition system is can be ordered from the Handar (now

Vaisala Inc.) Web site at http://www.vaisala.com. You will need to consult these manuals for detailed step-by-step installation guidance.

Unpacking and Inspecting the Equipment

The first step to install the time-series sampling system is to unpack and inspect the equipment. As soon as you receive the equipment, you should follow the following steps:

1. Remove the packing material surrounding the equipment.
2. Using the enclosed packing slip, perform an inventory of all items. If you are missing any items, contact the manufacturer immediately.
3. Conduct a thorough visual inspection of all items. If you observe any damage, contact the manufacturer and the carrier.

Preparing and Assembling the Equipment

The second step to install the time-series sampling system is to conduct a series of preparation and assembly activities on land and at the sampling location. Complete the following list of preparation and assembly activities:

Installation and preparation on land:

- Calibrate your water quality monitoring sensor according to manufacturer's instructions.

- Install the sampling system base software program on your land-base station computer.

- Ensure your battery to supply power to the sampling system is charged.

Installation at the site:

- Secure Handar unit on the sampling platform.

- Assemble sensor package.

- Install telemetry antennas and correctly point directional antennas.

- Run cables along platform structure and tie cables to the structure with tie-wraps.

- Connect cables (At the lower end of a cable, allow the cable to form a loop with the low point well below the connector on the Handar unit panel. This lets the moisture running down the cable drip to the ground at the low point and keeps it from running into the connectors).

- Assemble the electrical system.

- Connect the Handar unit to the electrical system.
- Connect the sensor package (Connect sensor cables to sensor and data acquisition system).
- Position and connect the solar panel.
- Connect power supply.
- Perform electrical testing to ensure proper operation.
- Initialize data acquisition system.
- Load data acquisition software.
- Test the sensors.
- Set the clock.
- Set start time and interval

3.1.7 Operating the Time-Series Sampling System

This section discusses the basic steps for operating the time-series sampling system. The procedures were summarized from the user's manual for the data acquisition system, which can be ordered from the Handar (now Vaisala Inc.) Web site at http://www.vaisala.com. You will need to refer to this manual, for detailed step-by-step operation guidance.

Viewing and Retrieving Data

In order to examine and collect data from the DAS while it is running in the field, connect your programming set to the DAS and use the *RETRIEVE DATA* command of the ONLINE menu. If you just want to look at the most recent data in memory to see how things are currently going, proceed as follows:

(1) Select *RETRIEVE DATA* command.

(2) Select *ALL DATA STORES*.

(3) To view the most recent items, select *DISPLAY*.

(4) Select either *ALL* data, *LAST MEASUREMENTS*, or *INCLUSIVE PERIOD*, depending on which data you would like to view.

(5) Press *ENTER* for the data to appear on the screen.

Printing Data

If you have a printer connected to your programming set, and you want to have a printed version of the screen display, follow the steps below:

(1) Select *RETRIEVE DATA* command.

(2) Select *ALL DATA STORES*.

(3) To print the most recent items, select *PRINTER*.

(4) Select either *ALL* data, *LAST MEASUREMENTS*, or *INCLUSIVE PERIOD*, depending on which data you would like to print.

(5) Press *ENTER* for the data to print.

Saving Data Files

The procedure for transferring data from the DAS memory to a file on the hard disk or floppy disk in your programming set is nearly the same as for viewing and retrieving data. If you want to save data files, proceed as follows:

(1) Select *RETRIEVE DATA* command.

(2) Select *ALL DATA STORES*.

(3) To save the data, select *DISK*.

(4) Choose either *TEXT* or *BINARY* format

(5) Specify a file name and a path using standard DOS notation to store the data.

Inspecting and Changing Parameters

Parameters are numbers or characters that you provide to control program operation. They include such items as measurement times and intervals to control process schedules, sensor calibration information, and current values and offsets. Initial values of all these items are required during programming, but you can change some of them after loading the program into the data acquisition system. Parameters that you can inspect and change in the data acquisition system are called *field accessible*. To change field accessible parameters, proceed as follows:

(1) Select *ALTER PARAMETERS* in the ONLINE menu.

(2) The screen displays a list of the names of all the field accessible parameters together with their current values. Move the highlight to one you want to change and select it by pressing *ENTER*.

(3) If you see the message *EDITING ACCESS DENIED*, you cannot change the parameter in the present mode of the DAS. Just above this message, there will be a label, for example *ALTERABLE IN STOP MODE ONLY*, that explains the restrictions on the parameter. If the number is displayed, you can change it.

(4) After making your changes, press ENTER and you will see the list of parameters again with the new value for the one you changed. The change will affect all sensors and processes that use that parameter.

3.1.8 Maintaining the Time-Series Sampling System

The scheduled maintenance activities for your time-series sampling system will likely involve cleaning and calibration of your water quality monitoring sensors and replacement of desiccant for the water level sensor. Maintenance frequency is generally governed by the fouling rate of the sensors, and this rate varies by sensor type, hydrologic environment, and season. The performance of temperature and specific conductance sensors tends to be less affected by fouling, whereas the dissolved oxygen, pH, and turbidity sensors are more prone to fouling. The use of wiper or shutter mechanisms on modern turbidity instruments has decreased the fouling problem significantly. For stations with critical data quality objectives, service intervals may be weekly or more often. Monitoring sites with nutrient-enriched waters and moderate to high temperatures may require service intervals as frequently as every third day. In cases of severe environmental fouling, the use of an observer for servicing the water quality monitor should be considered. In addition to fouling problems, physical disruptions (such as recording equipment malfunction, sedimentation, electrical disruption, debris, or vandalism) also may require additional site visits. The service needs of water quality monitoring stations equipped with telemetry can be recognized quickly, and the use of satellite telemetry to verify proper equipment operation is recommended. The USGS Web site (http://water.usgs.gov/pubs/wri/wri004252/#pdf) is a good source for background information on operation and maintenance of near-real time water quality monitoring systems. (The information in this Section is summarized from the USGS document titled "Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Site Selection, Field Operation, Calibration, Record Computation, and Reporting". This document is available from the USGS Web site listed above.)

Jefferson Parish Project Maintenance Activities

Jefferson Parish team services the time-series sampling system at least once per week to conduct routine maintenance activities. In case of physical disruptions (such as recording equipment malfunction, sedimentation, electrical disruption, debris, or vandalism), the Jefferson Parish team conducts additional site visits. Since the Jefferson Parish system is equipped with satellite telemetry, proper equipment operation can be verified at all times allowing quick identification of any service needs of the water quality monitoring station. The following general maintenance functions are conducted on the Jefferson Parish system:

- Daily review of the sensor function by checking the transmitted data
- Weekly inspection of the site for signs of physical disruption
- Weekly inspection of the sensors for fouling, corrosion, or damage
- Weekly change of desiccant used on the "dry" atmospheric side of the differential transducer used for water level measurements
- Check if desiccant for the water level sensor is active (active desiccant is colored blue whereas inactive desiccant is colored pink) and replace it as needed
- Battery/power check
- Routine sensor cleaning and servicing
- Calibration

The Jefferson Parish project team cleans, calibrates, and inspects the monitoring equipment according to detailed instructions provided by the equipment manufactures. The sensors are cleaned carefully and thoroughly to remove algae and any other organisms that foul the sensors. The pH, turbidity, and conductivity sensors are calibrated against known standard solutions. The temperature sensor is generally not calibrated, but the team makes comparisons of the temperature readings by using USGS District-certified thermometers or thermistors. Although field calibration is possible, rough water in Lake Salvador and temperature changes in the field can complicate calibration efforts. Thus, calibration of the dissolved oxygen sensor is conducted in the controlled environment of the USGS laboratory to facilitate the process. The team has two dissolved oxygen sensors, which are being switched between field use and lab calibration on a weekly basis.

The detailed maintenance requirements and procedures for the sampling equipment are available from the user's manuals of the individual pieces of equipment. The user's manual for the YSI 6600 sensor package can be downloaded from the Yellow Springs Instruments, Inc. Web site at http://www.ysi.com. The user's manual for the data acquisition system is can be ordered from the Handar (now Vaisala Inc.) Web site at http://www.vaisala.com.

Figure. 3.6. Picture of the antenna at the LSU Costal Studies Institute taken during the January 9, 2001 site visit.

3.2 Satellite/Remote Sensing Technology

3.2.1 Available Satellite Data

Satellite image data can be used to provide regional maps of the surface or near-surface distribution of physical and biological components/characteristics of water bodies. Data from the NOAA Polar Orbiting Environmental Satellites (POES) can be received directly via antenna, such as is done at the Earth Scan Laboratory, Coastal Studies Institute at LSU. A picture of the antenna used at the LSU Coastal Studies Institute is shown in Figure 3.6 above. The data can be viewed and analyzed close to realtime. The Orbview-2 SeaWiFS (Sea-viewing Wide Field of View Sensor) has a 2-week embargo on research use. A list of SeaWiFS ground stations is provided in Appendix B. The NOAA satellites are equipped with an Advanced Very High Resolution Radiometer (AVHRR). Orbview-2 carries the SeaWiFS ocean color sensor.

Advanced Very High Resolution Radiometer - a broad-band, four or five channel scanner, sensing the visible, near-infrared, and thermal infrared portions of the electromagnetic spectrum. Important functions of the AVHRR include:

- Deriving Sea Surface Temperatures
- Deriving the Normalized Difference Vegetation Index
- Deriving atmospheric aerosols over the oceans
- Monitoring volcanic eruptions and supporting an operational NOAA warning of volcanic ash in the atmosphere during eruption events
- Other applications requiring high temporal resolution of daily coverage, with moderate spectral and spatial resolution, operational stereoscopic coverage, and calibrated thermal sensors.
  [Source: http://www.ngdc.noaa.gov/seg/globsys/avhrr3.shtml]

There are four types of AVHRR data:

- High Resolution Picture Transmission (HRPT)
- Global Area Coverage (GAC)
- Local Area Coverage (LAC)
- Automatic Picture Transmission (APT)

HRPT Data are full resolution (1-km) real time data received directly by ground stations. GAC data are sampled onboard to represent a 4.4-km pixel, stored and played back to a NOAA ground stations in Virginia, Alaska, and Lanion, France. LAC data are 1-km recorded onboard and played back to the NOAA ground stations. APT is an analog derivative of HRPT data transmitted at a lower resolution and high power for low-cost very high frequency (VHF) ground stations. For the Jefferson Parish EMPACT document, LSU receives HRPT data. [Source: http://www.ngdc.noaa.gov/seg/globsys/avhrr3.shtml]

Sea-viewing Wide Field-of-view Sensor - a sensor that provides quantitative data on global bio-optical properties to the Earth science community. Subtle changes in ocean color signify various types and quantities of marine phytoplankton (microscopic marine plants), the knowledge of which has both scientific and practical applications.

The concentration of microscopic marine plants (or phytoplankton) can be derived from satellite observation and quantification of ocean color. This is due to the fact that the color in most of the world's oceans in the visible light region (wavelengths of 400-700 nm) varies with the concentration of chlorophyll and other plant pigments present in the water, i.e., the more phytoplankton present, the greater the concentration of plant pigments and the greener the water.

Since an orbiting sensor can view every square kilometer of cloud-free ocean every 48 hours, satellite-acquired ocean color data constitute a valuable tool for determining the abundance of ocean biota on a global scale. [Source: http://seawifs.gsfc.nasa.gov/SEAWIFS/BACKGROUND/SEAWIFS_BACKGROUND.html]. The SeaWiFS data have an embargo period of at least 14 days and therefore are not available in real time on the Web site [Source: EMPACT 1st Year Report, November 2000, Walker, et al].

The SeaWiFS Project operates a research data system, which gathers, processes, archives, and distributes data received from an ocean color sensor. The data can also be obtained as a "data buy" from a private contractor, Orbital Sciences Corporation (OSC). OSC operates the SeaStar satellite which carries the SeaWiFS sensor. [Source: http://seawifs.gsfc.nasa.gov/SEAWIFS/BACKGROUND/SEAWIFS_970_BROCHURE.html]

3.2.2 Use of Satellite Data - Jefferson Parish Project

The LSU Coastal Studies Institute (CSI) manages the Earth Scan Laboratory (ESL) (http://www.esl.lsu.edu). The ESL is an earth station telemetry site for the capture of NOAA AVHRR, Orbview-2 SeaWiFS and GOES-8 digital satellite image data. The mission of the ESL is to support research, education, and public service/emergency response with near-real time or archived remotely sensed satellite and aircraft data. ESL's mission also includes processing, analysis, interpretation, and dissemination of the remotely sensed data. These satellite data are a valuable asset for environmental management and decision making that involves environmental conditions, such as:

- Monitoring conditions of coastal and estuarine waters, their surface temperature, turbidity (reflectance) levels, and coastal inundation for fisheries management

- Detecting river flooding in local detail for state disaster-related decision makers.
  [Source: http://antares.esl.lsu.edu/htmls/intro.html]

The Jefferson Parish project uses satellite data to monitor regional changes in temperature, reflectance (suspended solids) and chlorophyll *a* in Louisiana lakes, bays, and the coastal ocean adjacent to the Davis Pond diversion project.

3.3 Water Quality Field Sampling

The USGS District Office in Baton Rouge, Louisiana, takes weekly and special event field samples to "surface truth" the remote sensing data and to validate the time-series water quality sampling data. "Surface truthing" satellite data involves measuring reflectance and relating the digital measurements of turbidity and fluorescence to suspended solids and chlorophyll *a* measurements taken from field samples.

3.3.1 Water Quality Field Sampling and Analysis Team

The USGS District Office in Baton Rouge, Louisiana, collects water quality field samples. Jefferson Parish provides a trained environmental technician and the parish's boat to assist the USGS with water sample collection.

LSU-CEI is responsible for analysis of water samples and providing the resulting data in tabular and graphic form. The LSU-CEI lab analyzes the field samples for chlorophyll *a*, nutrients, suspended solids, salinity, and pH and provides graphical summaries of each parameter within one week of laboratory analysis. The chlorophyll *a* and nutrient analyses on water samples are used to surface-truth satellite images. LSU-CEI scientists interpret the water quality and remotely sensed data and post it to a Web site. LSU-CEI provides quarterly reports of all data (with allowances for a one month delay in processing and Quality Assurance and Quality Control) to the project manager at Jefferson Parish. Graphical summaries of each parameter are updated within one week of laboratory analysis, but are subject to subsequent QA/QC procedures. Monthly graphics of key parameters are sent to the EMPACT manager for Jefferson Parish. A tabular summary of samples received, status and completion are maintained as part of a routine chain-of-custody procedure. Data are also presented on an LSU Web page, which will be linked to the Jefferson Parish EMPACT home page.

LUMCO identifies harmful algal species contained in each sample, provides the resulting data in tabular and graphic form, and coordinates with the Louisiana Department of Health and hospitals regarding possible threats to human health.

3.3.2 Sampling Locations and Frequency

Water samples for lab analysis are taken weekly from seven stations in Lake Salvador and Lake Cataouche. (Cataouche is a smaller lake to the north of Salvador. Both lie in the direct flow path of the Davis Pond Diversion.) Collection stations were chosen by Dr. Chris Swarzenski, a scientist with the USGS who has been doing marsh grass research in the area for the past 15 years, to compliment and augment monthly monitoring in the area by others (USACE, Louisiana Department of Natural Resources, United States Park Service, and Turner). The coordinates and a map depicting the location of collection sites is shown in Figure 3.7.

Additionally, samples are taken from the upper Barataria Basin to the Gulf of Mexico during two separate collection dates during the summer months when conditions are most conducive to phytoplankton growth. The relation between surface characteristics from the field samples and satellite data are described in more detail in Section 4.

Figure 3.7. Map and Coordinates (lat/long or UTM) of Water Quality Field Sampling Locations

LC1 (294423, 901254) Southwesterly of platform
LC2 (294549, 901325) West of platform
LC3 (294748, 901405) Northeasterly of No. 2
LC4 (295001, 901426) Northeasterly of No. 3
LC5 (294943, 901207) Easterly of No. 4
LC 6 (294901, 901011) Southeasterly of No. 5 (in channel on east side of Couba Island)
LC 7 (294738, 901043) Northeasterly of platform
LC 8 (294608, 901116) Platform

4. COLLECTING, TRANSFERRING, AND MANAGING TIME-RELEVANT WATER QUALITY DATA

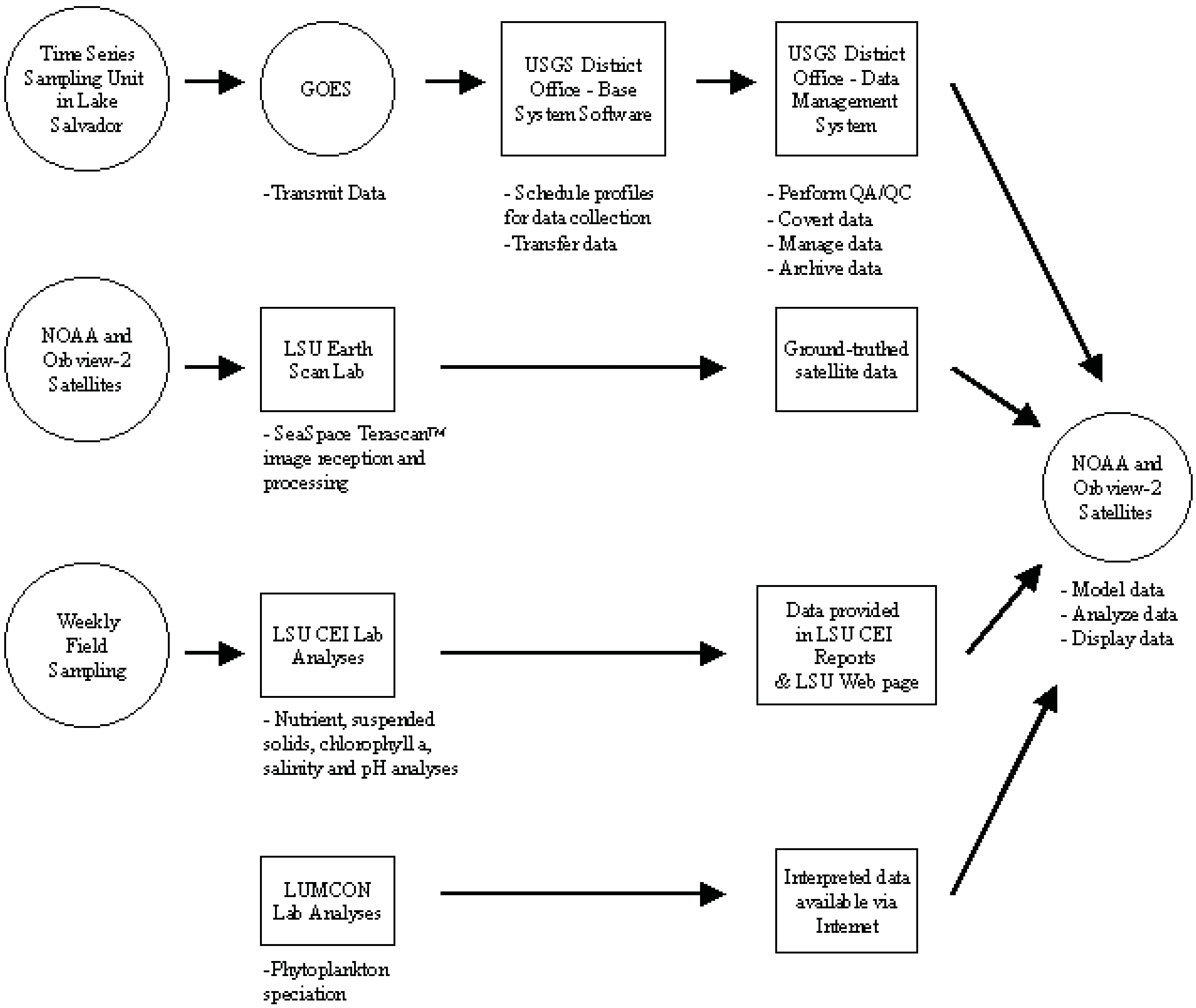
In order to effectively assess water quality and the impacts of water quality management activities, such as river diversions into estuaries, it is necessary to monitor water quality over time (i.e., monitor pre- and post-diversion water quality). The water quality monitoring should take into account water quality parameters important to the local community. Conducting a comprehensive manual sampling program that covers different times of the day, as well as different seasons and seasonal events, presents distinct challenges. As a result, many water quality monitoring programs, such as the Jefferson Parish Project, rely on automated systems, in which water sampling units collect data at programmed intervals and then transmit the data to a land-based station for storage, retrieval, and analysis. In addition, the Jefferson Parish project relies on remote sensing data to monitor water parameters. However, limited field sampling still has to be conducted to "surface truth" the satellite data.

Using the Jefferson Parish Project as a model, this chapter provides you and your community with "how-to" instructions on how to operate and maintain such data collection systems. If you are responsible for or interested in implementing time-series water sampling, you should carefully read the technical information presented in Section 4.2, which discusses setting up and using a sampling station for data collection and transfer, and managing the data at the base station. If you are interested in using remote sensing technology to monitor water quality parameters, you should read the information presented in the Section 4.3. This section provides detailed information on satellite data acquisition, processing, interpretation, ground-truthing, and data transfer and management. Details on water quality field sampling are discussed in Section 4.4, which provides details on sampling, water quality parameter analyses phytoplankton speciation, and data transfer and management. Readers interested in an overview of the system should focus primarily on the introductory information in Section 4.1 below.

4.1 System Overview

The water quality monitoring program for the Jefferson Parish Project uses three types of data: (1) time-series water sampling data; (2) satellite data; and (3) water quality field sampling data. The data are collected and analyzed by four separate entities. Time-series water sampling data and satellite data can be accessed through links from the Jefferson Parish Web site at http://www.jeffparish.net/pages/index.cfm?DocID=1228.

Figure 4.1 System Overview



The field sampling data are available via the Internet at http://its2.ocs.lsu.edu/guests/ceilc/. A schematic of the main components of the data collection, transfer, and management system for the Jefferson Parish project is presented in the figure on the following page.

The time-series water sampling data are collected by an automated system, in which a sampling unit collects hourly data and then transmits the data via GOES to the USGS District Office every four hours for storage, retrieval, and analysis. The sampling unit is located in Lake Salvador, a key outfall area of the Davis Pond Freshwater Diversion Project.

Satellite data collected by NOAA satellites are received and processed using SeaSpace Terascan™ system which operates at the Earth Scan Laboratory, Coastal Studies Institute at LSU. This software package performs calibration, geometric correction, and more specialized processing for the determination of temperature, reflectance (turbidity), and chlorophyll *a* concentrations. Water sampling results are used to "surface truth" satellite reflectance measurements and to relate the digital measurements of turbidity and fluorescence to suspended solids and chlorophyll *a*.

Water quality field sampling is conducted weekly from seven stations in Lake Salvador and Lake Cataouche (a smaller lake north of Lake Salvador) to ground-truth remote sensing data and validate time-series water sampling data. The LSU-CEI analyzes the samples for chlorophyll *a*, nutrients, and suspended solids. The LUMCON provides data on phytoplankton speciation including identification of harmful algal species. The field sampling data are interpreted and made available via the Internet.

4.2 Time-Series Water Quality Sampling

A data collection, transfer, and management system can benefit your community in two ways: It enables you to automate the collection of water quality samples, and it enables you to control the resulting data flexibly and easily. By using the system's software, you can program your time-series water sampling unit to collect water quality data at specified intervals. Then you can call the sampling unit as needed for data transmission or program your system to call for transmissions of data at specified times. Once the data arrive, the information can be formatted and stored or otherwise prepared for export to another database, or it can be analyzed using geographical information system or data visualization software.

The sampling station unit is installed on a platform in the water and programmed to collect water quality data at specified intervals. The sampling unit has a multiprobe water quality sensor manufactured by YSI. This YSI Model 6600 data collection station is equipped with two optical ports for temperature and conductivity measurements plus a pressure and turbidity probe and dissolved oxygen and pH sensors. The data collected by the sampling station unit is transmitted via GOES to the USGS District Office at set time intervals and displayed on the USGS Internet home page. The data is archived as part of the USGS national hydrologic information system and resides in INGRES, a software developed by the USGS. Data security is managed by established USGS procedures.

The land-based station at the USGS District Office is basically a computer equipped with two main parts: (1) the base system software used to create profile schedules of sampling parameters and to communicate with the sampling station unit to transmit schedules and receive sampling data and (2) the database management system used to format, quality check, and store collected data.

The sampling station unit and the base station computer are equipped with communications hardware featuring a satellite radio transmitter. This equipment allows the sampling station unit and computer to "talk" to each other over long distances. Because of this communication ability, the sampling station unit becomes part of a remote data acquisition system controlled from the land-base station. At the base station, an operator runs the sampling station-base software to connect to the sampling station unit for data collection and transfer.

The system's flexibility enables you to establish sampling and data transfer protocols based on your specific monitoring needs. For example, you might program your sampling station unit to sample every hour, 7 days a week, to monitor general trends. You might also want to conduct sampling specific to certain events, such as conditions conducive to algal blooms, during which you might monitor water quality on a 30-minute basis.

The system can collect and store data for future use, or it can retrieve and transmit collected data in near-real time. Each sampling station unit stores collected data in its on-board computer, making the data available for download on demand by the base station. The unit can also serve as a temporary archive by retaining a copy of all transmitted data files. Once the unit runs out of space, it will overwrite data as necessary, beginning with the oldest data.

The remainder of this section provides information on how the data collected by the sampling system are transferred to the base station, how the data are managed, and which troubleshooting and data quality assurance steps are taken. These steps are illustrated using the Jefferson Parish project as an example.

How often should data be collected?

The Jefferson Parish time-series sampling station collects samples on an hourly basis and transmits the data via GOES to the USGS District Office every four hours. The data is then displayed on the USGS Internet home page.

4.2.1 Data Collection Equipment Calibration

USGS members of the Jefferson Parish team perform routine, weekly maintenance and calibration of the sensors with independent equipment. This independent equipment is tested to ensure accuracy and reliability of the field instrumentation. The USGS district office ensures that adequate testing is carried out and the documented results fully characterize the performance and capabilities of the instruments. The USGS Hydrologic Instrumentation Facility (HIF) conducts testing, evaluation, and documentation of instrument performance. USGS districts purchase instruments through HIF when possible. HIF can also perform independent testing for the district offices. The USGS Web site (http://water.usgs.gov/pubs/wri/wri004252/#pdf) is a good source for background information on calibration and data QA/QC of "real-time" water quality monitoring systems. Table 4.1 shows some USGS sensor calibration requirements. USGS recommends that equipment adjustments be made until the equipment meets their recommended calibration criteria. Otherwise, equipment that cannot meet the calibration criterial should be replaced. The information in this Section is summarized from the USGS document titled "Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Site Selection, Field Operation, Calibration, Record Computation, and Reporting" available from the USGS Web site listed above. The USGS guidelines referred to in this document have evolved based on decades of experience with water-quality monitoring.

4.2.2 Transferring Your Collected Data to the Base Station

As a first step, you will need to determine what kind of data communication or telemetry equipment to install on your sampling station unit. Telemetry equipment enables data to be transferred from a sampling station to a receiving station (i.e., the base station). You can choose between a number of telemetry equipment options including cellular telephone modem, a 900 MHz transceiver, and a satellite radio transmitter.

Jefferson Parish Telemetry Equipment

The USGS, a key partner in the Jefferson Parish EMPACT project, uses automated earth-satellite telemetry for the transmission of data via satellite from the time-series sampling system located in lake Salvador. The data are being collected on an hourly basis and transmitted via GOES. Every four hours a data set that consist of eight hours of monitoring data are being transmitted (one redundant data set from the past four hours and one current four hour data set).

Table 4.1. Sensor Calibration and Accuracy Requirements

Sensor	USGS-Recommended Calibration Accuracy	Calibration
Temperature	+/- 0.2°C	Annual 5-point calibration over temperature range of 0-40°C. Three or more 2-point calibration checks per year for thermistors over the maximum and minimum expected temperature range.
Dissolved Oxygen	+/- 0.3 mg/L	Calibration is conducted weekly at 0.0 mg/L and 100% dissolved oxygen saturation.
Specific Conductance	The greater of +/- 5 uS/cm or +/- 3 % of the measured value	Standards bracketing the expected full range are used to calibrate the specific meter to the appropriate units for particular field conditions. The specific conductance standards are available from the USGS Ocala Quality Water Service Unit (QWSU).
pH	` 0.2 pH units	Two standard buffers bracketing the expected range of values are used to calibrate the PH electrode, and a third is used to check for linearity. The pH-7 buffer is used to establish the null point, and the pH-4 or pH-10 buffer is used to establish the slope of the calibration line at the temperature of the solution. The temperatures of the buffers should be as close as possible to the samples being measured. Standard buffers are available from QWSU.
Turbidity	The greater of +/- 5 NTU or +/- 5 % of the measured value	Conduct 3 point calibration at values of 0, 10, and 100 NTU using standards based on either Formazin or approved primary standards, such as styrene divinylbenzene polymer standards.

The access to GOES to transmit information is limited to specified users such as governmental agencies like USGS or the Corps of Engineers. Thus, if you want to use satellite telemetry to transmit your data from the sampling system to the base station, you may want to enter into a cooperative agreement with an organization such as USGS.

The GOES are operated by the NESDIS of NOAA. The GOES Satellite Radio Module consists of a 10-watt transmitter that can be set to any of the allowable 199 domestic GOES and 33 international channels assigned by NESDIS. The normal configuration of GOES consists of the GOES East The normal configuration of GOES consists of the GOES East satellite stationed 21,700 miles above the equator at 75 degrees west longitude and the GOES West satellite is at 135 degrees west longitude.

Data are transmitted by the data acquisition system on an assigned UHF-band frequency in the direction of the GOES. The GOES repeats the message in the S-band, which is received at the NESDIS ground station at Wallops Island, Virginia. The data are then re-broadcast to the DOMSAT satellite, which is a low orbiting communications satellite, and then retrieved on an eight-foot dish at the USGS office in Baton Rouge. A schematic of the data transfer process is shown in Figure 4.2.

4.2.3 Managing Data at the Base Station

This section provides you with background information on managing data at the base station. It discusses the basic data management steps conducted at the base station including processing, QA/QC, distribution, and storage.

The base station software used by USGS is called ILEX, which is a specialized software that was developed specifically for USGS by an outside contractor. The Local Readout Ground Station (LRGS) at the USGS district office in Baton Rouge receives data from all USGS data collection sites. By entering specific site codes, data from specific USGS monitoring sites can be filtered out and kept for processing.

The data received by the LRGS are processed, checked to assure they do not fall outside the range of set thresholds, and distributed. The data are stored/archived as part of the USGS national hydrologic information system and resides in INGRES, a software developed by USGS. Data security is managed by established USGS procedures. USGS is currently coordinating with the EPA to make the archived data available in STORET, a software used by the EPA. The data are displayed near-real time on the USGS Hydrowatch Web site, from where they can be accessed by anyone who has access to the Internet including Federal, State, and local agencies, academia, industry, the public, policy-makers, and managers. Figure 4.3 shows the data transfer to the base station and the basic data management steps taken at the base station.

Data-Processing Procedures

To ensure time-relevant access to the data and to avoid data management problems, the water quality monitoring data should be processed soon after data collection and retrieval. When processing the data, no corrections should be made unless they can be validated or explained with information or observations in the field notes or by comparison to information from other data sources. The USGS data processing procedures consist of six major steps: (1) initial data evaluation, (2) application of corrections and shifts, (3) application and evaluation of cross-section corrections, (4) final data evaluation, (5) record checking, and (6) record review. These processing procedures, which are described in detail in the sections below, are summarized from the USGS document titled "Guidelines and

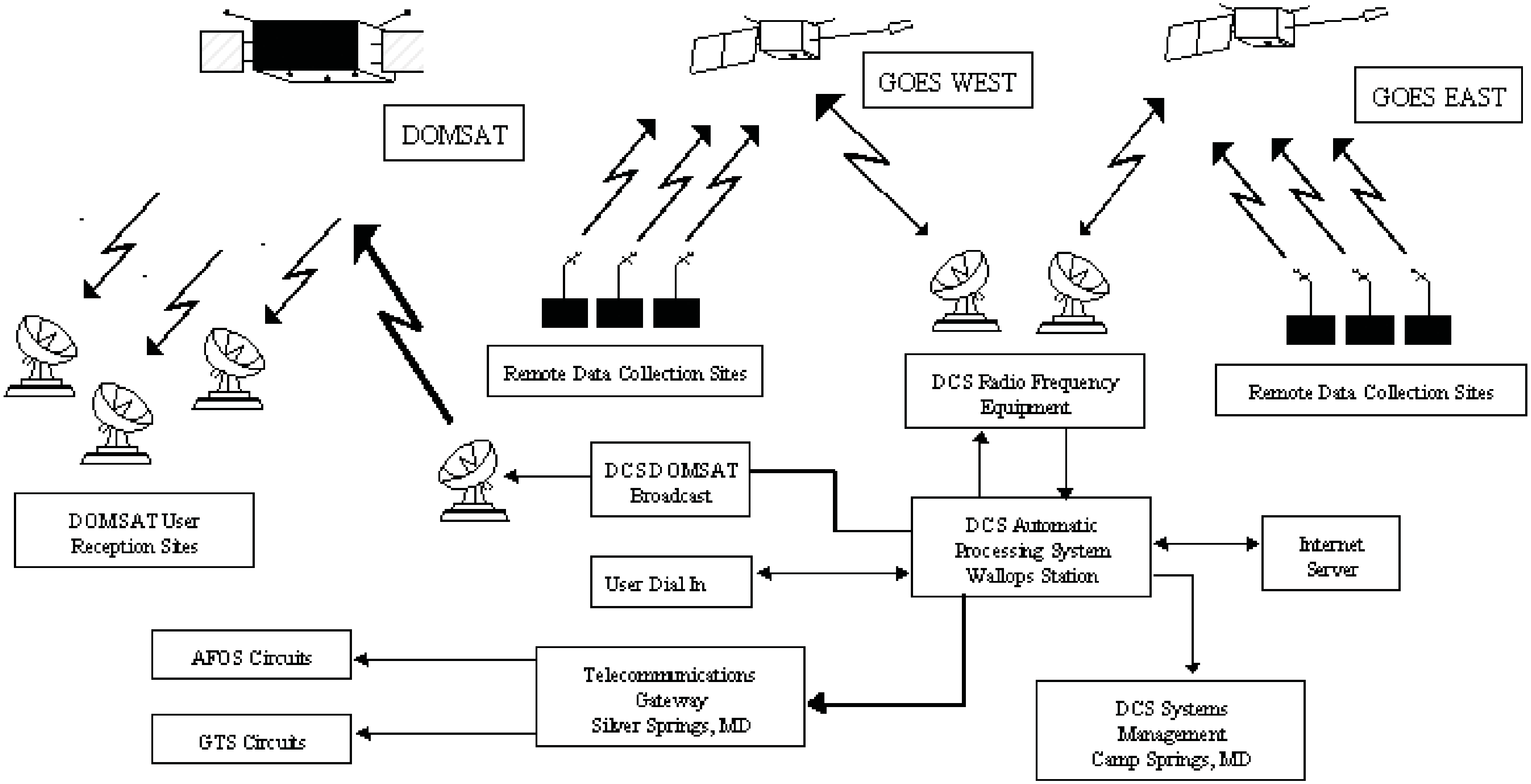
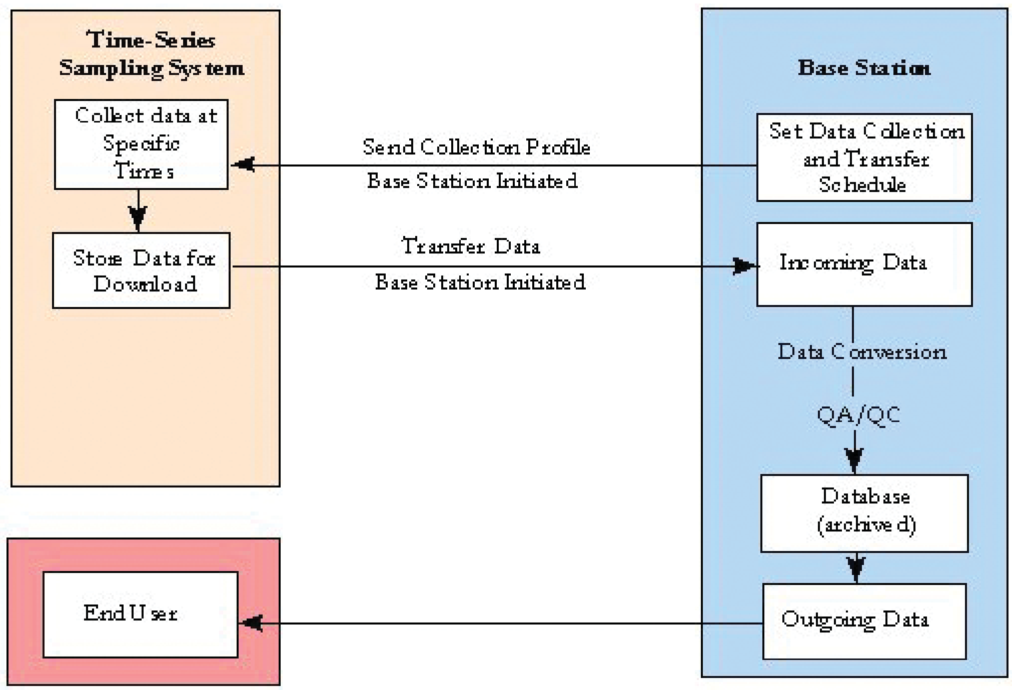


Figure 4.2 Schematic of the GOES DATA Collection System (DCS) and Data Transfer Process
Source: http://www.osd.noaa.gov/sats/dcs/dcs-figure.htm

Figure 4.3. Data Transfer and Management Diagram



Standard Procedures for Continuous Water-Quality Monitors: Site Selection, Field Operation, Calibration, Record Computation, and Reporting" available from the USGS Web site at http://water.usgs.gov/pubs/wri/wri004252/#pdf.

Initial Data Evaluation

In the initial data evaluation step, USGS checks the success of the raw field data transfer to the office database. This provides an opportunity for initial checks to evaluate and correct erroneous data. The raw field data may be stored in a variety of formats, depending on the recording equipment and the means of downloading data from the recording equipment. The conversion of raw data from the sampling system into a standard entry format to the USGS district database, or Automated Data-Processing System (ADAPS), is accomplished by using an on-line computer program, or Device Conversion and Delivery System (DECODES). After entry into ADAPS, primary data tables and plots can be produced for review.

Application of Corrections and Shifts

The application of corrections and shifts allows USGS to adjust data to compensate for errors that occurred during the service interval as a result of environmental or instrumental effects. There are three types of measurement-error corrections: (1) fouling, (2) drift, and (3) cross-section correction. USGS only make corrections to measurements when the type and degree of correction is known. If the deviation between the actual value and sensor reading exceed the criterion for water quality data shifts, as shown in Table 4.2, a correction is required. The correction is a linear interpolation over time between sensor inspections.

Table 4.2. Criteria for Water-Quality Data Shifts

Measured Physical Property	USGS-Recommended Shift Criteria (Apply Shift when Deviation Exceeds this Value)
Temperature	+/- 0.2°C
Dissolved Oxygen	+/- 0.3 mg/L
Specific Conductance	The greater of +/- 5 uS/cm or +/- 3 % of the measured value
pH	` 0.2 pH units
Turbidity	The greater of +/- 5 NTU or +/- 5 % of the measured value

Evaluation and Application of Cross-Section Corrections

Cross-section corrections allow USGS to adjust measurements of the monitoring equipment to reflect conditions more accurately in the entire cross section of the monitoring area (e.g., from bank to bank of the water body that you are monitoring). The application of cross-section corrections is intended to improve the accuracy and representativeness of monitoring measurements. However, USGS only makes cross section corrections, if the variability in the cross section exceeds the shift criteria. Corrections to the cross section are based on field measurements taken both horizontally and vertically in the water body cross section.

Final Data Evaluation

Final data evaluations consist of reviewing the data record, checking shifts, and making any needed final corrections. When completed, USGS verifies the data for publication and rates the data for quality. The data that USGS cannot verify or that are rated as unacceptable are retained for record-checking and review purposes but are not published in ADAPS. However, USGS archives unacceptable or unverified data following established USGS district policies.

Many USGS district offices have established quality-control limits for shifting data, which are commonly referred to as "maximum allowable limits." This means that data are not published, if the recorded values differ from the field-measured values by more than the maximum allowable limits. For the purpose of consistency within the USGS the limits are established at 10 times the calibration criteria for all standard continuous-monitoring data-gathering activities, except for more stringent requirements for DO and turbidity. Table 4.3 below shows the maximum allowable limits for continuous water quality monitoring sensors.

Table 4.3. USGS Recommended Maximum Allowable Limits for Continuous Water-Quality Monitoring Sensors

Measured Physical Property	Maximum Allowable Limits for Water Quality Sensor Values
Temperature	+/- 2.0°C
Dissolved Oxygen	The greater of +/- 2.0 mg/L or 20 %
Specific Conductance	+/- 30 %
pH	□2.0 pH units
Turbidity	+/- 30 %

After evaluating each record for maximum allowable limits, USGS applies one of four accuracy classifications to each measured physical property on a scale ranging from poor to excellent. The accuracy ratings are based on data values recorded before any shifts or corrections are made and depend on how much the recorded values differ from the field-measured values. For more details on the USGS data publication criteria guidelines refer to the USGS document titled "Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Site Selection, Field Operation, Calibration, Record Computation, and Reporting" available from the USGS Web site at http://water.usgs.gov/pubs/wri/wri004252/#pdf.

Record Checking and Record Review

In the record checking process, USGS thoroughly checks all data used in producing the final water quality record for completeness and accuracy before final review and publication. The hydrographer who is responsible for computing the water quality record first reviews the record, followed by a second check for completeness and accuracy by an experienced hydrographer. Finally, the USGS district water quality specialist or district-designated reviewer inspects the water quality record. In addition, all field data are verified for accuracy and transcription from field sheets, all shifts are checked to assure that the correct values are used for a shift, and all dates and numbers in the station manuscript are checked for accuracy.

Near-Real Time Data QA/QC versus Non-Real Time Data QA/QC

Depending on the type of data (near-real time versus non-real time data) you are providing to the public, you can spend different amounts of time and effort on quality control checks. If your goal is to provide near-real time data, there is no time for extensive manual QA/QC checks. On the other hand, if you are providing non-real time data, you have time to perform extensive quality checks, as described in the sections above. Performing quality checks on Jefferson Parish non-real time data can take from a few days to weeks or months, depending on the amount of data streaming into the project's base station.

When you are providing near-real time data, such as the data found on the USGS Hydrowatch Web site, time for QA/QC checks is limited. The checks that can be conducted must either be automated or can only focus on obvious data problems, if they are done manually. The near-real time data undergo two very basic QA/QC steps during the data management process.

The first QA/QC step is done while the data are processed by the DECODES software program at the USGS base station. USGS can enter set thresholds in the DECODES software for each water quality parameter. If the value for any given parameter falls outside the acceptable range entered for that parameter, the data point will be removed. For example, if a pH reading exceeding a pH of 10 is recorded, the data point will be removed because it falls in an unacceptable range for that particular parameter.

The second QA/QC step is taken at the base station when the data are imported into Microsoft Access. At this point, the data undergo a brief manual QA/QC step, at which outliers or obvious erroneous data points are deleted manually from the database.

Storing and Archiving the Data

It is recommended that you store and archive all sample records, raw data, quality control data, and results. A variety of media are available for archiving data (e. g., CD- ROMs, Zip disks, floppy diskettes, and hard copy). The server storing the data should also be backed up daily to prevent data loss.

4.2.4 Troubleshooting

This section contains information about common troubleshooting issues. Table 4.4 below can be used to identify the causes of some common difficulties that may occur while operating the YSI 6600 sensor package. The "symptom" column describes the type of difficulty that you might experience, the "possible cause" column describes the condition that might cause the stated symptom, and the "action" column provides simple steps that can be followed to correct the problem. [Source: The user's manual for the YSI 6600 sensor package, which can be downloaded from the Yellow Springs Instruments, Inc. Web site at http://www.ysi.com

Table 4.4. Common Troubleshooting Issues and Actions

Symptoms	Possible Cause	Action
Dissolved Oxygen reading unstable or inaccurate	Probe not properly calibrated	Follow DO calibration procedures
	Membrane not properly installed or punctured	Follow setup procedure
	DO probe electrodes require cleaning	Follow DO cleaning procedure
	Water in probe connector	Dry connector; reinstall probe
	Algae or other contaminant clinging to probe	Rinse DO probe with clean water
	Barometric pressure is incorrect	Repeat DO calibration procedure
	Calibrated at extreme temperature	Recalibrate at/near sample temperature
	DO charge to high (>100): (1) Anode polarized (tarnished) (2) Probe left on continuously	Enable DO charge parameter in sonde report menu. Run sonde, if charge is over 100, recondition probe. Follow DO cleaning procedure.
	DO charge too low (<25); insufficient electrolyte.	Replace electrolyte and membrane
	DO probe has been damaged	Replace probe
	Internal failure	Return sonde for service
pH, chloride, ammonium, or nitrate readings are unstable or inaccurate. Error messages appear during calibration.	Probe requires cleaning	Follow probe cleaning procedure
	Probe requires calibration	Follow calibration procedures
	pH probe reference junction has dried out from improper storage	Soak probe in tap water or buffer until readings become stable
	Water in probe connector	Dry connector; reinstall probe
	Probe has been damaged	Replace probe
	Calibration solutions out of spec or contaminated	Use new calibration solutions
	Internal failure	Return sonde for service
Level Sensor unstable or inaccurate	Desiccant is spent	Replace desiccant
	Level sensor hole is obstructed	Follow level sensor cleaning procedure
	Level sensor has been damaged	Return sonde for service
	Internal failure	Return sonde for service
Conductivity unstable or inaccurate. Error messages appear during calibration	Conductivity improperly calibrated	Follow recalibration procedure
	Conductivity probe requires cleaning	Follow cleaning procedure
	Conductivity probe damaged	Replace probe
	Calibration solution out of spec or contaminated	Use new calibration solution
	Internal failure	Return sonde for service
	Calibration solution or sample does not cover entire sensor	Immerse sensor fully

Table 4.4. Concluded - Common Troubleshooting Issues and Actions

Symptoms	Possible Cause	Action
Installed probe has no reading	Sensor has been disabled	Enable sensor
	Water in probe connector	Dry connector; reinstall probe
	Probe has been damaged	Replace probe
	Report output improperly set	Set up report output
	Internal failure	Return sonde for service
Temperature unstable or inaccurate	Water in connector	Dry connector; reinstall probe
	Probe has been damaged	Replace probe
Turbidity probe unstable or inaccurate. Error messages appear during calibration	Probe requires cleaning	Follow probe cleaning procedure
	Probe requires calibration	Follow calibration procedure
	Probe has been damaged	Replace probe
	Water in probe connector	Dry connector; reinstall probe
	Calibration solutions out of spec	Use new calibration solutions
	Wiper is not turning or is not synchronized	Activate wiper. Assure rotation. Make sure set screw is tight.
	Wiper is fouled or damaged	Clean or replace wiper
	Internal failure	Return probe for service

4.3 Satellite/Remote Sensing Technology

4.3.1 Data Acquisition

As mentioned earlier, LSU receives two different satellite data streams; NOAA AVHRR and Orbview-2 SeaWiFS. AVHRR satellite data are available to anyone who has the capability to receive it. NOAA does not charge any fee for an entity to establish and operate a station to receive AVHRR data nor does NOAA require station operators to make themselves known to NOAA. However, NOAA recommends that operators subscribe to NOAA's mail outs and make use of its on-line bulletin board. NOAA maintains an office to support potential operators of HRPT at the following address:

Coordinator, Direct Readout Services
NOAA/NESDIS
Washington, DC 20233

HRPT ground stations can be constructed using commercial equipment for under $100,000. However, some radio amateurs have constructed systems for $100s using personal computers, surplus antennas, and circuit boards.
[Source: http://www.ngdc.noaa.gov/seg/globsys/avhrr3.shtml]

If your project is not considered "research," the SeaWiFS data can be purchased from Orbimage, since they own the commercial rights to SeaWiFS. Note that Orbimage refers to SeaWiFS data as OrbView-2. If your project is considered research, you may apply to become a NASA-Authorized SeaWiFS user. To become an Authorized SeaWiFS data user, you must read the *SeaWiFS Dear Colleague Letter* and *Appendices* to gain an understanding of the terms of the user agreement. The applicant must then submit a short proposal, which includes the title of the project, a scientific rationale for the request, the processing level of the data required, and plans for the publication/dissemination of the results or data access. The applicant must print, sign, and complete a hard copy of the *Research Data Use Terms and Conditions Agreement*. The applicant must mail the proposal and original hard copy of the form to:

Dr. Charles R. McClain
SeaWiFS Project
NASA/GSFC Code 970.2
Building 28, Room W108
Greenbelt, MD 20771

Additional procedures for requesting data should be followed if the applicant desires to become an authorized SeaWiFS Direct Readout Ground Station or an authorized SeaWiFS Temporary Real-Time User or Station. There are not any specific deadlines for receipt of proposals to obtain SeaWiFS data. [Source: http://seawifs.gsfc.nasa.gov/SEAWIFS/ LICENSE/checklist.html]

Once approved as an authorized user, you can receive data for free from the Goddard Distributed Active Archive Center (DAAC) after the data is at least two weeks old. If your project is considered research and your organization wants to receive HRPT SeaWiFS data, you can apply to become an authorized SeaWiFS Ground Station. Current SeaWiFS users who want to get data in real-time from an existing SeaWiFS Ground Station, can apply to become an authorized SeaWiFS Temporary Real-Time User. [Source: http://seawifs.gsfc.nasa.gov./SEAWIFS/ ANNOUNCEMENTS/getting_data.html]

LSU is an authorized SeaWiFS Direct Readout Ground Station and has applied for and received authorization to become a Temporary Real-Time User Station. However, since the data must be held for two weeks prior to publication, the SeaWiFS data are not placed on the LSU Web site.

If a new user wants a turnkey operation to obtain SeaWiFS data, SeaSpace TeraScan SeaWiFS systems can be purchased. [Note that you must still obtain a decryption device and decryption key from NASA to read the data.] The TeraScan SeaWiFS system can be configured to support land-based, shipboard, or portable applications and is comprised of the following components:

- Polar Orbiting Tracking Antenna (1.2 m and 1.5 m)
- Global Positioning System (GPS) Antenna/Receiver
- Telemetry Receiver
- SGP Interface Unit (SGPI)
- Workstation
- Uninterruptible Power Supply (UPS)
- TeraScan Software

The specifications for the TeraScan SeaWiFS system are described below.

Antenna

Specifications	1.2 m Antenna	1.5 m Antenna
Reflector Diameter	1.2 m (4 ft)	1.5 m (5 ft)
Input Frequency	1691 - 1714 MHz	1691 - 1714 MHz
Acquisition Elevation	8 degrees	5 degrees
LNA Gain	30 dB minimum LNA Gain	30 dB minimum LNA Gain
LNA Noise Figure	<0.8 dB	<0.8 dB
Input Bandwidth	15 MHz	15 MHz
Downconverter Gain	22 dB minimum	22 dB minimum
Elevation Range	0 to 90 degrees	0 to 180 degrees
Azimuth Range	± 265 degrees	± 265 degrees
Elevation/Azimuth Tracking Rate	6 degrees per second	6 degrees per second
Position Accuracy	0.5 degrees	0.5 degrees
Temperature Range	-30°C (-22°F) - without heater to 70°C (158°F)	-30°C (-22°F) - without heater to 60°C (140°F)
Humidity	0 to 100%	0 to 100%
Maximum Wind Force	161 km/hr (100 mph)	161 km/hr (100 mph)
Radome Dimension	1.55 m (61") diameter by 1.67 m (65.90") high	1.88 m (73.88") diameter by 1.82 m (71.94") high
Antenna/Radome Weight	95 kg (210 lbs)	131 kg (290 lbs)
Antenna Shipping Weight	227 kg (500 lbs)	273 kg (600 lbs)

GPS

- Satellites tracked: 8
- Satellites used in a solution: 4
- Positional Accuracy: ±100 m (330 ft)
- System Time Accuracy: ± 0.1 second

Receiver

- Model: HR-250
- IF input frequency range: 128 - 145 MHz
- Demodulator Type: PSK-PLL

- IF input frequency range: 128 - 145 MHz
- Demodulator Type: PSK-PLL
- Bit rate: 665.4 Kbps
- Bit error rate: Within 1 db of theoretical
- Programmable IF input frequency selection

Workstation

- Type: Sun ULTRA-10
- Processor: 440 MHz
- Memory: 128 MB RAM
- Internal Hard Drive Capacity: 18 GB
- Internal CD-ROM Capacity: 644 MB
- Monitor Size: 21"
- Display Resolution: 1280 x 1024 x 24 bit
- LAN Types: 10/100 BaseT
- External DAT 4 mm Tape Storage: 24 GB compressed
- Modem: 56 Kbps
- Operating System: Solaris 7
- Keyboard and mouse
- PCI Frame Synchronizer
- PCI SCSI Controller
- PCI Serial Multiplexer

UPS

- Output Power Capacity 1400 VA
- Dimensions: 0.18 m (7") W x 0.23 m (9") H x 0.42 m (18") D

Options

- Antenna Pedestal
- Antenna Heater
- Color Printer
- 100 m (330 ft) Antenna Control and Signal Cable

For more information about the TeraScan SeaWiFS system refer to their Web site, the source of this information, at http://www.seaspace.com/ main product_line/seawifs/seawifs.html.

4.3.2 Data Processing

Acquisition and processing of the satellite data are performed using the SeaSpace TeraScan™ image reception and processing system operated at the LSU Earth Scan Laboratory (http://www.esl.lsu.edu). This software performs calibration, geometric correction, and additional specialized processing for the determination of temperature, reflectance (turbidity), and chlorophyll *a*.

AVHRR - Dr. Nan Walker and Adele Hammack (LSU-CSI) view satellite imagery from the NOAA satellites daily (at least 8 times per day) and processes these images with specialized software to produce color-enhanced imagery of water temperature and turbidity (reflectance). At the end of each month, Dr. Walker provides a written description of the more interesting images taken during the month to assist the public in interpreting the turbidity and temperature changes that are visible in the satellite images.

For the EMPACT project, sea surface temperatures (SST) are computed, in either Celsius or Fahrenheit, with NOAA AVHRR satellite data using a modification of the MCSST technique described by McClain et al (1985). Surface reflectance is computed in percent albedo with NOAA AVHRR satellite data using a modification (Walker and Hammack, 2000) of the Stumpf atmospheric correction technique (1992). The technique corrects for incoming solar irradiance, aerosols, sunlight and Rayleigh scattering.

Dr. Walker uses a commercial software package suite called TeraScan™, which is produced by SeaSpace. You can find SeaSpace's Web site at http://www.seaspace.com. The TeraScan™ software suite includes software for data acquisition and scheduling called TeraCapCon and TeraTrack. TeraMaster & TeraPGS are used for product generation. TeraVision is used for developing images to visualize satellite data. TeraPGS is used to distribute data images according to user specifications. The image processing of temperature and reflectance is a multi-step process and is outlined below.

- Calibrate visible and thermal infrared data from count values to science units.
- Screen the data for image quality.
- Calculate temperatures and reflectances.
- Navigation/registration images to project on a rectangular map.
- Scale temperatures and reflectances.
- Produce GIF images of temperatures and reflectances.
- Post images on LSU Web site (http://www.esl.lsu.edu/research/empact.html).

[Source: EMPACT 1st Year Report, Satellite Remote Sensing of Surface Water Temperature, Surface Reflectance, and Chlorophyll a Concentrations: Southeastern Louisiana, Nan D. Walker, Adele Hammack, and Soe Myint, November 2000.]

SeaWiFS - The Orbview-2 satellite broadcasts SeaWiFS data in real time to the GSFC HRPT Station as well as other stations. LSU receives the SeaWiFS data in real-time via their satellite. LSU uses the SeaSpace TeraScan™ software suite to process (calibrate and atmospherically correct) and visualize the SeaWiFS data. The software is based upon the SeaDAS software used by NASA. The NASA OC2 algorithm is used to estimate chlorophyll *a* concentrations with the 490 and 555 nm bands (O'Reilly et al., 1998).

[Source: EMPACT 1st Year Report, Satellite Remote Sensing of Surface Water Temperature, Surface Reflectance, and Chlorophyll a Concentrations: Southeastern Louisiana, Nan D. Walker, Adele Hammack, and Soe Myint, November 2000.]

4.3.3 Data Interpretation

Wind measurements from monitoring stations are used to interpret the image patterns and to write the monthly text that is provided on the LSU Web site. The hourly time-series measurements at the Lake Salvador monitoring station are obtained from the USGS and used to interpret the satellite data.

[Source: EMPACT 1st Year Report, Satellite Remote Sensing of Surface Water Temperature, Surface Reflectance, and Chlorophyll a Concentrations: Southeastern Louisiana, Nan D. Walker, Adele Hammack, and Soe Myint, November 2000.]

4.3.4 Ground Truthing

Ground truthing is a process of comparing and correlating satellite data to actual field measurements. Ground truthing of sea temperatures in the Jefferson Parish project showed very similar results when comparing satellite and field measurements of surface sea temperatures taken at the eight sampling points shown in Figure 3.7. The linear regression of the temperature data-sets using 173 data points show a strong statistical linear correlation with an R^2 of 0.951. However, the satellite reflectance values, when compared to YSI turbidity field measurements, were not very similar (R^2 = 0.43). The differences are thought to result from several factors. For example, the satellite reflectance measurements were made at 580-680 nm and are related to light reflected from near the water surface by suspended material in the water column. The YSI probe measures backscatter from particles suspended in the water column (4 feet below the surface) in the 830-890 nm region. Other factors, which affect the satellite reflectances and YSI backscatter results, include the concentration of inorganic and organic material, type of inorganic sediment (clay, silt, and sand), and additional pigments (e.g., from other chlorophyll and colored dissolved organic matter).

[Source: EMPACT 1st Year Report, Satellite Remote Sensing of Surface Water Temperature, Surface Reflectance, and Chlorophyll a Concentrations: Southeastern Louisiana, Nan D. Walker, Adele Hammack, and Soe Myint, November 2000.]

The mapping of chlorophyll *a* with SeaWiFS in coastal regions requires extensive collection of water samples to validate the technique and develop regional algorithms if necessary. The SeaWiFS radiance data is collected in 6 visible channels which can be used to map suspended solids, suspended sediments and chlorophyll *a*. On April 26, 2000, a SeaWiFS ground truth experiment was conducted in Barataria Bay and the coastal ocean, seaward of the bay. The satellite-derived chlorophyll *a* estimates using SeaWiFS were very similar to the chlorophyll *a* concentrations of the field samples.

A cubic regression model yielded the best relationships between field and satellite data, with a an R^2 of 0.92. However, the correlation was not as strong for chlorophyll values measured in Lakes Cataouche and Salvador, probably due to higher concentration of colored dissolved organic matter.

Turbidity was estimated from two SeaWiFS channels (555 nm and 670 nm). Regression analysis revealed that the 670 nm channel yielded the highest statistical relationship between the satellite and field measurements. (R^2 of 0.84 - nonlinear power relationship).

[Source: EMPACT 1st Year Report, Satellite Remote Sensing of Surface Water Temperature, Surface Reflectance, and Chlorophyll a Concentrations: Southeastern Louisiana, Nan D. Walker, Adele Hammack, and Soe Myint, November 2000.]

4.3.5 Data Transfer

As discussed earlier, the LSU ESL receives the NOAA AVHRR and SeaWiFS satellite data. Through a sequence of processing steps computations are made of surface temperature, surface reflecance and chlorphyll a. GIF images are posted on the LSU Web site in quasi real-time.

The GSFC EOS DAAC is responsible for the distribution of SeaWiFS data to all approved SeaWiFS data users.

4.3.6 Data Management

The NOAA AVHRR temperature and reflective imagery is provided on the LSU Web site usually the same day the data are received (i.e., almost real-time). Dr. Walker provides interpretive text with the imagery to assist the public in understanding the image pattern.

The GSFC EOS DAAC is responsible for permanently archiving and distributing the SeaWiFS data. LSU processes the SeaWiFS data as they are received; however because the data have a 14 day embargo period, they are not available in real-time nor are they posted on the LSU Web site.

4.4 Water Quality Field Sampling

Water samples for lab analysis are taken weekly from eight stations in Lake Salvador and Lake Cataouche. (Cataouche is a smaller lake to the north of Salvador (Figure 3.7). Both lie in the direct flow path of the Davis Pond Diversion.). Collection stations were chosen by Dr. Chris Swarzenski, a scientist with USGS, who has been doing marsh grass research in the area for the past 15 years to compliment and augment monthly monitoring in the area by others (USACE, Louisiana Department of Natural Resources, United States Park Service, and Turner).

Additionally samples are taken from the upper Barataria Basin to the Gulf of Mexico during two separate collection dates during the summer months when conditions are most conducive to phytoplankton growth. These weekly and special event samples are to "surface truth" the satellite reflectance measurements and to relate the digital measurements of turbidity and fluorescence to suspended solids and chlorophyll *a*. These water samples provide baseline information on variations in water quality in the study region before the opening of the Davis Pond Diversion.

4.4.1 Water Quality Analyses

The LSU-CEI laboratory analyzes the field water samples for the following parameters: (1) water salinity; (2) pigments (chlorophyll *a* and phaeophytin a); (3) suspended load (sediment and organic); (4) carbon (total, inorganic, and total organic carbon); and (5) nutrients (Ammonium, Nitrate, Nitrite, Phosphate, and Silicate). The analytical techniques used to conduct the water quality analyses are described below.

Salinity/Conductivity

Salinity or conductivity of each sample is measured upon return to the laboratory using a Haake-Buchler Digital Chloridimeter® [http://www.analyticon.com/manurefy.html]. This device measures the amount of chloride in the sample by titrating it with silver. Salinity measurements are necessary to interpret the circulation and bulk impacts of the freshwater diversion.

pH

A Corning Model pH-30 waterproof pH meter is used to measure pH of the samples upon return to the laboratory [http://www.scienceproducts.corning.com]. The pH measurements are necessary to convert the total carbon dioxide measurements to alkalinity.

Chlorophyl *a* and Pheo-Pigments

Chlorophyll *a* containing plankton are concentrated from a volume of water by filtering at a low vacuum through a glass fiber filter (GFF). The pigments are extracted from the phytoplankton using a solution of 60% Acetone and 40% dimethyl sulfoxide (DMSO). The samples are allowed to steep for 2 to 24 hours (maximum) to extract the chlorophyll *a*. The samples are then centrifuged to clarify the solution. The fluorescence is then measured before and after acidification with 0.1 N HCl. The fluorescence readings are then used to calculate the concentration (in µg/l) of chlorophyll *a* and pheophytin *a* in the sample extract. This procedure is a modification of EPA method 445.0 (Arar and Collins 1992) in which DMSO is used in lieu of grinding for extraction of the pigments.

Suspended Load

The suspended load is determined by filtering a known volume of water through a combusted (550 C) and pre-weighed glass fiber filter (Whatman Type GF/F or equivalent). The filters are dried (at 60 C) then re-weighed to determine total suspended load in mg/l. The filters are then combusted at 550 C, cooled, then re-weighed to determine organic suspended load (APHA, 1992). The sediment or non-organic suspended load is determined by subtracting the organic suspended load from the total suspended load.

Carbon

Total carbon (TC) is measured by employing High Temperature Catalytic Oxidation (HTCO) using a Shimadzu® TOC-5000A analyzer [http://www.ssi.shimadzu.com]. The machine operates by combusting the water sample (at 680 centigrade) in a combustion tube filled with a platinum-alumina catalyst. The carbon in the sample is combusted to CO_2, which is detected by a non-dispersive infrared gas analyzer (NDIR) that measures the total amount of carbon in the sample. Inorganic carbon (IC) is analyzed by first treating the sample with phosphoric acid (to remove organic carbon) and then performing the above analysis to obtain the total amount if inorganic carbon in the sample. Total organic carbon (TOC) is obtained by subtracting the IC value from the TC value.

Nutrients

The water samples are analyzed for nutrients with a Technicon Auto-Analyzer II [http://www.labequip.com] using the methods listed in Table 4.5 for each nutrient:

Table 4.5. Methods and Detection Limits for Nutrient Analyses

Nutrient Limit	Method	Detection
Nitrate-Nitrite	EPA Method 353.2	0.05 mg/l
Nitrite	EPA Method 353.2	0.05 mg/l
Ammonia	EPA Method 350.1	0.01 mg/l
Silicate	Technicon Method 186-72W/B	0.03 mg/l
Phosphorus	EPA Method 365.2	0.01 mg/l

4.4.2 Phytoplankton Identification

Water samples are also sent to Louisiana University Marine Observatory Consortium (LUMCON) where the harmful algal species present in the sample are identified by Dr. Quay Dortch. The Gulf of Mexico Program is currently providing funds to support this research.

Prior experience in counting phytoplankton in Louisiana coastal waters shows that the phytoplankton range in size from 1 µ to greater than 100 µ with the tiny phytoplankton often dominating the biomass. Traditional methods of counting phytoplankton have missed or underestimated these small phytoplankton, whereas the more recently developed epifluroescence methods can be used to count both small and large phytoplankton. Table 4.6 shows common phytoplankton groups counted in each size fraction. Methods other than the epifluroescence method, such as differential interference contrast (DIC) or scanning electron microscope (SEM), can also be used for identification when necessary.

The method for preserving and counting phytoplankton is adapted from Murphy and Haugen (1985), Shapiro and Haugen (1988), and Shapiro et al. (1989). In this method, one hundred milliliters of seawater are preserved with 50% glutaraldehyde to a final concentration of 0.5% (by volume) and refrigerated until samples are processed. One aliquot of sample is filtered through a 3 µm polycarbonate filter and onto a 0.2 µm polycarbonate filter without prior staining. The 3 µm filter is discarded and the 0.2 µm filter retained (0.2 to 3 µm size fraction). Another aliquot of sample is filtered through an 8 µm polycarbonate filter and then a 3 µm filter; both filters are retained (3 to 8 and >8 µm size fractions). Before filtration this aliquot is made up to 25 ml with filtered water of approximately the same salinity and stained with 0.05 ml proflavine monohydrochloride (Sigma P-4646, 1.5 g/liter in distilled, deionized water). If possible, all samples are filtered without vacuum, but if necessary, <100 mm vacuum is applied. All filters are transferred to slides and mounted with low fluorescence, low RFA

Table 4.6. Common Phytoplankton Groups Counted in each Size Fraction

Size	Phytoplankton Groups
0.2-3 µm	Coccoid cyanobacteria -- mostly Synechococcus Autotrophic eukaryotes Heterotrophic eukaryotes
3-8 µm	Photosynthetic flagellates and non-flagellates Heterotrophic flagellates and non-flagellates Cryptomonads Athecate dinoflagellates Diatoms Coccoid cyanobacteria
> 8 µm Diatoms	Dinoflagellates Ciliates Cryptomonads Colonial cyanobacteria Colonial, freshwater chlorophytes Coccoid cyanobacteria [1]

Many coccoid cyanobacteria occur in aggregates, especially when suspended particulate matter concentrations are high, which do not break up during size fractionation.

epi-fluorescence microscope [http://www.olympus.co.jp] with blue and green excitation (excitation filters BP-490 and BP-545, barrier filters O-515 and O-590, and dichromatic mirrors DM500 and DM580, respectively). The 0.2 and 3 µm pore size filters are counted immediately at 1000x. The 8 µm pore size filters are stored frozen and counted as soon as possible. Three different counts are made on the 8 µm filters, using different magnification and counting different areas of the filter, in order to adequately count small, abundant organisms, as well as large, rarer organisms. To avoid counting an organism more than once they are separated according to length. Phytoplankton is identified to the nearest possible taxon and the previous table describes the types of organisms usually observed in each size fraction. It is possible for some groupings of taxa and even individual species, to be present in more than one size fraction, if the size of colonies or individuals varies considerably or if they occurred both singly and in aggregates of sediment, organic matter and cells. The 0.2 and 3 µm filters are discarded after counting, because they quickly become uncountable; 8 µm filters are archived frozen at Louisiana Universities Marine Consortium.

4.4.3 Data Transfer and Management

The personnel collecting the water samples complete a field documentation form, of which one copy is kept on file by Jefferson Parish and one copy accompanies the samples to the lab. These water samples are delivered to the LSU-CEI laboratory within 6 hours of collection and are stored on ice or in a refrigerator until analyzed for corruptible analytes. The LSU-CEI laboratory has existing QA/QC plan approved under EPA project X-9996097-01. The processing for Chlorophyll *a* begins within 12 hours of sample delivery, and usually within 1 hour. The dissolved nutrient samples are stored frozen until analysis, usually within 2-4 weeks (sample analysis is more economical if done in batches of >50 samples).

Sub-samples of the water samples are sent to LUMCON immediately after sample collection for identification of harmful algal species. The Gulf of Mexico Program is currently providing funds to support this research. Project funds are used to interpret this data set and make it available to the public via the Internet; interpretive text is written or reviewed by Dr. Dortch.

LSU-CEI provides quarterly reports of all data (with allowances for a one month delay in processing and QA and QC) to the project manager at Jefferson Parish. Graphical summaries of each parameter, averaged for each lake, are updated within one week of laboratory analysis, but are subject to subsequent QA/QC procedures. Monthly graphics of key parameters are sent to the EMPACT manager for Jefferson Parish. A tabular summary of samples received, status and completion are maintained as part of a routine chain-of-custody procedure. Data are also presented on an LSU Web page linked to the Jefferson Parish EMPACT home page.

Jefferson Parish disseminates the monthly graphics of key parameters to the Jefferson Parish Marine Fisheries Advisory Board, the Davis Pond Freshwater Diversion Advisory Committee, Louisiana Department of Health and Hospitals and other stakeholders as requested, for their review and feedback.

Plots of the weekly field water sampling data from August 19, 1999 through August 17, 2000 are available on the LSU-CEI Web site at http://its.ocs.lsu.edu/guests/ceilc/.

The EPA is in the planning stages to make such data available through their EMPACT website [http://www.epa.gov/empact]. Currently, the EMPACT website has a link to the Jefferson Parish website.

5. PRESENTING WATER QUALITY MONITORING DATA

Once your water quality monitoring network is in place and you have collected or received the resulting data, you can provide your community with time-relevant water quality information using data visualization tools to graphically depict this information. Using data visualization tools, you can create graphical representations of water quality data that can be downloaded on Web sites and/or included in reports and educational/outreach materials for the community. The types of data visualization software used by the Jefferson Parish EMPACT team are Microsoft Excel and SeaSpace's TeraScan™ satellite imagery software.

Section 5.1 provides a basic introduction and overview to data visualization and is useful if you are interested in gaining a general understanding of data visualization. **Section 5.2** contains an introduction to the software data visualization tools used on the Jefferson Parish EMPACT project. You should consult **Section 5.2** if you are responsible for choosing and using data visualization software to model and analyze your data.

5.1 What is Data Visualization?

Data visualization is the process of converting raw data to images or graphs so that the data are easier to comprehend and understand. A common example of data visualization can be seen when you watch the weather report on television. The electronic pictures of cloud cover over an area or the location and path of an impending hurricane are examples of satellite data that have been visualized with computer software. Displaying data visually enables you to communicate results to a broader audience, such as residents in your community. A variety of software tools can be used to convert data to images. Such tools range from standard spreadsheet and statistical software to more advanced analytical tools such as:

- Satellite imaging software products
- Geographic Information Systems (GIS)
- Computer Models
- Statistical techniques

By applying such tools to water quality data, you can help residents in your community gain a better understanding of factors affecting the water quality in area lakes or nearby estuaries (e.g., chlorophyll *a* or turbidity). Once you begin using satellite data visualization tools, you will be impressed with their ability to model and analyze your data. You can then use the visualized data for a variety of purposes such as:

- Exploring trends in lake elevation, chlorophyll concentration, pH, dissolved oxygen concentration, salinity, specific conductance, turbidity, and water temperature.
- Studying spatial patterns of sea-surface temperature.
- Studying spatial patterns of near-surface reflectance.
- Making resource management decisions.
- Supporting public outreach and education programs.

There are a number of commercially available data visualization tools that allow you to graphically represent real-time satellite data. Section 5.2 focuses on the software tools which were used to visualize the satellite data in the Jefferson Parish EMPACT project. These software tools are listed in Table 5.1 below.

Table 5.1. Software Tools to Visualize Satellite Data

Tool Group	Tools	Primary Uses
SeaSpace's TeraScan™ Software Suite http://www.seaspace.com	TeraCapCon	Enables the user to program the system for automatic capture, archiving, and processing of the satellite data.
	TeraTrack	Reports the information related to a satellite pass capture; reports information that can be used for diagnosing reception problems; insures quality control performance.
	TeraMaster	Views, creates, or modifies a data set that defines an area of the earth's surface in terms of map projection (shape), extends, and pixel resolution.
	TeraScan™ Product Generation System (TeraPGS)	Automatically generates and distributes products according to user specifications.
	TeraVision	Displays and manipulates data images and overlays.
Database and Spreadsheet Software	Microsoft Access Microsoft Excel	Displays raw data (parameters) from Lake Salvador in tables. Creates 1- to 7-day summary hydrographs of various Lake Salvador data. Allows to Investigate correlations or trends in water quality variables.

Many computer users are familiar with Microsoft Access (a database software) and Excel (a spreadsheet software). For this reason, the remainder of this chapter will only focus on the satellite imagery software.

5.2 Satellite Acquisition, Processing, and Visualization Software

There are various vendors which offer satellite data visualization software. The USGS also posts visualized satellite data on their Web site. This section discusses only the satellite data acquisition, processing, and visualization software used for the Jefferson Parish EMPACT project.

As mentioned earlier, the Jefferson Parish Project utilized the SeaSpace's TeraScan™ software suite. This software can be used to acquire, process, visualize and disseminate the AVHRR and SeaWiFS satellite data. Provided below is a description of the TeraScan™ software suite. More information about this software can be found on SeaSpace's Web site (**http://www.seaspace.com**).

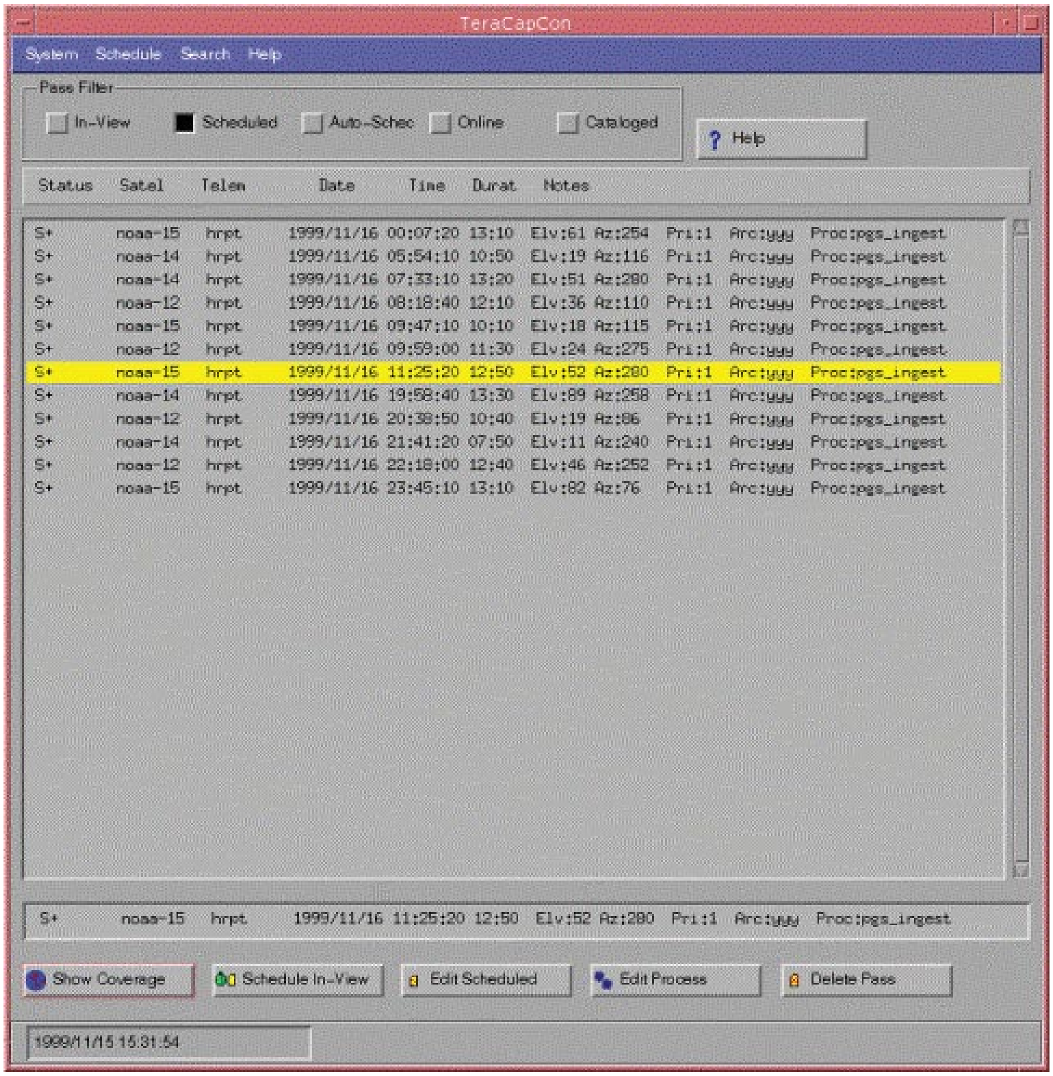
TeraCapCon

TeraCapCon is the graphical user interface (GUI) that provides automatic, "hands-off" scheduling and archiving of satellite data. With TeraCapCon, the user can define the autoscheduling parameters that govern the daily acquisition (or capture) of the satellite data. Such parameters include the following:

- Which satellites to select for data collection,
- The minimum satellite elevation at the satellite's highest point relative to the receiver,
- The minimum sun elevation,
- The time of day when the data are to be collected,
- The number of days of passes to be obtained,
- Whether or not the data should be archived on tape,
- Specify which processing script to run on the data.

These autoscheduling parameters can be easily edited. In addition, the user can view the upcoming swath of the pass from a polar orbiting satellite. Figure 5.1 is a screen shot from the TeraCapCon software.

Figure 5.1. TeraCapCon Screen Shot

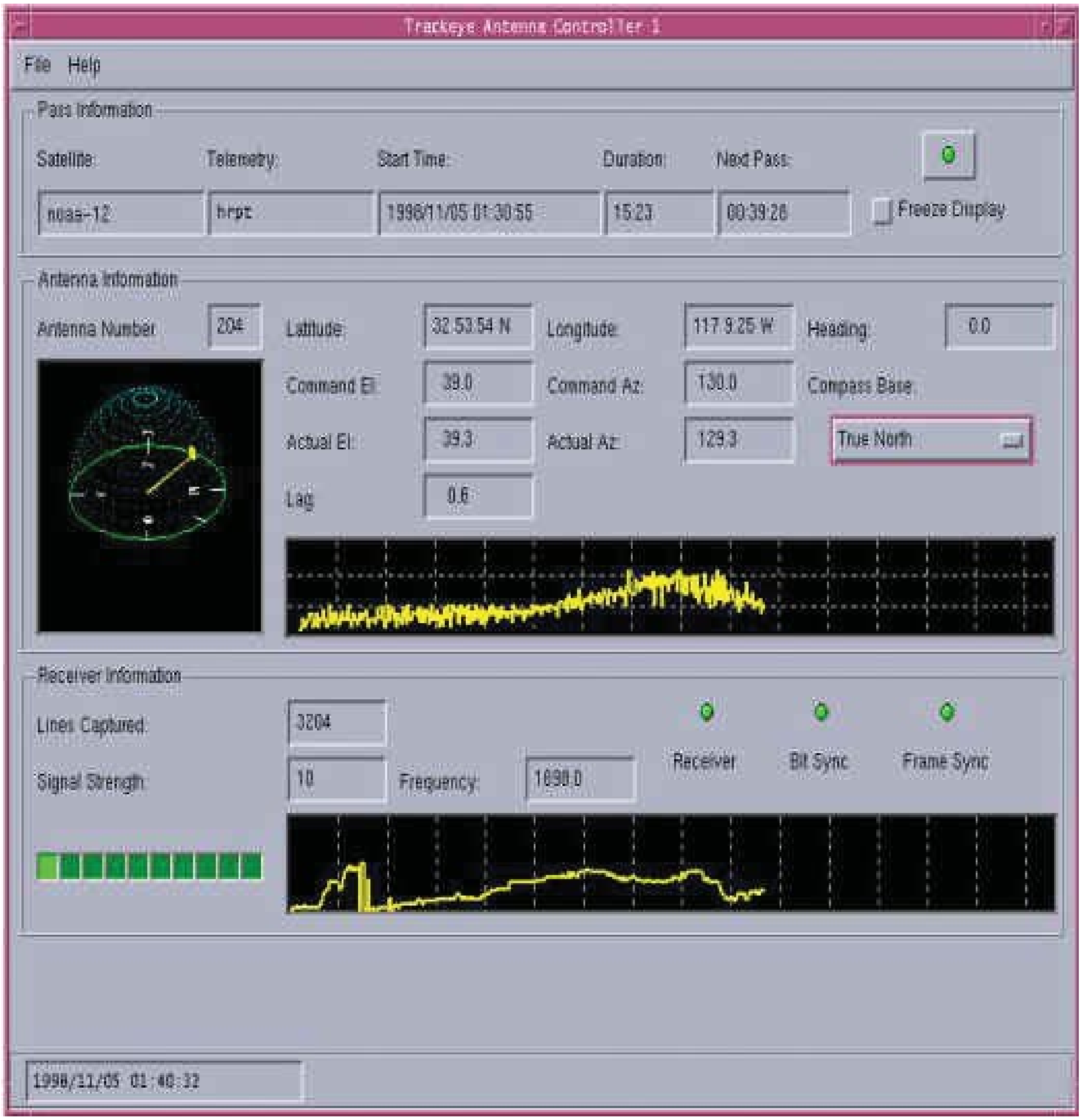


[Image Courtesy of SeaSpace Corporation].

TeraTrack

TeraTrack is the GUI that reports information used for diagnosing reception problems and insuring quality control performance. Such information related to the satellite pass capture includes signal strength, lag time between the actual pointing direction of the antenna and the commanded pointed direction. The software also displays the functionality of the receiver, synchronizer, and frame synchronizer. Figure 5.2 is a screen shot from the TeraTrack software, which provides satellite pass information, antenna information, and receiver information.

Figure 5.2. TeraTrack Screen Shot

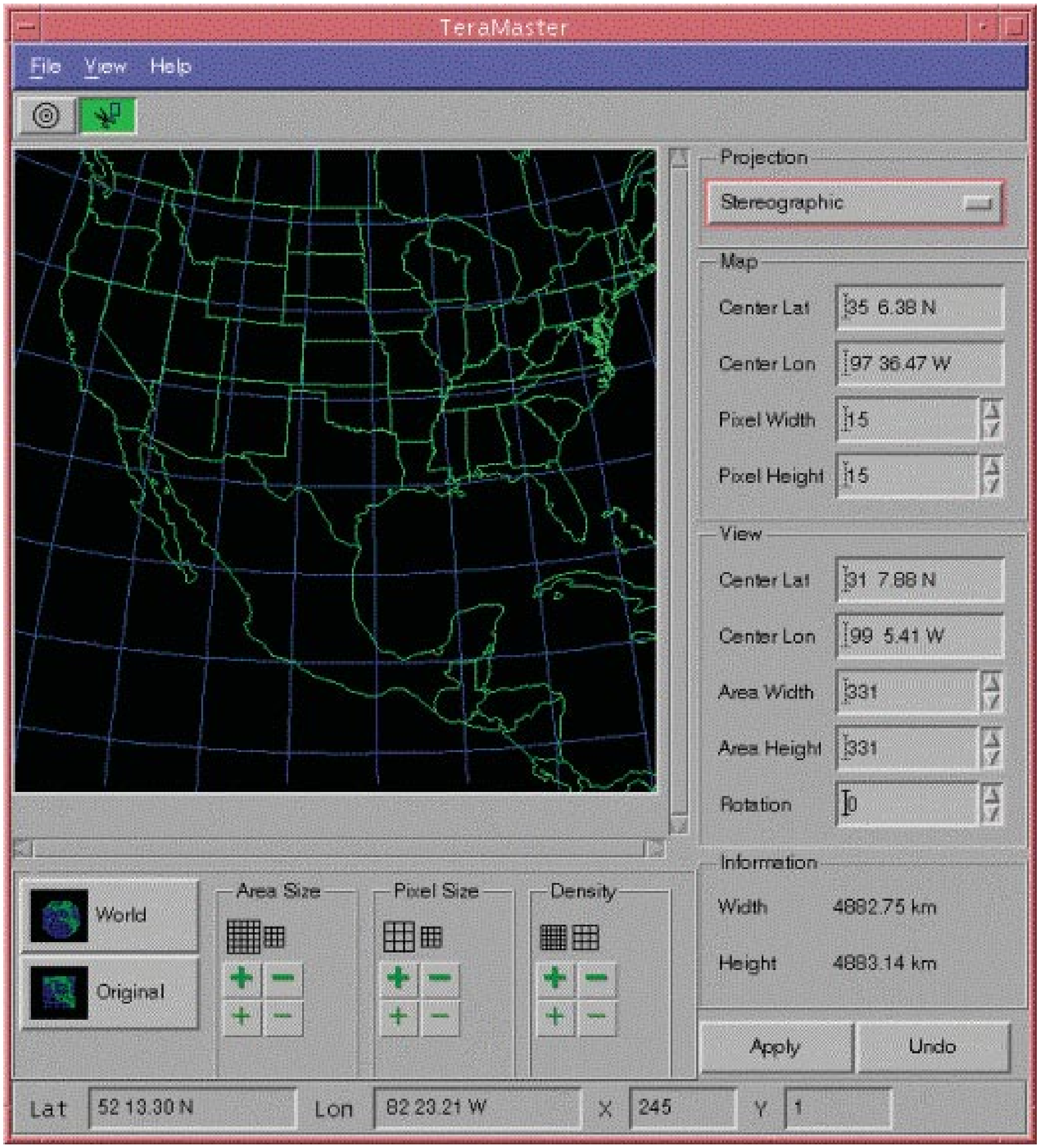


[Image Courtesy of SeaSpace Corporation].

TeraMaster

TeraMaster is a GUI for viewing, creating, or modifying a data set that defines an area of the earth's surface in terms of map projection (shape), extents, and resolution. This data set is referred to as a master. The user can specify a master area anywhere in the world by using the computer mouse or entering latitudes and longitudes into the data fields. Figure 5.3 is a screen shot of the TeraMaster software.

Figure 5.3. TeraMaster Screen Shot



[Image Courtesy of SeaSpace Corporation]

TeraScan™ Product Generation System (TeraPGS)

TeraPGS automatically generates and distributes products (TeraScan™ data sets and picture products) according to the specifications provided by the user. The picture products can be produced in any of the following formats:

- JPEG
- TIFF

- MARTA-PCX
- GIF
- PNG
- PostScript

TeraPGS has three primary components: (1) the GUI, (2) the product generation (processing) scripts, and (3) the distributor.

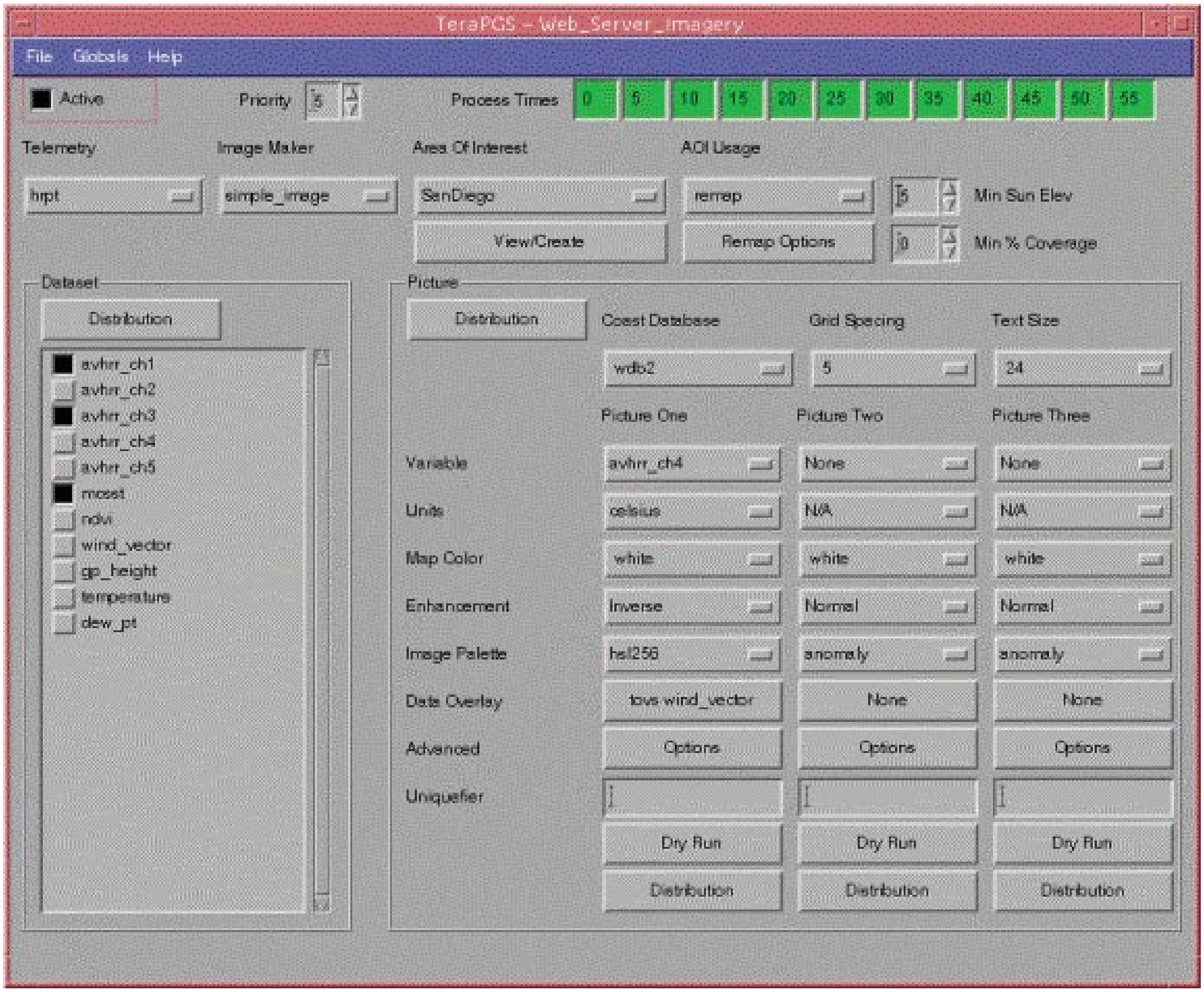
TeraPGS - GUI: The GUI allows the user to create, edit and store product definitions. These product definitions can dictate which TeraScan™ data set to use and the type of picture representations to be generated from the data. The software has a "dry run" feature, which allows the user to test product definitions by generating and displaying the product locally prior to being sent to a delivery destination (e.g., Web site, database, or archive). The types of definition parameters include the following:

- Data selection by telemetry and variable, by time window, by geographic coverage, and by minimum sun elevation.
- Options for picture products.
- Data unit, palette, and enhancement selection.
- Delivery destinations and times.
- Notification of delivery success and/or failure.

Figure 5.4 is a screen shot of the TeraPGA - GUI.

TeraPGS - Product Generation (Processing) Scripts: The processing script generates either data sets or picture products according to the product definitions prescribed via the GUI. The software automatically logs the processing progress and notifies the user (via e-mail) in the event of a failure.

Figure 5.4. TeraPGS - GUI Screen Shot



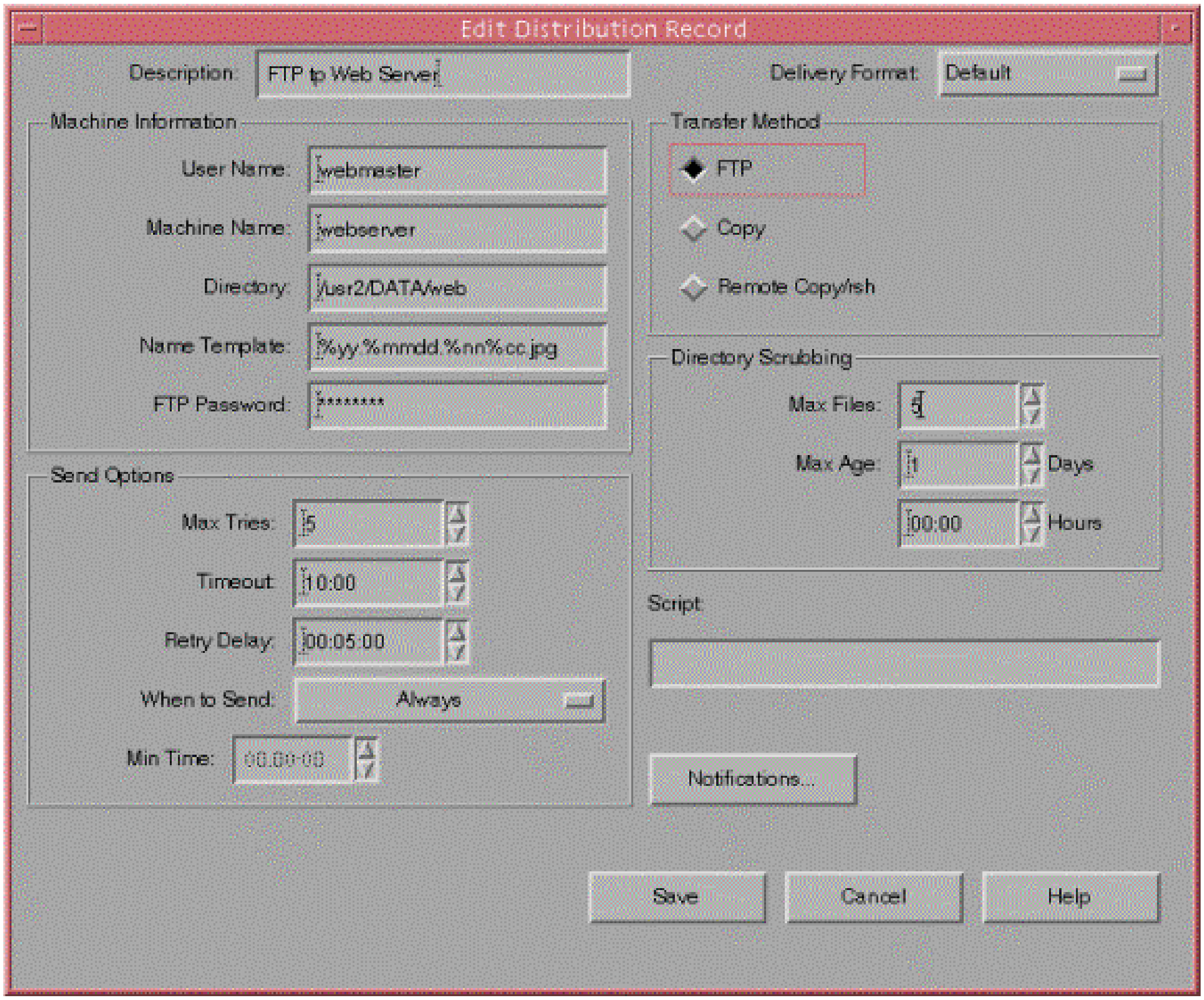
[Image Courtesy of SeaSpace Corporation]

TeraPGS - Distributor: The distributor is a server that manages the delivery of the products (e.g., data sets or pictures). The distributor's features include:

- Delivery of up to 50 products simultaneously to multiple users.
- Delivery of both data sets and picture products via FTP, copy, or remote copy.
- Data delivery retry options.

Figure 5.5 is a screen shot from the TeraPGS' Distributor software.

Figure 5.5. TeraPGS - Distributor Screen Shot

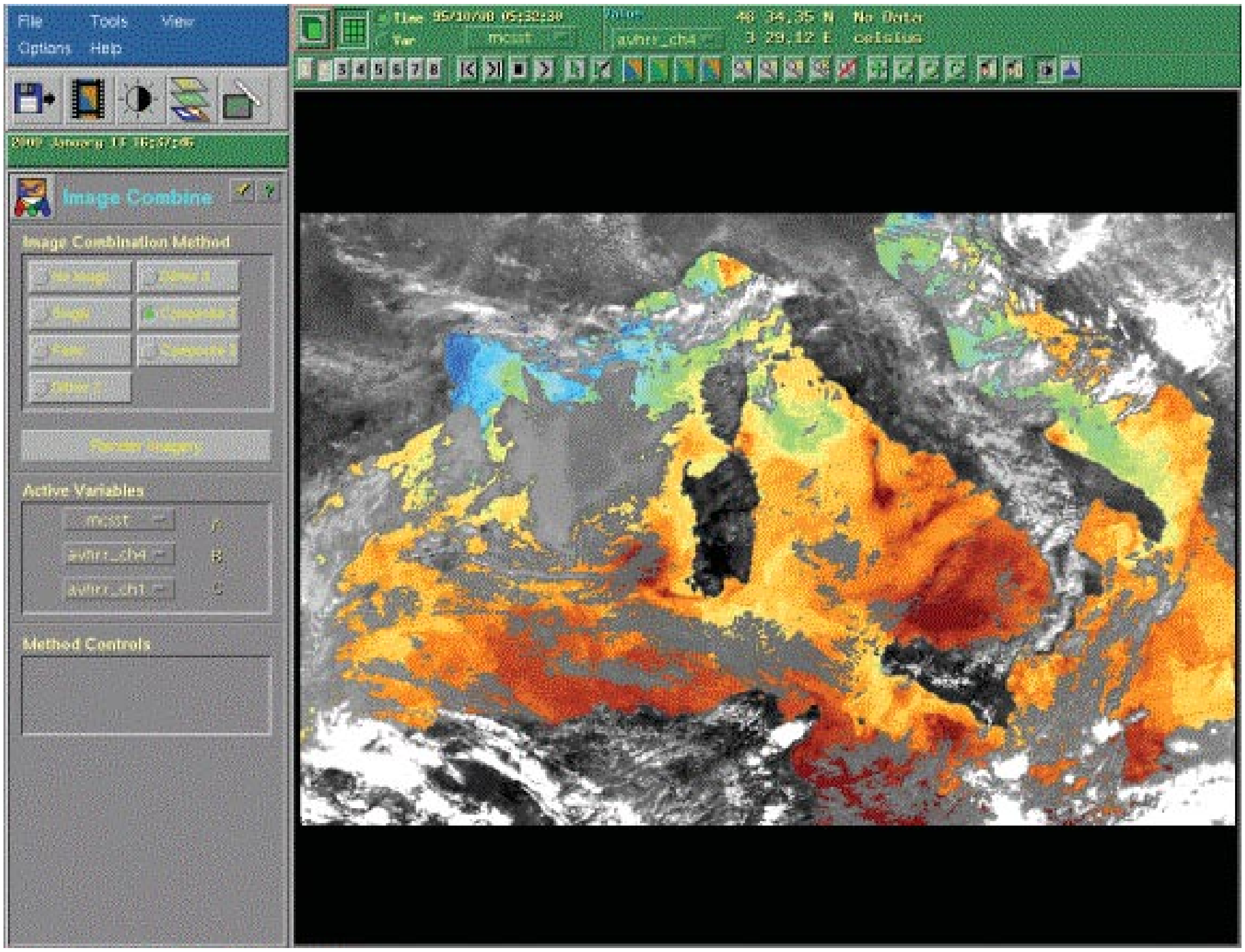


[Image Courtesy of SeaSpace Corporation]

TeraVision

TeraVision displays and manipulates data as images and overlays. Data can be presented as overlay images such as coast lines, contours, vectors, and stream plots. To enhance the user's understanding of the data, the software allows them to add a legend or to label areas of interest (e.g., sampling stations and lakes.) The software also has data analysis tools for generating and displaying histogram plots, profile plots, Skew-T diagrams, and scatter plots. To look for trends, LSU uses TeraVision to sequence visualized data of the same area at different times. Such trend analyses assist LSU when interpreting the data. Images can be enhanced via color palettes, convolution filters, and histogram equalization and printed to any color or black-and-white PostScript Level 2 printer. Figure 5.6 is a screen shot of the TeraVision software.

Figure 5.6. TeraVision Screen Shot



[Image Courtesy of SeaSpace Corporation]

Training

SeaSpace offers basic hands-on, instructor-led training courses for its TeraScan™ software. Such courses include a 4-day Scientific Training Program, a 3-day Operational/Forecasting Training Program, and an Operational program consisting of 2 half day sections. SeaSpace also offers customized training upon request. For more information about TeraScan™ training see the following Web site: **http://www.seaspace.com**/service/support/training.shtml.

6. COMMUNICATING TIME-RELEVANT WATER QUALITY INFORMATION

In addition to designing and implementing a time-relevant water quality monitoring system, you will also want to consider how and what types of data to communicate to the community. This chapter is designed to help you develop an approach for communicating pertinent water quality information to people in your community, or more specifically, your target audience. This chapter provides the following:

- The steps involved in developing an outreach plan.
- Guidelines for effectively communicating information.
- Resources to assist in promoting community awareness.
- The outreach initiatives implemented by the Jefferson Parish Team.

6.1 Developing an Outreach Plan for Time-Relevant Water Quality Reporting

Your outreach program will be most effective if you ask yourself the following questions:

- Who do you want to reach? (i.e., Who is your target audience?)
- What information do you want to distribute or communicate?
- What are the most effective mechanisms to reach my target audience?

Developing an outreach plan ensures that you have considered all important elements of an outreach project before you begin. The plan itself provides a blueprint for action. An outreach plan does not have to be lengthy or complicated. You can develop a plan simply by documenting your answers to each of the questions discussed below. This will provide you with a solid foundation for launching an outreach effort.

Your outreach plan will be most effective if you involve a variety of people in its development. Where possible, consider involving:

- A communications specialist or someone who has experience developing and implementing an outreach plan.

- Technical experts in the subject matter (both scientific and policy).

- Someone who represents the target audience (i.e., the people or groups you want to reach).

- Key individuals who will be involved in implementing the outreach plan.

As you develop your outreach plan, consider whether you would like to invite any organizations to partner with you in planning or implementing the outreach effort. Potential partners might include shoreline and lakeshore property owner associations, local businesses, environmental organizations, schools, boating associations, local health departments, local planning and zoning authorities, and other local or state agencies. Partners can participate in planning, product development and review, and distribution. Partnerships can be valuable mechanisms for leveraging resources while enhancing the quality, credibility, and success of outreach efforts. Developing an outreach plan is a creative and iterative process involving a number of interrelated steps, as described below. As you move through each of these steps, you might want to revisit and refine the decisions you made in earlier steps until you have an integrated, comprehensive, and achievable plan.

What Are Your Outreach Goals?

Defining your outreach goals is the initial step in developing an outreach plan. Outreach goals should be clear, simple, action-oriented statements about what you hope to accomplish through outreach. Once you have established your goals, every other element of the plan should relate to those goals. Here were some project goals for the Jefferson Parish EMPACT project:

- To provide the public with a weekly, or more frequent "weather report" on freshwater diversions and their impact on water quality and algal blooms in area water bodies.

- To gather baseline data in the Davis Pond Diversion outfall area to assist coastal scientist and managers in distinguishing the effects of river water from other ecosystem stressors.

- To use the data collected to confirm remote sensing data and calibrate the predictive ability of remote sensing data.

- To provide ground-truthed remotely sensed data on water quality and phytoplankton blooms to the agencies and organizations involved with public health, fisheries, and habitat related issues.

Whom Are You Trying To Reach?

Identifying Your Audience(s)

The next step in developing an outreach plan is to clearly identify the target audience or audiences for your outreach effort. As illustrated in the Jefferson

Parish project goals above, outreach goals often define their target audiences (e.g., the public, coastal scientists, fisheries, etc.). You might want to refine and add to your goals after you have defined your target audience(s).

Target audiences for a water quality outreach program might include, for example, the general public, local decision makers and land management agencies, educators and students (high school and college), special interest groups (e. g., homeowner associations, fishing and boating organizations, gardening clubs, and lawn maintenance/landscape professionals). Some audiences, such as educators and special interest groups, might serve as conduits to help disseminate information to other audiences you have identified, such as the general public.

Consider whether you should divide the public into two or more audience categories. For example: Will you be providing different information to certain groups, such as citizens and businesses? Does a significant portion of the public you are trying to reach have a different cultural or linguistic background from other members? If so, it likely will be most effective to consider these groups as separate audience categories.

Profiling Your Audience(s)

Once you have identified your audiences, the next step is to develop a profile of their situations, interests, and concerns. Outreach will be most effective if the type, content, and distribution of outreach products are specifically tailored to the characteristics of your target audiences. Developing a profile will help you identify the most effective ways of reaching the audience. For each target audience, consider:

- What is their current level of knowledge about water quality?
- What do you want them to know about water quality? What actions would you like them to take regarding water quality?
- What information is likely to be of greatest interest to the audience? What information will they likely want to know once they develop some awareness of water quality issues?
- How much time are they likely to give to receiving and assimilating the information?
- How does this group generally receive information?
- What professional, recreational, and domestic activities does this group typically engage in that might provide avenues for distributing outreach products? Are there any organizations or centers that represent or serve the audience and might be avenues for disseminating your outreach products?

Profiling an audience essentially involves putting yourself "in your audience's shoes." Ways to do this include consulting with individuals or organizations who represent or are members of the audience, consulting with colleagues who have successfully developed other outreach products for the audience, and using your imagination.

What Do You Want To Communicate?

The next step in planning an outreach program is to think about what you want to communicate. In particular at this stage, think about the key points, or "messages," you want to communicate. Messages are the "bottom line" information you want your audience to walk away with, even if they forget the details.

A message is usually phrased as a brief (often one-sentence) statement. For example:

- The freshwater diversion this week had a _____ effect on Lake Salvador.
- Salinity levels at the sampling station in Lake Salvador are dropped below ___ppt.
- The Hydrowatch site allows you to track daily changes on Lake Salvador.

Outreach products will often have multiple related messages. Consider what messages you want to send to each target audience group. You may have different messages for different audiences.

What Outreach Products Will You Develop?

The next step in developing an outreach plan is to consider what types of outreach products will be most effective for reaching each target audience. There are many different types of outreach: print, audiovisual, electronic, events, and novelty items. The table below provides some examples of each type of outreach product.

The audience profile information you assembled earlier will be helpful in selecting appropriate products. A communications professional can provide valuable guidance in choosing the most appropriate products to meet your goals within your resource and time constraints. Questions to consider when selecting products include:

- How much information does your audience really need? How much does your audience need to know now? The simplest, most effective, most straightforward product generally is most effective.

- Is the product likely to appeal to the target audience? How much time will it take to interact with the product? Is the audience likely to make that time?

Print	Audiovisual	Electronic	Events	Novelty Items
•Brochures	•Cable television programs	•E-mail messages	•Briefings	•Banners
•Educational curricula	•Exhibits	•Web pages	•Fairs and festivals	•Buttons
•Newsletters	•Kiosks	•Subscriber list servers	•One-on-one meetings	•Floating key chains for boaters
•Posters	•Public service announcements (radio)		•Public meetings	•Magnets
•Question-and-answer sheets	•Videos		•Community days	•Bumper stickers
•Editorials			•Media interviews	•Coloring books
•Fact sheets			•Press conferences	•Frisbee discs
•Newspaper and magazine articles			•Speeches	•Mouse pads
•Press releases				•Golf tees
•Utility bill inserts or stuffers				

- How easy and cost-effective will the product be to distribute or, in the case of an event, organize?

- How many people is this product likely to reach? For an event, how many people are likely to attend?

- What time frame is needed to develop and distribute the product?

- How much will it cost to develop the product? Do you have access to the talent and resources needed for development?

- What other related products are already available? Can you build on existing products?

- When will the material be out of date? (You probably will want to spend fewer resources on products with shorter lifetimes.)

- Would it be effective to have distinct phases of products over time? For example, an initial phase of products designed to raise awareness,followed by later phases of products to increase understanding.

- How newsworthy is the information? Information with inherent news value is more likely to be rapidly and widely disseminated by the media.

How Will Your Products Reach Your Audience?

Effective distribution is essential to the success of an outreach strategy. There are many avenues for distribution. The table below lists some examples.

EXAMPLES OF DISTRIBUTION AVENUES	
•Your mailing list •Partners' mailing list •Phone/Fax •E-mail •Internet •TV •Radio •Print media	•Hotline that distributes products upon request •Journals or newsletters of partner organizations •Meetings, events, or locations (e.g., libraries, schools, marinas, public beaches, tackle shops, and sailing clubs) where products are made available

You need to consider how each product will be distributed and determine who will be responsible for distribution. For some products, your organization might manage distribution. For others, you might rely on intermediaries (such as the media or educators) or organizational partners who are willing to participate in the outreach effort. Consult with an experienced communications professional to obtain information about the resources and time required for the various distribution options. Some points to consider in selecting distribution channels include:

- How does the audience typically receive information?
- What distribution mechanisms has your organization used in the past for this audience? Were these mechanisms effective?
- Can you identify any partner organizations that might be willing to assist in the distribution?
- Can the media play a role in distribution?
- Will the mechanism you are considering really reach the intended audience? For example, the Internet can be an effective distribution mechanism, but certain groups might have limited access to it.

- How many people is the product likely to reach through the distribution mechanism you are considering?

- Are sufficient resources available to fund and implement distribution via the mechanisms of interest?

What Follow-up Mechanisms Will You Establish?

Successful outreach may cause people to contact you with requests for more information or expressing concern about issues you have addressed. Consider whether and how you will handle this interest. The following questions can help you develop this part of your strategy:

- What types of reactions or concerns are audience members likely to have in response to the outreach information?

- Who will handle requests for additional information?

- Do you want to indicate on the outreach product where people can go for further information (e. g., provide a contact name, number, or address, or establish a hotline)?

What Is the Schedule for Implementation?

Once you have decided on your goals, audiences, messages, products, and distribution channels, you will need to develop an implementation schedule. For each product, consider how much time will be needed for development and distribution. Be sure to factor in sufficient time for product review. Wherever possible, build in time for testing and evaluation by members or representatives of the target audience in focus groups or individual sessions so that you can get feedback on whether you have effectively targeted your material for your audience. Section 6.3 contains suggestions for presenting technical information to the public. It also provides information about online resources that can provide easy to understand background information that you can use in developing your own outreach projects.

6.2 Elements of the Jefferson Parish Project's Outreach Program

The Jefferson Parish team uses a variety of mechanisms to communicate time-relevant water quality information - as well as information about the project itself - to the affected commercial and recreational users of Lake Salvador and other nearby water bodies. The team uses the Parish Web site as the primary vehicle for communicating time-relevant information to the public. Their outreach strategy includes a variety of mechanisms (e.g.,Internet, brochures, presentations at events, and television) to provide the public with information about the Jefferson Parish project. Each element of the project's communication program are discussed below.

Bringing together experts. The EMPACT project stakeholders are made up of a variety of organizations that provide input on the information generated from the project and how it is communicated. These stakeholders are identified below.

- Jefferson Parish Marine Fisheries Advisory Board
- Davis Pond Freshwater Diversion Advisory Committee
- Barataria-Terrebonne National Estuary Program (BTNEP)
- Lake Pontchartrain Basin Foundation
- SMSA Parishes
- Nearby State Agencies
- Local academic community

Brochure. The Jefferson Parish Environmental & Development Control Department published a brochure highlighting current projects overseen by the Coastal Zone Management (CZM) Program. The EMPACT project was announced in the brochure. The team distributed the CZM brochures through local libraries and during community events. Appendix C contains a reproduction of the brochure.

Newspaper. Shortly after the time-series sampling system became operational, two newspaper articles were run announcing the monitoring effort. The articles described the types of data to be collected, how the data were relevant to the community, how the data would be used, and where the public could access the data.

Survey. To determine specific issues of concern in the surrounding communities, the Jefferson Parish team used information already collected by BTNEP, one of the team members. To increase public awareness for the estuary's importance and problems, and to encourage residents, users, and decision makers to become more involved in the promotion and protection of the estuary, BTNEP held a series of eight public workshops in 1998. These workshops provided citizens with information about the program and allowed them to address any specific issues of concern. The Jefferson Parish team used this information to find out what was important to the communities regarding their wetlands. Also the team was able to determine their target audience:

- Commercial and recreational users of Lake Salvador.

- Residents of communities that could be impacted by diversion related to flooding.

- Louisiana citizens concerned about coastal erosion, hypoxia in the Gulf, eutrophication, and algal blooms.

Web site. The Jefferson Parish Web site can be accessed at http://www.jeffparish.net. The EMPACT project is discussed at http://www.jeffparish.net/pages/index.cfm?DOCID=1228. The Web site is the main avenue used by the team for disseminating the water quality information. The site has a static page which describes the Jefferson Parish EMPACT project. On the left side of the site, there are links to the USGS Hydrowatch site, which displays near-real time data from the time-series sampling system at Lake Salvador. An example of the results measured by the time-series sampling system is provided in Appendix D. The Web site also has a link to the Earth Scan Laboratory's Web site. An example of the reflectance results taken from satellite data is provided in Appendix E. The site also has links to learn more about the Davis Pond Diversion Project and the EPA's EMPACT program.

Piggybacking on existing events. The Jefferson Parish team has found some opportunities to promote the EMPACT project at other events. For example, BTNEP hosted a one-day Forum to discuss their Estuary Program. The team had the opportunity to give a power point presentation concerning the EMPACT project. The team also provided a poster presentation and handed out an information sheet about the project.

Developing the Lake Access Web Site

Experience Gained and Lessons Learned

The Jefferson Parish team uses a private contractor to manage their EMPACT Web site (http://www.jeffparish.net/pages/index.cfm?DOCID=1228). The team is considering ways to make the Web site more effective. Currently the site has only information about the EMPACT project and links to the data via Earth Scan and Hydrowatch. Because the information on the Jefferson Parish Web site is not routinely revised or changed, the team is concerned that individuals interested in the near-real time water quality data are going directly to the Earth Scan and/or Hydrowatch Web sites. As a result, the team does not know how many people are accessing data generated by the Jefferson Parish EMPACT project. The team is considering revising the Jefferson Parish site to store "live" data to attract users back to the Web site.

The Jefferson Parish Project team recommends that you design your Web site to include live changing data (e.g., daily) so that users will always find something new and different when they visit your site. The team also recommends that you set up procedures for notifying the project team when changes are made to your site. Such procedures could include providing your Web Master with a list of individuals (and their e-mail addresses) to contact when the site is modified (e.g., site has moved to a new address or new features are available).

Some of the local entities interested in the Lake Salvador data do not have Internet connectivity. As a result they do not have access to any of the near-real time data. At present, the team encourages them to visit their local library so they can access the Web site. The team is considering other avenues to relay the information to interested parties who do not have Internet access.

6.3 Resources for Presenting Water Quality Information to the Public

As you develop your various forms of communication materials and begin to implement your outreach plan, you will want to make sure that these materials present your information as clearly and accurately as possible. There are resources on the Internet to help you develop your outreach materials. Some of these are discussed below.

How Do You Present Technical Information to the Public?

Environmental topics are often technical in nature and full of jargon, and water quality information is no exception. Nonetheless, technical information can be conveyed in simple, clear terms to those in the general public not familiar with water quality. The following principles should be used when conveying technical information to the public:

- Avoid using jargon,
- Translate technical terms (e.g., reflectance) into everyday language the public can easily understand,
- Use active voice,
- Write short sentences,
- Use headings and other formatting techniques to provide a clear and organized structure.

The following Web sites provide guidance regarding how to write clearly and effectively for a general audience:

- The National Partnership for Reinventing Government has a guidance document, *Writing User-Friendly Documents*, that can be found on the Web at http://www.plainlanguage.gov.
- The American Bar Association has a Web site that provides links to on-line writing labs(http://www.abanet.org/lpm/bparticle11463_front.shtml). The Web site discusses topics such as handouts and grammar.

As you develop communication materials for your audience, remember to tailor your information to consider what they are already likely to know, what you want them to know, and what they are likely to understand. The most effective approach is to provide information that is valuable and interesting to the target audience. For example, the local fishers in the Lake Salvador area are concerned about some of the potential effects (e.g., changes in salinity and algae blooms) of the Davis Pond freshwater diversion. Also when developing outreach products, be sure to consider special needs of the target audience. For example, ask yourself if your target audience has a large number of people who speak little or no English. If so, you should prepare communication materials in their native language.

The rest of this section contains information about resources available on the Internet that can assist you as you develop your own outreach projects. Some of the Web sites discussed below contain products, such as downloadable documents or fact sheets, which you can use to develop and tailor your education and outreach efforts.

Federal Resources

EPA's Surf Your Watershed
http://www.epa.gov/surf3

This Web site can be used to locate, use, and share environmental information on watersheds. One section of this site, "Locate Your Watershed," allows the user to enter the names of rivers, schools, or zip codes to learn more about watersheds in their local area or in other parts of the country. The EPA's Index of Watershed Indicators (IWI) can also be accessed from this site. The IWI is a numerical grade (1 to 6), which is compiled and calculated based on a variety of indicators that point to whether rivers, lakes, streams, wetlands, and coastal areas are "well" or "ailing."

EPA's Office of Water Volunteer Lake Monitoring: A Methods Manual
http://www.epa.gov/owow/monitoring/volunteer/lake

EPA developed this manual to present specific information on volunteer lake water quality monitoring methods. It is intended both for the organizers of the volunteer lake monitoring program and for the volunteer(s) who will actually be sampling lake conditions. Its emphasis is on identifying appropriate parameters to monitor and listing specific steps for each selected monitoring method. The manual also includes quality assurance/quality control procedures to ensure that the data collected by volunteers are useful to States and other agencies.

EPA's Non Point Source Pointers (Fact sheets)
http://www.epa.gov/owow/nps/facts

This Web site features a series of fact sheets (referred to as "pointers) on nonpoint source pollution (e.g., pollution occurring from storm water runoff). The pointers covers topics including: programs and opportunities for public involvement in nonpoint source control, managing wetlands to control nonpoint source pollution, and managing urban runoff.

EPA's Great Lakes National Program Office
http://www.epa.gov/glnpo/about.html

EPA's Great Lakes National Program Office Web site includes information about topics such as human health, visualizing the lakes, monitoring, and pollution prevention. One section of this site (http://www.epa.gov/glnpo/gl2000/lamps/index.html) has links to Lakewide Management Plans (LaMP) documents for each of the Great Lakes. A LaMP is a plan of action developed by the United States and Canada to assess, restore, protect and monitor the ecosystem health of a Great Lake. The LaMP has a section dedicated to public involvement or outreach and education. The program utilizes a public review process to ensure that the LaMP is addressing their concerns. You could use the LaMP as a model in developing similar plans for your water monitoring program.

U. S. Department of Agriculture Natural Resource Conservation Service
http://www.wcc.nrcs.usda.gov/water/quality/frame/wqam

Under "Guidance Documents," there are several documents pertaining to water quality that can be downloaded or ordered. These documents are listed below.

- A Procedure to Estimate the Response of Aquatic Systems to Changes in Phosphorus and Nitrogen Inputs
- Stream Visual Assessment Protocol
- National Handbook of Water Quality Monitoring
- Water Quality Indicators Guide
- Water Quality Field Guide

Education Resources

Project WET (Water Education for Teachers)
http://www.montana.edu/wwwwet

One goal of Project WET is to promote awareness, appreciation, knowledge, and good stewardship of water resources by developing and making available classroom-ready teaching aids. Another goal of WET is to establish state- and internationally-sponsored Project WET programs. The WET site has a list of all the State Project WET Program Coordinators.

Water Science for Schools
http://wwwga.usgs.gov/edu/index.html

The USGS's Water Science for School Web site offers information on many aspects of water and water quality. The Web site has pictures, data, maps, and an interactive forum where you can provide opinions and test your water knowledge. Water quality is discussed under "Special Topics."

Global Rivers Environmental Education Network (GREEN)
http://www.earthforce.org/green

The GREEN provides opportunities for middle and high school-aged youth to understand, improve and sustain watersheds in their community. This site (http://www.igc.apc.org/green/resources.html) also includes a list of water quality projects being conducted across the country and around the world.

Adopt- A-Watershed
http://www.adopt-a-watershed.org/about.htm

Adopt- A- Watershed is a school-community learning experience for students from kindergarten through high school. Their goal is to make science applicable and relevant to the students. Adopt-A-Watershed has many products and services available to teachers wishing to start an Adopt-A-Watershed project. Although not active in every state, the Web site has a list of contacts in 25 States if you are interested in beginning a project in your area.

National Institutes for Water Resources
http://wrri.nmsu.edu/niwr/niwr.html

The National Institutes for Water Resources (NIWR) is a network of 54 research institutes throughout each of the 50 States, District of Columbia, the Virgin Islands, Puerto Rico, and Guam/Federated States of Micronesia. Each institute conducts research to solve water problems unique to their area and establish cooperative programs with local governments, state agencies, and industry.

Other Organizations

North American Lake Management Society (NALMS) Guide to Local Resources
http://www.nalms.org/

This Web site provides resources for those dealing with local lake-related issues. NALMS's mission is to forge partnerships among citizens, scientists, and professionals to promote the management and protection of lakes and reservoirs. NALMS's Guide to Local Resources (http://www.nalms.org/resource/lnkagenc/links.htm) contains various links to regulatory agencies, extension programs, research centers, NALMS chapters, regional directors, and a membership directory.

The Watershed Management Council
http://watershed.org/wmc/aboutwmc.html

The Watershed Management Council (WMC) is a nonprofit organization whose members represent a variety of watershed management interests and disciplines. WMC membership includes professionals, students, teachers, and individuals whose interest is in promoting proper watershed management.

Gulf of Mexico Program
http://gmpo.gov

The EPA established the Gulf of Mexico Program (GMP). Their mission is to provide information and resources to facilitate the protection and restoration of the coastal marine waters of the Gulf of Mexico and its coastal natural habitats. The GMP's Web site has links to existing coastal projects, has links to educator and student resources, and provides near-real time oceanic data.

The Barataria - Terrobonne National Estuary Program (BTNEP)
http://www.btnep.org

BTNEP is the result of a cooperative agreement between the EPA and the State of Louisiana under the National Estuary Program. The program's charter was to develop a coalition of government, private, and commercial interests to identify problems, assess trends, design pollution control, develop resource management strategies, recommend corrective actions, and seek implementation commitments for the preservation of Louisiana's Barataria and Terrebonne basins.

APPENDIX A

GLOSSARY OF TERMS & ACRONYM LIST

A

ADAPS: Automated Data - Processing System.

Algae: Simple single-celled, colonial, or multi-celled aquatic plants. Aquatic algae are (mostly) microscopic plants that contain chlorophyll and grow by photosynthesis. They absorb nutrients from the water or sediments, add oxygen to the water, and are usually the major source of organic matter at the base of the food web.

Algal blooms: Referring to excessive growths of algae caused by excessive nutrient loading.

Anoxia: Absence of oxygen in water.

APT: Automatic picture transmission.

AVHRR: Advanced very high resolution radiometer.

B

BTNEP: Barataria-Terrebonne National Estuary Program.

C

CEI: Coastal Ecology Institute.

Chlorophyll: Green pigment in plants that transforms light energy into chemical energy by photosynthesis.

CO_2: carbon dioxide.

CSI: Coastal Studies Institute.

CZM: Coastal Zone Management.

D

DAAC: Distributed Active Archive Center.

DAS: Data acquisition system.

dB: decibel

DECODES: Device Conversion and Delivery System

DIC: Differential interference contrast.

Dissolved oxygen (DO): The concentration of oxygen (O_2) dissolved in water, usually expressed in milligrams per liter, parts per million, or percent of saturation (at the field temperature). Adequate concentrations of dissolved oxygen are necessary to sustain the life of fish and other aquatic organisms and prevent offensive odors. DO levels are considered a very important and commonly employed measurement of water quality and indicator of a water body's ability to support desirable aquatic life. Levels above 5 milligrams per liter (mg O_2/L) are considered optimal and fish cannot survive for prolonged periods at levels below 3 mg O_2/L. Levels below 2 mg O_2/L are often referred to as hypoxic and when O_2 is less than 0.1 mg/, conditions are considered to be anoxic.

DMSO: Dimethyl sulfoxide.

DO: Dissolved oxygen.

DOMSAT: Domestic satellite. A DOMSAT system utilizes a geosynchronous satellite to re-broadcast satellite data received at a central reception and preprocessing center.

DVT(s): Data visualization tools.

E

EMPACT: Environmental Monitoring for Public Access and Community Tracking.

EPA: U.S Environmental Protection Agency.

ESL: Earth Scan Laboratory

Estuary: A semi-enclosed coastal area, where seawater mixes with fresh water from rivers.

Eutrophication: The process by which surface water is enriched by nutrients (usually phosphorus and nitrogen) which leads to excessive plant growth.

F

ft: feet.

FTP: File transfer protocol.

G

GAC: Global area coverage.

GFF: Glass fiber filter.

GIS: Geographic information systems.

GMP: Gulf of Mexico Program.

GOES: Geostationary operational environmental satellites.

GPS: Global positioning system.

GREEN: Global Rivers Environmental Education Network

GUI: Graphical user interface.

***u*g/l:** micrograms (10^{-6} grams)/liter.

***u*S/cm:** microsiemens per centimeter.

H

HAB: Harmful algal bloom.

HCl: hydrochloric acid.

HRPT: High resolution picture transmission.

HTCO: High temperature catalytic oxidation.

Hypoxia: Physical condition caused by low amounts of dissolved oxygen in water (i.e., less than 2 mg/l.)

I

IC: Inorganic carbon.

IWI: Index of Watershed Indicators

J

K

Kbps: kilobytes per second.

kg: kilogram.

km: kilometer.

km/hr: kilometers per hour.

L

lbs: pounds.

L: liter

LAC: Local area coverage.

LaMP: Lakewide Management Plans

LNA: Low noise amplifier.

LRGS: Local readout ground station

LSU: Louisiana State University

LSU-CEI: Louisiana State University Coastal Ecology Institute.

LUMCON: Louisiana University Marine Observatory Consortium.

M

m: meters.

mg: milligrams

mg/L: milligrams/liter

mph: miles per hour.

MHz: Megahertz.

N

NALMS: North American Lake Management Society.

NASA: National Aeronautics and Space Administration.

NDIR: Non-dispersive infrared gas analyzer.

Near-real time: Refers to data current enough to be used in day-to-day decision-making. These data are collected and distributed as close to real time as possible. Reasons for some small time delays in distributing the collected data include the following: (1) the time it takes to physically transmit and process the data, (2) delays due to the data transmission schedule (i.e., some collected data are only transmitted in set time intervals as opposed to transmitting the data continuously), and (3) the time it takes for automated and preliminary manual QA/QC.

NESDIS: National Environmental Satellite, Data and Information Service.

NIWR: National Institute for Water Resources.

NOAA: National Oceanic and Atmospheric Administration.

nm: Nanometer, 10^{-9} meter.

NSP: Neurotoxic shellfish poisoning.

NTU: Nephelometric turbidity unit.

Nutrient loading: The discharge of nutrients from the watershed into a receiving water body (e.g., wetland). Expressed usually as mass per unit area per unit time (kg/ hectare/ yr or lbs/acre/year).

O

ORD: Office of Research and Development.

Organic: Refers to substances that contain carbon atoms and carbon-carbon bonds.

OSC: Orbital Sciences Corporation.

P

PC: Personal computer.

PCI: Peripheral component interconnect.

pH scale: A scale used to determine the alkaline or acidic nature of a substance. The scale ranges from 1 to 14 with 1 being the most acidic and 14 the most basic. Pure water is neutral with a ph of 7.

Parameter: Whatever it is you measure - a particular physical, chemical, or biological property that is being measured.

Photosynthesis: The process by which green plants convert carbon dioxide to sugars and oxygen using sunlight for energy.

POES: Polar orbiting environmental satellites.

ppt: parts per thousand.

Q

Quality Assurance/Quality Control (QA/QC): QA/QC procedures are used to ensure that data are accurate, precise, and consistent. QA/QC involves established rules in the field and in the laboratory to ensure thatsamples are representative of the water you are monitoring, free from contamination, and analyzed following standard procedures.

QWSU: Quality Water Service Unit.

R

Remote Monitoring: Monitoring is called *remote* when the operator can collect and analyze data from a site other than the monitoring location itself.

S

Salinity: Measurement of the mass of dissolved salts in water. Salinity is usually expressed in ppt.

SeaWiFS: Sea-viewing Wide Field-of-view Sensor. The SeaWiFS is an Earth-orbiting ocean color sensor flown on the Orbview-2 satellite that provides quantitative data on global ocean bio-opticals properties to the science community. [Source: http://seawifs.gsfc.nasa.gov/SEAWIFS/BACKGROUND/ SEAWIFS_BACKGROUND.html]

SCSI: Small Computer System Interface (pronounced "scuzzy")

SEM: Scanning electron microscope.

SMSA: Standard metropolitan statistical area.

Specific Conductance: The measure of how well water can conduct an electrical current. Specific conductance indirectly measures the presence of compounds such as sulfates, nitrates, and phosphates. As a result, specific conductance can be used as an indicator of water pollution. Specific conductivity is usually expressed in *u*S/cm.

SST: Sea surface temperatures.

Surface Truthing: Relating the digital measurements of a parameter (e.g., turbidity and fluorescence) to field sample measurements for the same or a similar parameter.

Suspended solids: (SS or Total SS [TSS]). Organic and inorganic particles in suspension in a water mass.

T

TC: Total carbon.

Time-relevant environmental data: Data that are collected and communicated to the public in a time frame that is useful to their day-to-day decision-making about their health and the environment, and relevant to the temporal variability of the parameter measured.

TOC: Total organic carbon.

Turbidity: The degree to which light is scattered in water because of suspended organic and inorganic particles. Turbidity is commonly measured in NTU's.

U

UHF: Ultra high frequency, 300 to 3000 megahertz.

UPS: Uninterruptible power supply.

USGS: United States Geologic Survey.

USACE: United States Army Corps of Engineers.

V

VHF: Very high frequency, 88 to 216 megahertz.

W

WET: Water Education for Teachers.

WMC: Watershed Management Council.

X

Y

YSI©: Yellow Springs Instruments©.

Z

APPENDIX B

LIST OF AUTHORIZED SEAWIFS GROUND STATIONS/USERS

Name/Telephone No.	Affiliation	Address
Andrew B. Archer 303.790.8606, ext. 3136	Antarctic Support Association	61 Inverness Dr. East, Suite 300 Englewood, CO 80112
Dr. Robert Arnone 601.688.5268	Naval Research Lab/Stennis Space Center	Code 7243 Building 1105 Stennis Space Center, MS 39529
Mr. B. Edward Arthur Jr. 228.688.5265	Naval Research Lab/Stennis Space Center	Code 7340 Stennis Space Center, MS 39529-5004
Dr. Max P. Bleiweiss 505.678.3504	US Army Research Laboratory	AMSRL-IS-EW White Sands Missile Range, NM 88002-5501
Robert A. Kamphaus 757.441.6206	NOAA Ship Ron Brown	NOAA Ship Ron Brown Atlantic Marine Center 439 W. York Street Norfolk, VA 23510-1114
Dr. Francisco Chavez 831.775.1709	Monterey Bay Aquarium Research Institute	P.O. Box 628 7700 Sandholdt Rd. Moss Landing, CA 95039-0628
Prof. Duane E. Waliser 631.632.8647	Institute for Terrestrial And Planetary Atmosphere	MSRC/Endeavor Hall #205 State University of New York Stony Brook, NY 11794-5000
Dr. Kevin Engle 907.474.5569	Institute of Marine Science	University of Alaska Fairbanks Fairbanks, AK 99775-7220
Rafael Fernandez-Sein 787.834.7620, ext. 2263	University of Puerto Rico	NASA-URC Tropical Center for Earth and Space Studies University of Puerto Rico at Mayaguez Road 108, Km 1.0 Miradero PO Box 9001 Mayaguez, PR 00680-9001
Dr. Pierre Flament 808.956.6663	University of Hawaii at Manoa	1000 Pope Road Honolulu, HI 96822
Mr. Scott M. Glenn 908.932.6555, ext. 544	Institute of Marine and Coastal Sciences	Marine Science Building Rutgers, The State University 71 Dudley Road New Brunswick, NJ 08901-8521
Dr. Frank E. Hoge 757.824.1567	NASA/GSFC Wallops Flight Facility	Code 972 Building N-159 Wallops Island, VA 23337

Name/Telephone No.	Affiliation	Address
Dr. Michael Laurs 808.942.1279	Hawaii Regional Coastwatch Node	National Marine Fisheries Service Honolulu Laboratory 2570 Dole Street Honolulu, HI 96882
Mr. Ronald J. Lynn 619.546.7084	NOAA/La Jolla	National Marine Fisheries Service PO Box 271 La Jolla, CA 92007
John M. Morrison 919.515.7449	Department of Marine Earth and Atmospheric Science	North Carolina State University 1125 Jordan Hall Box 8208 Raleigh, NC 27695-8208
Thomas L. Mote 701.777.3164	Department of Space Studies	University of North Dakota Grand Forks, ND 58202-9008
Dr. Frank E Muller-Karger 813.553.3335	Department of Marine Science	University of South Florida 140 7th Avenue S. St. Petersburg, FL 33701
Dr. Norman B. Nelson 805.893.5303	University of California, Santa Barbara	ICESS, Ellison Hall Santa Barbara, CA 93106
Dr. Torben N. Nielsen 808.956.5896	University of Hawaii/HIGP	1680 East-West Road Post 619E Honolulu, HI 96816
Albert J. Peters 402.472.4893	University of Nebraska	113 Nebraska Hall Lincoln, NE 68588-0517
Dr. John N. Porter 808.956.6483	University of Hawaii	Hawaii Institute of Geophysics and Planetology 2525 Correa Rd. Honolulu, HI 96822
Mr. Raymond C. Smith	University of California, Santa Barbara	University of California Santa Barbara Ellison Hall, 6th Floor Santa Barbara, CA 93106
Greg Stossmeister 303.497.8692	University Corporation for Atmospheric Research	PO Box 3000, UCAR Boulder, CO 80307-3000
Dr. Byron D. Tapley	UT Center for Space Research	3925 West Braker Lane Suite 200 Austin, TX 78759-5321
Dr. Andrew Thomas 207.581.4335	University of Maine	School of Marine Sciences University of Maine 5741 Libby Hall, Room 218 Orono, ME 04469-5741
Nan D. Walker 225-388-2395	Louisiana State University	Coastal Studies Institute Howe-Russell Geoscience Complex Louisiana State University Baton Rouge, LA 70803
Dr. Kirk Waters 843.740.1227	NOAA Coastal Service Center	2234 South Hobson Ave. Charleston, SC 29405-2314

APPENDIX C

JEFFERSON PARISH BROCHURE

Coastal Use Permit Requirements

[illegible]

- **Uses of Local Concern** – [illegible]
- **Uses of State Concern** – [illegible]

[illegible]

Do I need a Coastal Use Permit?

[illegible]

What are wetland determinations and how do I request one?

[illegible]

[illegible]

What information do I need to submit to the CZM Program to determine if a permit or authorization is required?

- [illegible]
- [illegible]
- [illegible]
- [illegible]

Jefferson Parish Environmental & Development Control Department

Coastal Zone Management Program

[illegible]

Phone: [illegible]

Fax: [illegible]

Internet: [illegible]

Jefferson Parish Coastal Zone Management Program

Jefferson Parish Environmental & Development Control Department

Jefferson Parish Coastal Zone Management Program

The Jefferson Parish Coastal Zone Management (CZM) Program was approved by the state on January 4, 1985 in accordance with the the State and Local Coastal Resources Management Act of 1978 (Act 361). The CZM Program established major goals and policies for managing the parish's coastal resources and created guidelines for the issuance of local coastal use permits.

Louisiana has 40% of the nations remaining coastal wetlands and is experiencing 80% of coastal wetland loss. The Barataria Basin is the fastest-eroding area of Louisiana's coast. Jefferson Parish once had 50 miles of near-solid, healthy wetlands between it and the Gulf of Mexico. The wetlands protect developed areas against hurricane surges, provide natural treatment for stormwater runoff and provide a rich nursery ground for fisheries. Louisiana contains wetland habitats that have been estimated to produce over 30% of the nation's seafood harvest and to support up to 60% of the Mississippi Flyway's wintering waterfowl.

In addition to regulating development activities that impact the coastal zone, the CZM Program also designs, seeks funding for, and implements projects to combat coastal erosion and promote marsh restoration. A comprehensive Coastal Wetland Conservation and Restoration Plan was developed for the parish in 1993 in an effort to provide a long-term solution to coastal erosion and wetland loss. The CZM Program has secured over $41 million in state and federal funding through the Coastal Wetlands Planning, Protection and Restoration Act (The Breaux Bill) for wetland restoration projects that benefit marsh in Jefferson Parish.

Details about Breaux Bill projects follow.

Breaux Bill Projects in Jefferson Parish

Barataria Bay Marsh Creation
Priority List 1 - $1,676,424

The project involves using maintenance-dredged sediments to create marsh in shallow water areas adjacent to the channel. Queen Bess Island and Pelican Rookery restoration was completed for $945,678. Remaining funds will be used to purchase oyster leases for beneficial dredge material disposal.

Lake Salvador Shoreline Protection at Jean Lafitte National Historic Park
Priority List 1 - $60,000

The project is to restore the shoreline/marsh area at the northeast corner of Lake Salvador, specifically where the lake broke through the Bayou Segnette Waterway.

Jonathan Davis Wetland Protection
Priority List 2 - $4,200,063

The project will reduce the marsh loss rate, maintain and improve fish and wildlife habitat quality, and lower rates of water exchange, erosion and salt water intrusion in an area of wetlands west of Barataria, La.

Barataria Waterway "Dupre Cut" - West
Priority List 4 - $2,275,892

The project objective is to rebuild the west bank of the Dupre Cut to protect the adjacent marsh from unnatural water exchange and subsequent erosion. A rock dike will be constructed along 9,400 linear feet of the west bank of the Barataria Waterway.

Myrtle Grove Siphon
Priority List 5 - $15,525,925

The project is intended to convey up to 2,000 cfs of fresh and sediments from the Mississippi River to deteriorating tidal marshes in the vicinity of Bayou Dupont, east of Lafitte, Louisiana.

Naomi Outfall Management
Priority List 5 - $1,778,927

The project will manage the outfall of the existing eight siphons by controlling the movement of the diverted waters. The siphons divert sediment-laden water from the Mississippi River into the west bank wetlands to retard saltwater intrusion and enhance wetland productivity.

Barataria Waterway "Dupre Cut" - East
Priority List 6 - $3,027,621

The objective of this project is to rebuild the banks of the Barataria Waterway to protect the adjacent marsh from excessive tidal action and saltwater intrusion. The project consists of 3.3 miles of levee constructed with dredged material from the waterway; and 3.3 miles of rock armor.

Barataria Basin Landbridge - Phase I
Priority List 7 - $10,352,340

The objective of the project is to construct a cost-effective erosion control technique to stop the erosion on the southwestern shoreline of Bayou Perot and the southeastern shoreline of Bayou Rigolettes. The length of protection is estimated to be ± 8,000 feet.

Grand Terre Island Vegetative Plantings
Priority List 7 - $838,420

Grand Terre is a barrier island located adjacent to , and east of Grand Isle, Louisiana. In 1996, a 180 acre section on the east side of the island was filled with material dredged from the Barataria Waterway bar channel. This project will implement a planting protocol to re-vegetate the dredged material site and will include strategic degrading of retention dikes to enhance the ingress and egress of marine fisheries.

Barataria Basin Landbridge - Phase II
Priority List 8 - $7,161,749

This phase is a continuation of the original project authorized for Priority List 7. The project would protect the eastern shoreline of Bayou Rigolettes and the western shoreline of Bayou Perot. Phase II represents about 22% of the total length of the initially proposed shoreline protection.

Your Project Could Be Listed Here!

The Coastal Zone Management Program welcomes input from fishermen and other coastal users regarding ideas for future restoration projects in Jefferson Parish.

Jefferson Parish Christmas Tree/Marsh Restoration Project

The Jefferson Parish Christmas Tree/Marsh Restoration Project has saved valuable landfill space by recycling over 500,000 Christmas trees to construct approximately 13500 linear feet of shoreline fences and to fill abandoned, dead-end canals. Hundreds of acres of wetlands have been created or protected by this project. The idea of using brush fences to trap sediments and build land originated in Holland and was first adapted to Louisiana using Christmas trees in 1987. In 1991, the Louisiana State Wetland Trust Fund awarded small grants to coastal Parishes to develop Christmas Tree projects. Each year since the inception of the program, Jefferson Parish has had the largest project in the state, in number of trees recycled, amount of wetlands restored, and number of volunteers.

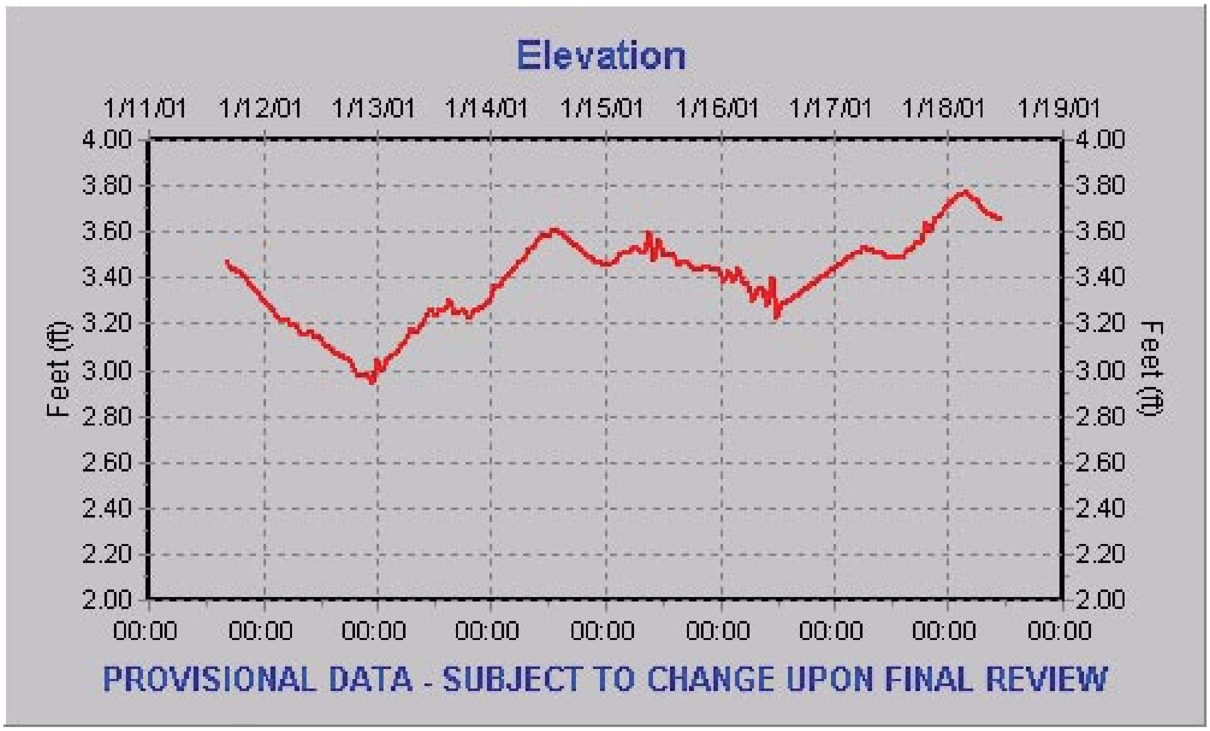
This project could not take place without a huge volunteer effort and strong corporate sponsorship. Each year, approximately 500 volunteers help in this hands-on project. Please call 736-6440 to volunteer.

Jefferson Parish EMPACT Project

The EPA Environmental Monitoring for Public Access and Community Tracking Program has awarded a $100,000 grant to Jefferson Parish to provide data that will enable citizens to track impacts of the Davis Pond Freshwater Diversion. Real-time water quality data from Lake Salvador and remote sensed images of the impact area will be available on the Environmental Department's web page.

APPENDIX D

EXAMPLE DATA FROM USGS HYDROWATCH


Elevation
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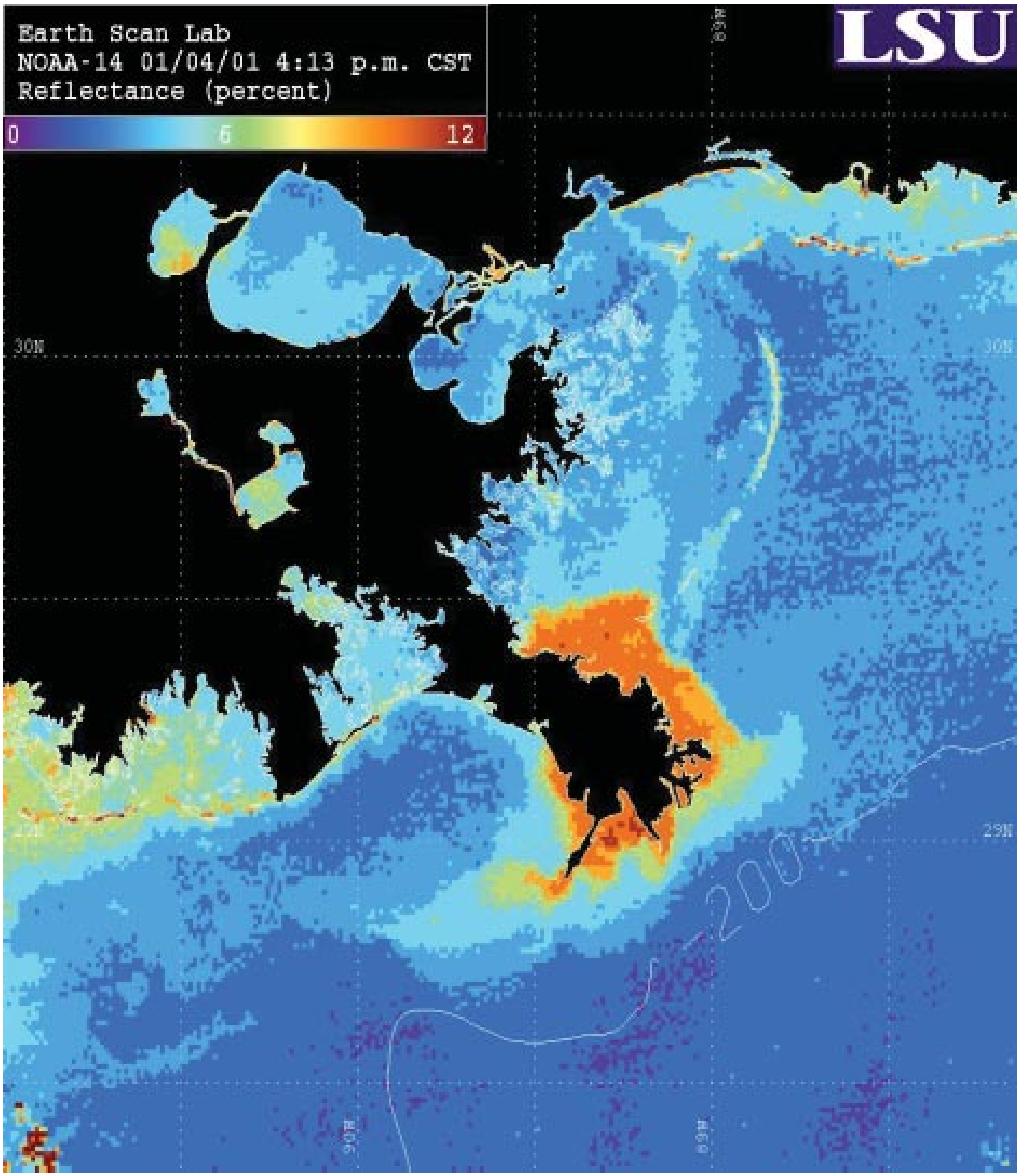
1/12/01
1/13/01
1/14/01
1/15/01
1/16/01
1/17/01
1/18/01
1/19/01
4.00
3.80
3.60
3.40
3.20
3.00
2.80
2.60
2.40
2.20
2.00
Feet (ft)
00:00
PROVISIONAL DATA - SUBJECT TO CHANGE UPON FINAL REVIEW

APPENDIX E

EXAMPLE DATA FROM EARTH SCAN LABORATORY
(Satellite Data - Reflectance)


Earth Scan Lab
NOAA-14 01/04/01 4:13 p.m. CST
Reflectance (percent)
0
6
12
LSU
30N
30N
29N
90W
89W
89W
200

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