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Produced by the NASA Center for Aerospace Information (CASI)
FINAL REPORT
OF
INVESTIGATION OF PEARL RIVER DATA COLLECTION SYSTEM
APPLICATIONS

CONTRACT NAS 8 - 31351
PREPARED FOR

GEORGE C. MARSHALL
SPACE FLIGHT CENTER
MARSHALL SPACE FLIGHT CENTER, ALABAMA

MISSISSIPPI
AIR AND WATER POLLUTION CONTROL COMMISSION
P. O. Box 827
JACKSON, MISSISSIPPI 39205

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Although acknowledgements could be given to many other people involved in this project, no one deserves it more than those people who worked on the river on a routine basis, performing maintenance when needed, installing and dismantling equipment, and logging daily field notes. Problems encountered in day-to-day maintenance of the DCP's were of such magnitude that extremely difficult and lengthy hours of labor were needed in order to overcome them. Mr. Mike Taylor and Mr. Jim Barr of the Mississippi Air and Water Pollution Control Commission, and Mr. Cadd Shapp of the Pearl River Basin Development District, cannot be commended enough for their role in this project.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION AND OBJECTIVES</td>
<td>1</td>
</tr>
<tr>
<td>DESCRIPTION OF THE STUDY AREA</td>
<td>2</td>
</tr>
<tr>
<td>HISTORY OF THE PROJECT</td>
<td>7</td>
</tr>
<tr>
<td>PROBLEMS ENCOUNTERED DURING THE PROJECT</td>
<td>12</td>
</tr>
<tr>
<td>EVALUATION AND CONCLUSIONS</td>
<td>15</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>17</td>
</tr>
<tr>
<td>APPENDIX A</td>
<td>19</td>
</tr>
<tr>
<td>APPENDIX B</td>
<td>27</td>
</tr>
</tbody>
</table>
PEARL RIVER DATA COLLECTION SYSTEM

INTRODUCTION AND OBJECTIVES

Section 106 of the Federal Water Pollution Control Act, as amended (P. L. 92-500), provides for the establishment and operation of appropriate devices, methods, systems, and procedures necessary to monitor and to compile and analyze data on the quality of navigable waters.

Pursuant to this provision, a cooperative agreement was reached in late 1974 between the Mississippi Air and Water Pollution Control Commission (MAWPCC), Marshall Space Flight Center (MSFC), National Space Technology Laboratories (NSTL), and the Pearl River Basin Development District (PRBDD) for the placement, operation and maintenance of a number of NASA developed data collection platforms (DCP's) on the Pearl River, and the reception, processing, and retransmission of water quality data from an ERTS satellite to the MAWPCC via computer linkup.

It was the objective of this project to demonstrate and evaluate the reliability of employing NASA developed remote sensing DCP's for in situ near real time monitoring of water quality in the Pearl River.
DESCRIPTION OF THE STUDY AREA

The Pearl River Basin shown in Figure 1 is located in east-central and south-central Mississippi and in the southeastern part of Louisiana. The Pearl River, flowing from its origin to the Gulf of Mexico, is over 643.6 kilometers (400 miles) long and drains approximately 22,688 square kilometers (8,760 square miles) of surface area.

As a broad view, the Pearl River Basin may be divided into two segments. The Upper Pearl River Basin begins at its headwaters and continues to the vicinity of Byram, Mississippi. In this section lies the two physiographic regions known as the North Central Hills and the Jackson Prairie. There is relatively little base flow to the Pearl River in these two regions. Consequently, the river is very shallow during the summer months and early fall. River banks vary from 3.65 to 12.19 meters (12 to 40 feet) high and the channel width varies from 30.4 to 121.9 meters (100 to 400 feet). Within this section is the Ross Barnett Reservoir, an impoundment of some 121.38 square kilometers (30,000 acres), located just north of Jackson, Mississippi, and extending some 691 kilometers (43 miles) in length.

The upper group of DCP's, consisting of three of the four buoys, is located within that portion of the Pearl River from the Ross Barnett Reservoir Dam south to approximately Tuckers Bluff, encompassing roughly 40.2 kilometers (25 river miles) as shown in Figure 2.
The hydrology of the Pearl River within the study area is entirely dependent upon the operation of the Ross Barnett Reservoir Dam. Annual precipitation in the Jackson area averages approximately 1.2 meters (50 inches), most of which falls from December through May. During the extremely dry months of August through October, the river is so low that navigation with anything but the smallest of boats is impossible. The river has a 7-day, 10-year low flow of 2.5 m³/sec (89 cfs), but the permit by which operation of the Barnett Reservoir is authorized stipulates a minimum spillway discharge of 4.8 m³/sec (173 cfs). Although the annual average discharge for the Pearl River at Jackson is 110.4 m³/sec (3,900 cfs), the average discharge during the study period was much higher due to the unusual amount of rainfall which occurred.

The Lower Pearl River Basin begins at Byram, Mississippi, and continues south to its estuarine mouth. The two physiographic regions which lie in this segment are the Southern Pine Hills and Pine Meadows. Geologic formations within these two regions provide a considerable amount of base flow. Although the drainage area of the Lower Pearl River Basin is less than twice that of the Upper Pearl River Basin, the baseflow contributed to the Pearl River by the lower section is ten times that of the upper section. Banks are much steeper in the lower section, varying from 6.09 to 27.43 meters (20 to 90 feet) high.
A fourth DCP is located in this lower segment near Monticello, Mississippi, approximately 321.8 kilometers (200 river miles) from the mouth of the West Pearl River. The 7-day, 10-year low flow of the Pearl River at the point of deployment (ICRR Trestle) is approximately 8.49 m$^3$/sec (300 cfs). Annual average precipitation is about 1.42 meters (56 inches), with runoff resulting in an average annual flow of approximately 172.69 m$^3$/sec (6,100 cfs).
FIGURE 1
PEARL RIVER BASIN
LOCATION MAP
HISTORY OF THE PROJECT

In February, 1975, personnel were secured by Pearl River Basin Development District to provide support services to the Mississippi Air and Water Pollution Control Commission as per the District's responsibilities delineated in the no-cost contract executed by and between Mississippi Air and Water Pollution Control Commission and the National Aeronautics and Space Administration. Certain of the personnel were oriented to the Pearl River Data Collection System and the specific equipment to be provided by NASA during the month of March, 1975. The buoys, canisters, and software were received during the latter portion of the month of March and early April. While equipment was being received, combined personnel of Mississippi Air and Water Pollution Control Commission and the Pearl River Basin Development District spent time cruising the river, flagging prospective locations for deployment of the water quality monitoring buoys, as well as potential launching sites for the water going craft. During the second and third weeks of April, under the supervision of Marshall Space Flight Center the initial data collection platform was deployed approximately 2.41 kilometers (1.5 miles) south of the spillway of the Ross Barnett Reservoir in North Jackson. The data collection platform was anchored by a 680.4 kilogram (1500 pound) concrete Coast Guard anchor connected by a combination of chain and stainless steel cable. The necessary software was installed and calibrated and the first transmission received on April 17, 1975.
Within the next 30 days, two more data collection platforms were deployed and activated in the Jackson vicinity. An additional 226.8 kilogram (500 pound) anchor was tied in series to the 680.4 kilogram (1500 pound) concrete Coast Guard anchor to provide additional anchorage security. However, in the course of the next 90 days, flash floods and sudden rises in the river, some as much as 7.62 meters (25 feet) in a three day period, inflicted considerable damage to two of the data collection platforms. In particular, one data collection platform was broken free from the anchor system apparently by a large floating tree trunk or other large debris in the river and found capsized approximately three miles downstream from its anchor point. The data collection platforms were capsized in place with severe water damage absorbed as a result of the canisters being submerged and water infiltrating the breather tube and the seals to the canisters.

The initial data collection platforms consisted of aluminum floats filled with styrofoam for buoyancy, antenna mount attached squarely in the center and on top thereof, tied by cable and chain to a stainless steel (water tight) canister which housed the software of the system. A cable linking the transmitter to the antenna provided the necessary interconnection of the system for transmission purposes. Subsequent to the problems encountered by inundation of the data collection platforms, Marshall Space Flight Center provided a redesigned antenna float, which also housed the
soft ware in watertight boxes mounted on the float deck
The redesigned floats provided a more practical and workable
approach to maintenance of the data collection system. The
desirability of the single-unit float system versus the two
part system as initially deployed revolves primarily around
the fact that deployment of one piece of equipment is obviously
less complicated than deployment of two where size does not
make the former impractical. In addition, vandalism can be
reduced by the fact that there is no linkage between the two
earlier employed units, which might invite disconnection or
other similar tampering.

At this point, transmissions had been sporadically
received from the National Space Technology Laboratories in
Hancock County, Mississippi. However, as a result of the
physical problems of deployment, little continuity had been
achieved through use of the Pearl River Data Collection
System. In September, 1975, a quick evaluation of work
accomplished since the inception of the system revealed that
the principal problems resulted not from inadequacies of the
equipment or the concept of the system, but rather the
physical elements presented by the Pearl River.

During fall of 1975 and early spring of 1976, the three
data collection platforms deployed in the Jackson area
performed adequately utilizing the Hydrolab equipment. It
is reasonable to state that the results provided by the
Hydrolab readings did conform to the independent measurements
when taken and provided an efficient and accurate method for
the collection of data. From time to time, old and worn out elements of the Hydrolab systems required service maintenance. The only route for servicing the Hydrolab equipment was by shipment of the sensor to Marshall Space Flight Center for subsequent transmittal to the home plant in Texas. The delay experienced by such necessities averaged about six weeks per unit. All units at one time or another required such service and replacement of old worn out parts.

In the spring of 1976, the system was expanded to include two deployment sites in the vicinity of Monticello, Mississippi, as shown on Figure 1. Martek brand sensors were provided by Marshall Space Flight Center under the no-cost contract for use at these locations. In February and March of 1976, anchors were deployed at two favorable locations. In the course of anticipating shipment of the necessary analyzing equipment, considerable vandalism was inflicted on the floats and antennas over a period of about six weeks. One antenna was stolen and one float was disconnected from its anchor and set adrift. The float was recovered, while the antenna is still missing. In addition, both of the antennas were damaged by fire arm vandalism.

In early April, 1976, MAWPCC and PRBDD personnel visited Marshall Space Flight Center for orientation to the new Martek equipment. Orientation included calibration and general maintenance of the sensor equipment. To date, the Martek units have provided inadequate data and frequently
fail to transmit any intelligible data. Two of the Martek units were used temporarily in the Jackson area prior to use at the Monticello locations.

A fourth data collection platform was activated near Wanilla just above Monticello, Mississippi, in early June, 1976. A Hydrolab analyzer was installed in the original float-canister DCP arrangement. Similar problems to those encountered earlier reoccurred in that seepage into the canister created problems which affected the operation of the equipment. Certain hardware equipment was replaced and greater care was taken in sealing the canisters, thus solving the problem.

The fifth data collection platform proposed for the Monticello area was never deployed due to the vandalism discussed earlier.
PROBLEMS ENCOUNTERED DURING THE PROJECT

Problems encountered during the 18 months of this project were associated with both the physical characteristics of the Pearl River and the equipment. Probably the most frequent and difficult problem to deal with was the lack of convenient access to the buoys, coupled with erratic stages of the Pearl River. During the course of the Pearl River Data Collection System, the Pearl River fluctuated from a low of 1.11 meters (3.5 feet) on the Jackson gage to a high of approximately 11.58 meters (38 feet). During the late spring of 1975, when the river rose 7.62 meters (25 feet) within three days of flash flooding, the original anchor system (bottom anchor) was not adequate to cope with such flows and subsequently, two of the buoy units were inundated and severely damaged. Although this problem was solved by redesigning the anchor system using an overhead suspended cable, the problem of erratic stages continued to handicap the day-to-day maintenance of the system.

The original two-part DCP's required a relatively large pontoon boat for routine maintenance and instrument calibration, since the entire 204.1 kilogram (450 pound) instrument housing had to be pulled from the river. However, at the low stages experienced frequently during the first summer months, the pontoon boat was too large to navigate the river. Consequently, maintenance of the buoys was impossible as long as the river stage remained approximately 1.98 meters (6.5 feet) or less. Although the installation of the
single unit DCP's allowed easy maintenance from a small johnboat, the lack of proper launching ramps made launching and drydocking extremely difficult and laborious.

The telephone link from NSTL to the MAWPCC Data Processing Center in Jackson evidenced acceptable workability. However, the tracking by NSTL lacked consistency and predictability. On several occasions, transmission from NSTL was interrupted for as long as two weeks, either as a result of antenna repairs or other internal problems with the handling of the data at NSTL. A confidence gap immediately arose as a result of this lack of continuity of receiving the data.

Although the periodic breakdown of old and worn parts was to be expected, a skilled electronics technician was never utilized locally to recognize and remedy minor problems in the hydrolab circuitry. Additional delays of many weeks in collecting meaningful data was experienced when small elements had to be shipped off for repair or replacement.

Even though field personnel were sent to Texas to learn how to calibrate and perform maintenance of the new Martek equipment, data received from these instruments were, generally speaking, unreliable. For example, temperature during the summer months of 1976, as measured by one of the Marteks, was consistently reading 283.15 °K (10 °C) or lower, while the other Martek instruments measured more reasonable values of 298.15 - 303.15 °K (25 - 30 °C). Other Martek instruments displayed frequently unreliable data with respect to the other parameters, as indicated in
Appendix A. Initially these values were checked in the field using independent field instruments. Although calibration and maintenance were routinely maintained, the values as transmitted rarely produced reliable results.

As with all projects of this nature, vandalism was an expected problem. Although vandalism did occur occasionally, the problems resulting from this were very minor. The most serious problems occurred in the Monticello area in the spring of 1976. The extent of this vandalism has already been discussed in the section entitled "History of the Project".

One other problem which at certain times had a significant bearing on the transmission of data was the angle of transmission from the data collection platform to the satellite overhead. The Pearl River Valley is heavily wooded throughout, especially along the bank lines. In the Jackson vicinity the banks are generally high and with the tall trees on the banks, a substantial barrier stood between a direct transmission from the antenna on the data collection platform to the satellite overhead when the satellite was at a low angle to the earth's horizon. As the stages dropped to 0.91 to 1.22 meters (3 to 4 feet), the angle obviously was more impaired and the frequency of an effective transmission was thus reduced.
EVALUATION AND CONCLUSIONS

The foregoing chapter would appear to point toward a rather negative evaluation of the Pearl River Data Collection System. Our experience with the system reflects a positive approach to this concept of remote sensing. Streams such as the Pearl River, however, present very difficult environments for a system such as this to perform to an efficiency which would justify the costs. Without accomplishing an extensive cost-effectiveness analysis, it is evident that the quality and quantity of data received does not justify the capital expenditure required for the deployment of such a system if the State of Mississippi were to proceed with such, nor the daily operation and maintenance costs which would obviously be high as a result of the physical impairments presented by the Pearl River.

The overriding problem encountered throughout the project period was that the system never was stabilized for any length of time so that applications of the data could be developed. It is our opinion that with (1) a reasonably stable hydraulic system, (2) sufficiently skilled and available manpower, and (3) access to the DCP's with a small amount of effort, a workable and reliable remote sensing program can be established. An example of such a program would be in its use on certain critical reservoirs or lakes used for water supply and/or recreation. Other uses of remote sensing equipment may be developed in the areas of
in-line monitoring of sewer systems and in-plant monitoring of major wastewater treatment plant effluents.
ABSTRACT

The objective of this project was to demonstrate and evaluate the reliability of employing NASA developed remote sensing DCP's for the monitoring of water quality in the Pearl River.

Three DCP's were employed in the Jackson, Mississippi, area from April, 1975 to October, 1976 and a fourth in the Monticello, Mississippi, area from June, 1976 to October, 1976, with analytical equipment capable of measuring pH, dissolved oxygen, temperature, and conductivity.

Throughout the project period problems relating to the physical characteristics of the Pearl River hampered the acquisition of continuous, reliable data. Specifically, rapid changes in river stage and limited access to the buoys caused equipment damage and routine maintenance problems. In addition, long delays were experienced when broken or worn parts had to be shipped back to Texas for repair or replacement. Vandalism was more of a problem in the Monticello area than the Jackson area.

In spite of the maintenance problems encountered with the system, the three DCP's in the Jackson area provided efficient and accurate data during the fall of 1975 and early spring of 1976. However, by fall of 1976, it was evident that the quality and quantity of the data did not justify the capital expenses or daily operation and maintenance costs which would obviously be high as a result of the physical impairments presented by the Pearl River.
It is the author's opinion that the DCP's can be used to establish a reliable remote sensing program for water quality monitoring where there exists (1) a reasonably stable hydraulic system, (2) sufficiently skilled and available manpower, and (3) access to the DCP's with a small amount of effort.
APPENDIX A

WATER QUALITY DATA COLLECTED DURING THE PEARL RIVER DATA COLLECTION SYSTEM

---------------------------------------------------------------------------------
APPENDIX B

PEARL RIVER DATA COLLECTION SYSTEM
PROJECT SYSTEMS
DOCUMENT

-27-
PEARL RIVER
DATA COLLECTION SYSTEM
APPLICATIONS PROJECT
PROJECT SYSTEMS
DOCUMENT

January 10, 1975

Prepared
By
National Aeronautics and Space Administration
National Space Technology Laboratories
Bay St. Louis, Mississippi 39520

CONCURRENCE:

NASA/ NSTL

NASA/ MSFC

STATE OF MISSISSIPPI

Mississippi Air and Water Pollution Control Commission
Pearl River Basin Development District
PEARL RIVER DATA COLLECTION SYSTEM APPLICATIONS PROJECT

1.0 OBJECTIVE

The objective of this project is to demonstrate the application of NASA developed technology in satellite relayed data collection systems to a specific need expressed by the State of Mississippi to determine the feasibility of continuous near real time monitoring of data collection platforms to be placed in the Pearl River near Jackson, Mississippi. This document is intended to describe the cooperative efforts involved in the demonstration project including the plans, schedules, interagency commitments, and goals of the project.

2.0 NASA/MSFC PARTICIPATION

Data Systems Laboratory
Point-of-Contact - Mr. Rex Morton
NASA-AC-205-453-0991
Huntsville, Alabama

NASA/ Marshall Space Flight Center (MSFC) will provide three data collection platforms (DCP), with sensors to the Pearl River Basin Development District (PRBDD). Capability and operation of DCP s is described in paragraph 3.0. The three DCPs will be equipped with four sensors each to measure:

- Dissolved oxygen
- Temperature
- Conductivity
- pH

An earth resources data buoy (ERDB) will house sensor electronics, transmitter timer, and batteries. The antenna is housed separately on a flotation platform. Each of the three DCPs will consist of one buoy, one antenna/flotation, one antenna cable, mooring lines, and anchors. NASA-MSFC will make a site survey and provide the three DCPs to the A&WPCC during February 1975. NASA-MSFC will furnish an on-site representative to assist with the deployment, check-out and on-the-job training of maintenance personnel.

Documentation will be provided as follows:

- Instructions for operating in-situ water quality analyzer (Hydrolab)
- Field operations and Maintenance Manual on ERTS-Data Collection Platform (General Electric)
- Interconnect Diagram ERTS Data Collection Buoy
NASA-MSFC will provide technical consulting services for data collection on an as-required basis to the Air and Water Pollution Control Commission (A&WPCC). Figure 1 is an artist sketch of a typical data collection platform (A&WPCC DCPS will be packaged in a MSFC-designed buoy).

Table 1 is a summary of ERTS Data Collection Platform Characteristics.

NASA-MSFC will provide calibration data on individual sensors to NSTL so that received data may be converted by NSTL into engineering units prior to transmission to A&WPCC.

3.0 PEARL RIVER BASIN DEVELOPMENT DISTRICT, STATE OF MISSISSIPPI

Point-of-Contact - Mr. Alvin Beck
AC 601-351-6301
Jackson, Mississippi

The Pearl River Basin Development District will furnish a suitable boat, a crane capable of hoisting 400 pounds, and personnel for installation of data buoys/antennas at three locations (see Figure 2). Boat, crane, and installation personnel shall be available during the first week in February 1975. On-the-job training will be conducted by NASA-MSFC in operations and maintenance of buoy/DCPs for personnel selected by Pearl River Basin Development District. After deployment and during the demonstration period, NASA-MSFC should be contacted in case of equipment failure. Pearl River Basin Development District will review the boat, crane, and operating procedures with NASA-MSFC to ensure compatibility prior to deployment.

4.0 NASA-NSTL PARTICIPATION

Point-of-Contact - Mr. Henry Austin
AC-601-688-2125
Bay St. Louis, Mississippi

A project systems document will be prepared by NASA-NSTL and coordinated with participating agencies before the project begins. NASA-NSTL will provide equipment and personnel to receive the water quality data from the three DCPS and transmit this data over an A&WPCC telephone line to A&WPCC computers in Jackson, Miss. Initially, NSTL will track, process data, convert to engineering units, and transmit data daily, Monday through Friday, to A&WPCC. This data will normally be transmitted to A&WPCC computers in approximately 15 minutes after an ERTS pass. Exact times of data transmissions will be coordinated between NSTL and A&WPCC. Telephone line rental (call-up basis) and telephone company MODEM/coupler will be provided to NSTL by A&WPCC.

NSTL has synchronous and asynchronous communications capabilities for transmitting data to A&WPCC computer facilities. Data rates, formats, etc., will be negotiated between NSTL and A&WPCC.

NASA-NSTL will coordinate and host periodic evaluation and review meetings as shown on the project milestone schedule, page 7 and will prepare, with the assistance of participating agencies, a project report at the conclusion of the project.
Figure 1. Artists Sketch of Typical Data Collection Platform
Table 1. Summary of ERTS Data Collection Platform Characteristics

![Antenna Assembly Diagram]

**ANTENNA**

**Electrical:**
- Type
- Impedance

**Mechanical:**
- Reflector Size
- Weight
- Mounting Provision

**CROSSED DIPOLE WITH A BIFOLIUM RADIATION PATTERN**
50 ohm nominal

**ELECTRONIC UNIT**

**Electrical:**
- Signal Input
- Power Input
- Transmitter
- Frequency
- Power Drain

8 analog channels (0-5V), or eight 8-bit serial digital words, or eight 8-bit parallel digital words, or combination of the above in 8 word message format.
24 ± 3 Vdc
FM, 5 watts output (minimum)
101.55 MHz
56 watts for 38 milliseconds (during transmissions)
70 milliwatts average power (maximum)

**Mechanical:**
- Size
- Weight
- Environment
  - Temperature—Operating
  - Relative Humidity
  - Altitude

10.5 x 8.5 x 6.0 inches
15 lbs. (maximum)
-40°F to 125°F
0% to 97%, with condensation
-260 ft to +17,500 ft.
Figure 2. Approximate Locations of Deployment Earth Resources Data Buys
This project is planned to be the first direct computer to computer transmission of data from the NSTL Satellite Data Acquisition and Processing System.

5.0 AIR AND WATER POLLUTION CONTROL COMMISSION, STATE OF MISSISSIPPI

Point-of-Contact - Mr. John Smith
AC-601-354-7513
Jackson, Mississippi

A&WPC is responsible for coordination with NASA-MSFC, NASA-NSTL/Mississippi State University, and Pearl River Basin Development District in a cooperative satellite data relay project to demonstrate the feasibility and operational costs of continuous water quality monitoring stations. A&WPC is responsible for evaluating and analyzing data transmitted by NSTL. Frequency of data, formats, etc., will be provided to NSTL. Costs of communications line to NSTL and MODEM/coupler terminal at NSTL will be the responsibility of A&WPC.

NASA-NSTL will be reimbursed on a "cost additive" basis for costs incurred as a direct result of this project. Arrangements for transfer of funds to NSTL will be made through the Office of the Governor, Mississippi Office of Science and Technology located at NSTL.

6.0 ERTS RELAY SYSTEM

Data collection platforms were originally developed to demonstrate the use of satellites for collecting information simultaneously from a large area. The Earth Resources Technology Satellite (ERTS) spacecraft acts as a simple relay: receiving, frequency translating, and retransmitting the burst messages from the DCPs. No on-board recording, processing, or decoding of the data is performed. Unified S-Band (USB) equipment, used for narrowband telemetry, is used to retransmit the DCP messages to the receiving sites. Continuation of data collection is planned throughout the 1970's by employing ERTS-B and ERTS-C satellites.

The three DCPs to be installed in the vicinity of Jackson, Mississippi, are well within a mutually visible range of DCPs/ERTS Satellite/NSTL. During high elevation ERTS passes, it is possible to receive up to three separate transmissions from a DCP (three minutes apart) from each orbital pass of the satellite. These high elevation passes occur at NSTL about 9:30 AM and 9:30 PM Central Standard Time. At least one message can be relayed from each platform every 12 hours with a two-shift operation.

7.0 MILESTONE SCHEDULE

The Pearl River Data Collection System Applications Project milestone schedule is shown on Table 2.
<table>
<thead>
<tr>
<th>Event Description</th>
<th>1974</th>
<th>1975</th>
<th>1976</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configure Three DCPs - (MSFC)</td>
<td></td>
<td>12/74 - 2/1/75</td>
<td></td>
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<tr>
<td>PRBDD Boat - Equip. &amp; Personnel Available</td>
<td>2/7/75</td>
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<td>MSFC Deliver 3 DCPs to PRBDD</td>
<td>2/7/75</td>
<td></td>
<td></td>
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<tr>
<td>PRBDD Install 3 DCP/Buoys in Pearl River</td>
<td>2/15/75 - 2/22/75</td>
<td></td>
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<td>A&amp;WPCC Comm. Link to NSTL</td>
<td></td>
<td>1/75 - 2/22/75</td>
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<td>Checkout of DCPs/Satellite/NSTL/A&amp;WPCC Computers Link</td>
<td>2/22/75 - 3/1/75</td>
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<td></td>
<td>7/1/75 - 12/1/75</td>
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<td></td>
<td>12/15/75</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>1/1/76 - 6/30/76</td>
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<td>Operational Demonstration</td>
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<td>Project Conclusion &amp; Final Report</td>
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