NUECES ESTUARY ADVISORY COUNCIL

RECOMMENDED MONITORING PLAN

FOR RINCON BAYOU, NUECES DELTA

Monitoring Subcommittee:

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BOR	Buerau of Reclamation
CBBEP	Coastal Bend Bays & Estuaries Program
City	City of Corpus Christi
CCS	Center for Coastal Studies
CBI	Conrad Blucher Institute
CPUE	Catch per Unit Effort
DMS	Data Management Strategy
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
EII	Ecological Indicator Index
EMAP	Environmental Monitoring and Assessment Program
EPA	U.S. Environmental Protection Agency
GERG	Geochemical and Environmental Research Group
GIS	Geographic Information System
GPS	Global Positioning System
NEAC	Nueces Estuary Advisory Council
NEP	Net Ecosystem Production
NRA	Nueces River Authority
NWS	National Weather Service
Plan	Recommended Monitoring Plan for Rincon Bayou
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
SWQM	Surface Water Quality Monitoring Program
TAMU	Texas A&M University
TAMU-CC	Texas A&M University Corpus Christi
TCOON	Texas Coastal Ocean Observation Network
TMDL	Total Maximum Daily Load
TNRCC	Texas Natural Resource Conservation Commission
TOC	Total Organic Carbon
TPWD	Texas Parks and Wildlife Department
TSS	Total Suspended Solids
TSWQS	Texas State Water Quality Standards
TWDB	Texas Water Development Board
WWTP	Waste Water Treatment Plant
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTMSI	University of Texas Marine Science Institute

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INTRODUCTION

In response to the Texas Natural Resource Conservation Commission (TNRCC) operating rule for the Nueces Estuary adopted 4 April 2001, the City of Corpus Christi (City) must "implement an on-going monitoring and assessment program designed to facilitate an adaptive management program for freshwater inflows into the Nueces Estuary." To facilitate the development of an integrated monitoring program which will measure the effects of freshwater diversion from the Nueces River on the upper reaches of the Nueces Estuary, the Nueces Estuary Advisory Council (NEAC) has prepared a "Recommended Monitoring Plan for Rincon Bayou, Nueces Delta" (Plan). The Plan is designed to provide quality data that can be used to determine the environmental and ecological impacts of the diversion on the Nueces Delta ecosystem. The Nueces River overflow channel was dug to a depth of 1.0 ft-msl in October 2001 to increase opportunities for inflow into Rincon Bayou. In addition a pipeline will be constructed that can deliver up to 3,000 acre-ft/month from Calallen Pool to Rincon Bayou. The Plan seeks to promote cooperation and communication among all agencies, organizations, and other stakeholders involved in monitoring activities in the Nueces Delta. The Plan integrates and builds upon current monitoring efforts within the Nueces Delta to optimize resource expenditures, while working in accordance with the distinct objectives of the groups involved.

Monitoring Plan Development

A subcommittee of NEAC members, other members of NEAC, and the general public met three times (27 March, 2 April, 7 June 2001, and 3 May 2002) to develop an initial monitoring plan to be submitted at a later time to the full NEAC group for consideration. Members of the NEAC subcommittee include:

Terri Nicolau, Chair, CBBEP
John Adams, TAMU-CC, CBI
Gabrielle Grunkemeyer (replaced James Dodson), NRA
Eduardo Garaña, City
Paul Montagna, UTMSI
Brien A. Nicolau, TAMU-CC, CCS
Jim Tolan, TPWD

During these meetings, the subcommittee outlined and discussed several key issues regarding monitoring in the Nueces Estuary. The topics included current and previous monitoring programs (Appendix A),

station locations (Appendix B), monitoring objectives, questions, schedules, data needs, and data acquisition (i.e., which data to collect and by whom).

Additionally, the subcommittee developed several questions to guide development of the Plan:

1. What effects will the proposed diversion of up to 3,000 acre-ft/month directly into Upper Rincon Bayou have on the Nueces River tidal segment?

2. Will TNRCC water quality standards be maintained in the Nueces River tidal segment (e.g., dissolved oxygen)?

3. Will there be impacts on species of concern (e.g. Diamond-Back Terrapin) found in the Nueces River Tidal Segment and other areas of the Nueces Delta?

4. Will there be positive downstream impacts, and how far downstream will they be detectable?

5. How will positive impacts be defined and quantified?

6. What water quality model will provide the best information for our purposes?

7. What data are needed to develop an adequate model of the Nueces River salinity structure?

8. How do we best determine the ecological benefits of freshwater diversion on Rincon Bayou?

9. How can operating scenarios, e.g., the "pulse vs. trickle", "volume vs. frequency," "monthly vs. seasonal targets," or "pass-through banking" be best determined?

Monitoring Coordination

The Plan promotes cooperation among agencies, researchers and stakeholders by incorporating and coordinating efforts into an integrated monitoring plan. This cooperation will minimize duplication of effort among agencies, reduce the cost of monitoring, and provide integrated results to scientific, regulatory, and stakeholder communities in an efficient and timely manner.

OBJECTIVES

Based on questions raised by the subcommittee, three primary objectives of the recommended Rincon Bayou, Nueces Delta Monitoring Plan are to:

1. Determine if "no harm" occurs as a result of freshwater diversion from the Nueces River into Rincon Bayou.
2. Assess any benefits of the diversion on Rincon Bayou.

3. Assist the City in developing an optimal operational management procedure for freshwater pass-throughs based on sound science (i.e., science based on testable hypotheses or questions).

These objectives can be accomplished with intensive field sampling and modeling programs. Technical interpretation of data obtained from these two sources should be based on a basic understanding of ecological principals governing estuarine ecology.

MONITORING PROGRAM DESIGN

Assessment of ecological benefits to Rincon Bayou due to the freshwater diversion can be accomplished by enacting an intensive field program to monitor indicators of ecosystem function and integrity. Field studies should continue to use historical stations where long-term, baseline data is available. Using previously collected data ensures a sufficient temporal baseline of environmental conditions that are needed to make accurate scientific determinations of ecosystem change. Thus, the minimum field sampling plan should replicate or continue the previous monitoring performed during the Bureau of Reclamation (BOR) Rincon Bayou Demonstration Project. The BOR project, however, was limited to only three ecosystem components (i.e., marsh vegetation, benthos, and water column nutrients and productivity) within a relatively short distance (about 4 miles) from the diversion channel. In contrast, the proposed Plan has broader goals to detect change among more ecosystem components (i.e., epibenthos, nekton, zooplankton, ichthyoplankton, and avifauna) and to detect downstream effects to Nueces Bay (about 8 miles).

A model to compute "what if" scenarios can be used to assess "no harm" and to develop an optimal release procedure (i.e., test effects of different release strategies). The model should simulate hydrodynamic changes and coupled ecological responses to facilitate determination of positive downstream impacts within Rincon Bayou and the extent to which they occur. The model could be the most valuable component of the monitoring plan, allowing us to integrate data collected in the field and to design better release strategies in the future.

To develop the hydrodynamic model, additional field studies are required. The Nueces River bathymetry is not well known and needs definition. Furthermore, a special "event study" should be performed to gather data during or following flooding or droughts, which do not occur during normally scheduled, long-term monitoring programs. The ecosystem is characterized by wet and dry periods, and abundant information suggests that most ecological change, and consequent benefits, occurs during discrete flood events. Thus, water quality should be assessed during at least two dry and two wet events. To capture short-time scale information during the event, a water current flowmeter and datasonde should be placed in the Nueces River at the point of diversion. It should be noted, however, that monitoring during events does not replace or eliminate the need for monitoring historical stations.

The field monitoring in Rincon Bayou and the Nueces River is initially recommended to last four years and a final integrated report should be prepared in the fifth year. The four-year sampling period is a

minimum necessary period because year-to-year variability in climate and inflow is large. However, because many climatological events often occur on decadal time scales, a four-year period will not be representative of long-term natural variability. Data from just a short 4-year period may not capture sufficient natural variability to determine the effect of the diversion. It is likely that monitoring over a 10 - 30 year period will be necessary to answer these questions posed above.

FIELD MONITORING

After careful consideration of the monitoring objectives, the subcommittee suggests that all current monitoring should be continued. Monitoring continuity provides adequate and comparable data necessary to determine "no harm" and would facilitate development of a hydrologic model. However, existing monitoring programs will not be sufficient to meet all of the monitoring needs. Therefore, the following data should be collected and analyzed at fixed stations on a regular schedule:

- BOR Demonstration Project ecosystem components:
  - Water column properties and primary production
  - Benthos
  - Vegetation
- Other important ecosystem components:
  - Ichthyoplankton
  - Epifaunal invertebrates and nekton
  - Avian usage surveys
  - Aerial photography and ground-truth survey

Duplicating Previous Rincon Bayou Monitoring

Water Column Properties and Primary Production

Water column properties are important indicators of freshwater inflow effects in estuarine ecosystems because it dilutes sea water. Water column parameters are easily quantified in the field using a multi-parameter data sonde at discrete times and locations. Continuous monitoring at a specific site is possible with a permanent mooring of a sonde. The instrument provides measurements on multiple parameters including salinity, temperature, dissolved oxygen (DO), pH and measurement depth. Parameters such as DO and pH may not be accurate after a certain period past deployment because of instrument drift, so rigorous quality control must be in place to insure acceptable data. Additionally, water column nutrient concentrations, chlorophyll *a* (phytoplankton biomass) and primary production should be quantified. Samples should be collected monthly to identify variability within seasonal time scales. Water column data measurements should include:

- Salinity
- Temperature
- DO (concentration and % saturation)

- pH
- Secchi disk depth
- Inorganic nutrients (phosphate, ammonium, nitrate + nitrite, silicate)
- Chlorophyll *a*
- Primary production

Benthos

Estuarine benthic infauna (bottom dwelling organisms that live in the sediments) are particularly susceptible to changes in freshwater inflow because of their relative immobility. Because benthos are relatively long-lived they integrate effects over time. However, populations can change frequently, so monthly sampling is recommended. Sediment grain size defines habitat for benthos, but changes slowly so can be measured just once per year. Benthic data measurements should include:

- Abundance
- Diversity
- Biomass
- Species distribution
- Sediment grain size

Vegetation

Emergent vegetation species composition and abundance reflect the history of a salt marsh area and provide an indicator of long-term environmental conditions. Sediment characteristics affect marsh plant and animal communities and growth potential. Plants grow on seasonal cycles, so sampling should be performed quarterly. Vegetation data measurements should include:

- Pore water salinity
- Pore water nitrogen (ammonium and nitrate+nitrite)
- Soil moisture
- Leaf area index (LAI)
- Plant species percent cover and composition

Long-term Continuous Monitoring

Continuous, long-term monitoring of water quality parameters is needed at several stations in the Nueces River, Rincon Bayou, and Nueces Bay. Moored data sondes, which measure salinity and temperature, are currently located at station 105 (CBI SALT05) in the Nueces River and at stations 450 and 463 in Rincon Bayou. The CBI 011 gauge at White's Point should be reactivated and renamed station 311 to be consistent with current naming conventions.

Two new gauges are needed that measure current flow and water level. The gauges should be placed in the mouth of Rincon Bayou (location of previous USGS gauge for BOR project) and called 168A,

and just beneath the IH37 overpass at station 168. During the BOR project it was discovered that the Calallen Dam gauge did not capture stream flow from Hondo Creek and this could be a significant source of inflow during local rain events. Sondes recording salinity should be placed at the Rincon Bayou gauge. Rainfall at this site should also be measured.

Additional Field Data Needs

Ichthyoplankton

Use of Rincon Bayou as a recruitment and nursery habitat for fisheries species is an important indicator of the areas ecological value. Recruitment typically occurs in spring. High intensity sampling should occur from February to May at two-week intervals. Ichthyoplankton data measurements should include:

- Larval/juvenile fish species abundance
- Larval/juvenile shrimp species abundance

Epifaunal Invertebrates and Nekton

Estuarine epifauna (larger organisms living on top of sediments, e.g., crabs or shrimp) and nekton (swimming organism, e.g. fish) are important commercially and recreationally. Most of these organisms have estuarine-dependent life cycles and use marsh habitats . They should be sampled monthly. Epifaunal data measurements should include:

- Abundance
- Diversity
- Biomass
- Species distributions

Avian Usage Surveys

Bird use of habitats is a good indicator of increased habitat functioning. A record of birds seen during monthly sampling trips should be maintained to ascertain usability. Bird data measurements should include:

- Bird species
- Bird count
- Location, date, and time

Aerial Photography and Ground-truth Surveys

Large-scale, long-term changes in the landscape and marsh vegetation can be monitored by aerial photographic surveys. Aerial surveys should be performed once every 5 to ten years and compared

with previous aerial surveys. Since the last survey was performed in 1995, one survey is needed in 2005. Aerial surveys must be ground-truthed and classified to properly interpret the photographs. Measurements from aerial surveys should include:

- Landscape Coverage and Vegetation Types
- Mapping of Features

Table 1. Summary of sampling parameters, frequency, and stations for the fixed field sampling program. Current stations sampled in the Allison waste water treatment plant (WWTP) project that will be used in the new project and new stations needed to assess the questions posed in the Rincon Bayou diversion project.

Sampling Parameter	Frequency	New Stations	Current Stations
Water column quality and chlorophyll *a*	Monthly	168, 466C, 400F, 463, 313	104, 104A, 104B, 301, 450, 451
Phytoplankton primary productivity	Monthly	168, 466C, 400F, 463	104, 104A, 450, 451
Benthos	Monthly	466C, 400F, 463, 313	104, 104A, 301, 450, 451
Water flow/elevation	Continuous	168, 168A	105, 450,463, 311
Vegetation and sediment chemistry	Quarterly	463, 501, 562	450, 451
Ichthyoplankton	Feb to May, 2-week intervals		451, 104A, 313, 301
Epifaunal invertebrates and nekton	Monthly	313	104, 104A, 450, 451
Avian usage surveys	Monthly	313	104, 104A, 301, 450, 451
Aerial photography	Once	Entire delta	

MODELING TO INTEGRATE DATA

The subcommittee strongly recommends application of models as analytical tools to integrate various data components. Models are necessary to understand the linkages and causality in ecology that can only be inferred from correlations among data collected. Furthermore, models are critical to

understanding the sensitivity of the system to changes in management strategies. Models cannot be said to be true "predictors" of the future because we cannot predict the weather patterns that ultimately drive the system. However, it is only by linking models and field data that we can understand the possible range of future effects and quantify the critical parameters in the system. Although modeling is common in monitoring plans in other areas, this has not been done in the Nueces River and Rincon Bayou. The model should explore coupling between physical and biological processes. This can be accomplished by linking a physical model that computes salinity structure to an ecological model that computes productivity. The three main benefits of the modeling component are that it can be used to integrate data, predict effects of different water management strategies, and test the question of "no harm" to the River.

The physical and biological models must be verified, so additional short-term sampling would be necessary. Data should be collected from both low and high flow periods (seasonal highs and lows as well as extreme events), which are not necessarily based on a fixed "once-per-month" sampling schedule. Sampling should be performed during two periods to obtain replicate data.

Model Adaptation and Application

Physical model

The 3D hydrodynamic model should be based on established methods for solving the hydrostatic Navier-Stokes equations with the Boussinesq approximation for density effects. The water surface should be allowed to adjust its height based on tidal forcing to obtain wetting/drying of the tidal flats in the Rincon Bayou (i.e., the rigid-lid approximation cannot be used). The model grid should be fine enough to capture the spatial variability in bathymetry and patchiness that results due to shallow water levels. The model algorithms should be numerically stable for a time step size of at least 10 or 15 minutes to be practical for seasonal to annual simulations. Atmospheric effects must be modeled, including wind-forced circulation, mixing, sediment resuspension due to wind-induced turbulence, heat exchange with the atmosphere and evaporative fluxes leading to hypersalinity. Conservation of mass should be enforced explicitly in the numerical solution of the velocity field to simplify transport solutions for the ecological model. Vegetation in tidal areas should be modeled as additional drag terms in the momentum solution. Models that incorporate these effects already exist, so this project will not be developing a physical model from scratch. Instead, the effort will be directed at adapting a general model to the particular characteristics of the Nueces River and Rincon Bayou.

Ecological model

An ecological model should use salinity, temperature, nutrient concentrations and water level generated by the 3D hydrodynamic model to predict biological responses. Because ecological processes occur at larger spatial and temporal scales than physical processes, the physical data used should be aggregated in both space and time to compute the net transport between larger cells than used in the physical model. As long as the hydrodynamic model is formulated on conservative principles, this aggregation will be inherently conservative of fluxes. The ecological model will be based on known biological

relationships between abiotic factors and primary production.. As with the physical model, ecological models for estuarine systems already exist, so the effort of this work is directed at adapting and validating a model for the conditions in the Nueces River and Rincon Bayou.

To provide adequate data for the model of the Nueces River salinity structure, monitoring at Stations 104, 104A, 104B should remain on a fixed schedule. Additionally, monitoring of historical stations should continue, as the water quality data collected for the 3-D model is not replacing the long-term data set. In addition to new data collected in this program, the historical data below are available for model development and should be utilized if applicable:

- TPWD River surveys
- UTMSI, CCS, and CBI Allison WWTP Project
- UTMSI Rincon Bayou Demonstration Project
- UTMSI historical data from long-term inflow studies
- TNRCC SWQM station data
- Nueces River Segment classification study (APAI)

Three additional types of field data will be needed to develop the model: (1) Nueces River and Rincon Bayou bathymetry, (2) Rincon Bayou atmospheric data, and (3) short-term events monitoring within both the Nueces River and Rincon Bayou.

Bathymetric Data

To model hydrology of the Nueces River, detailed bathymetry is needed from the saltwater dam to Nueces Bay. For Rincon Bayou, bathymetry of the main channel is also needed, but a good topographic map of the entire wetland area is needed as well.

Atmospheric Data

Atmospheric data is needed on a long-term, continuous basis because Rincon Bayou is broad and shallow, and heat flux will drive circulation. Parameters needed are wind speed, direction, air temperature and relative humidity measured in Rincon Bayou itself. A single wind station is sufficient. Data from Corpus Christi will not work because it is biased based by nearness to the ocean and Corpus Christi Bay. We also need short wave radiation data although this may be available at one of the nearby airports. Ideally, there should be a shortwave and longwave radiation sensor in Rincon Bayou because the heat budgets are likely to be very sensitive, thus getting the evaporation rate correct is going to be a major issue for the model.

Short-term Events Monitoring

In addition to continuous monitoring, short-term (1 to 2 weeks) events monitoring should occur during or after an extremely wet or dry period (Table 2). Two wet and two dry periods should be studied. Monitoring will take place in existing and new stations located in the Nueces River, Rincon Bayou, and

Nueces Delta. Short-term event monitoring includes fixed, discrete-time measurements of salinity, temperature, and DO by data sonde, and chlorophyll and nutrients.

Table 2. Existing and new stations for short-term (1 to 2 weeks) events monitoring of water quality parameters.

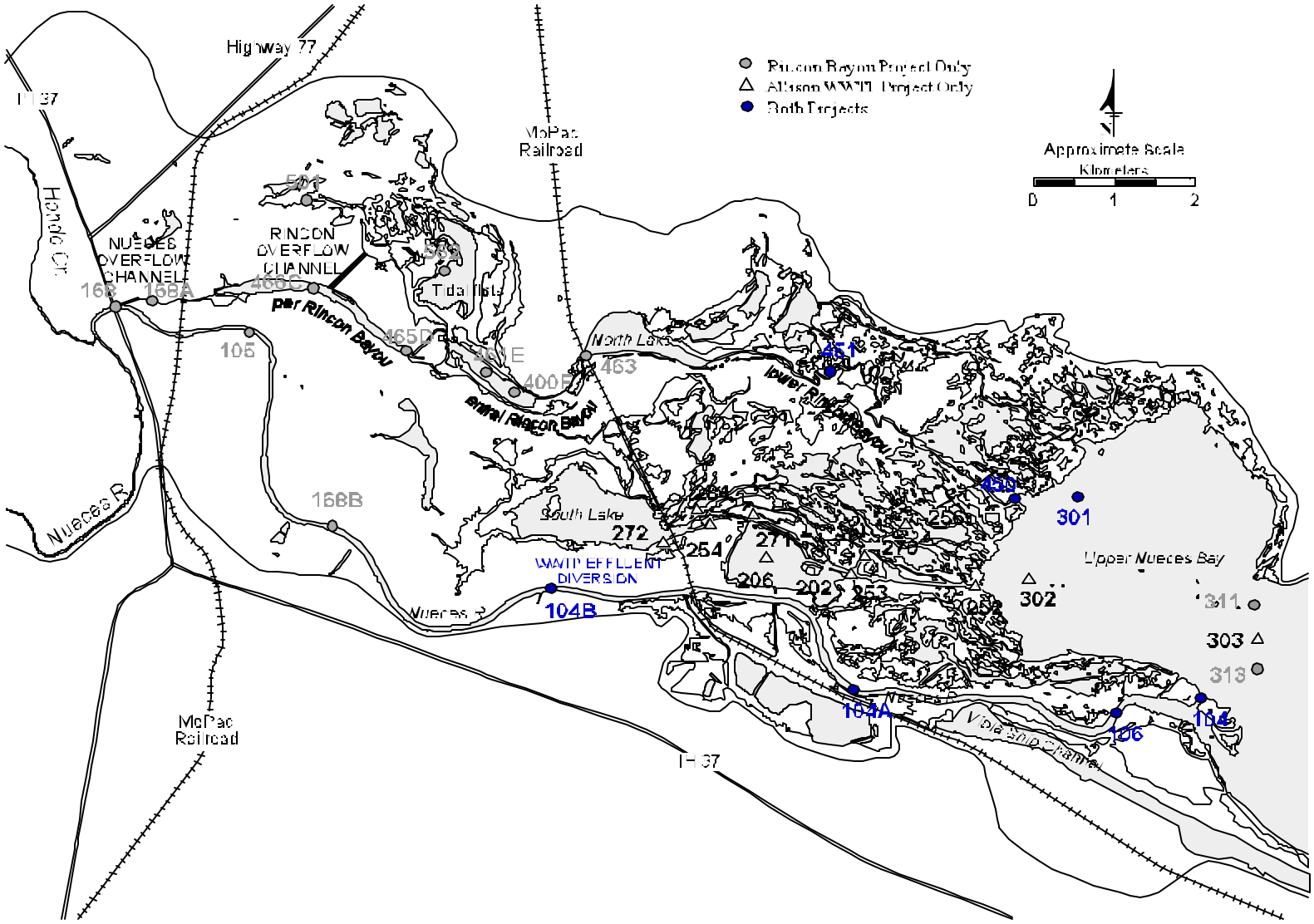
Location	Stations
Nueces River	168, 168A, 168B, 104B, 104A, 106, 104, 313
Rincon Bayou	USGS, 466C, 465D, 461E, 460F, 463, 451, 450,301

Net Ecosystem Production

Net Ecosystem Production (NEP) is the average production by all terrestrial plants calculated from measurements of atmospheric carbon dioxide (CO_2) flux and vertical wind speed measured at a single height above the surface. The Environmental Physics Laboratory in the Department of Soil and Crop Sciences, Texas A&M University (TAMU), has been measuring NEP near the Rincon Overflow Channel in the upper Rincon Delta in response to freshwater inflow since 1997 with funding provided by SeaGrant and U.S. Department of Agriculture (USDA). Measurements have shown substantial increases in NEP in response to freshwater inflow with the duration of these increases dependent on the magnitude, frequency and duration of the freshwater pulses. The measurement system consists of an instrument tower containing a fast response anemometer to measure wind speed and an open-path infrared gas analyzer to measure CO_2 concentration. The system also contains sensors to provide a continuous record of the surface energy balance, evaporation, water depth, rainfall and general meteorological conditions. The system, thus measures all meterological information necessary for any modeling studies. The system is controlled by a single data logger, and data are automatically downloaded via modem and cellular phone to the laboratory at TAMU. Power is provided by 12 volt batteries charged by solar panels. The current TAMU study, funded by USDA, will continue through 2005.

It is likely the upper Rincon Delta, where instruments are currently deployed, will be minimally affected by the freshwater diversion. Thus, a second NEP measurement system with an identical array of instrumentation should be installed in the vicinity of the Central Rincon Bayou. This system will be portable so it can be moved if needed to capture the full impact of the freshwater pulses on ecosystem productivity.

Figure 1. Location of sampling stations for the current Rincon Bayou project and the Allison Effluent WWTP project. Modified from Volume II Findings: Rincon Bayou Demonstration Project Concluding Report, Bureau of Reclamation, 2000.



REPORTING

Quality Assurance Statement

Under the monitoring plan, standard scientifically acceptable sampling and analytical methods should be used. The performing party should provide a statement on quality processes that will be used to assure that results of the research satisfy the intended project objectives. The statement should be fashioned after the U.S. Environmental Protection Agency quality assurance/quality control (QA/QC) requirements for research projects that complies with the requirements of ANSI/ASQC E4, "Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs." This Statement should, for each item listed below, present the required information, reference the relevant portion of the project description containing the information, or provide a justification as to why the item does not apply to the proposed research.

1. Discuss activities to be performed or hypothesis to be tested and criteria for determining acceptable data quality. Such criteria may be expressed in terms of precision, accuracy, representativeness, completeness, and comparability or in terms of data quality objectives or acceptance criteria. Furthermore, these criteria must also be applied to determine the acceptability of existing or secondary data to be used in the project. In this context secondary data may be defined as data previously collected for other purposes or from other sources, including the literature, compilations from computerized data bases, or results from models of environmental processes and conditions.

2. Describe the study design, including sample type and location requirements, any statistical analyses that were or will be used to estimate the types and numbers of physical samples required, or equivalent information for studies using survey and interview techniques.

3. Describe the procedures for the handling and custody of samples, including sample collection, identification, preservation, transportation, and storage.

4. Describe the procedures that will be used in the calibration and performance evaluation of the sampling and analytical methods and equipment to be used during the project.

5. Discuss the procedures for data reduction and reporting, including a description of all statistical methods, with reference to any statistical software to be used, to make inferences and conclusions. Discuss any computer models to be designed or utilized with associated verification and validation techniques.

6. Describe the quantitative and/or qualitative procedures that will be used to evaluate the success of the project, including any plans for peer or other reviews of the study design or analytical methods prior to data collection.

Data Management, Synthesis and Reporting

All data are expected to be fully quality assured by the agency or party responsible for the monitoring and, if needed, assigned data qualifiers noting any problems. The data will be compatible with standard Geographical Information Systems (GIS) formats for easy data transfer.

An Ecological Indicator Index (EII) should be developed for assessment purposes. The study should produce indicators of ecological conditions summarizing the effects of altered inflows (i.e., reduced flow in the River and increased flow in the Bayou). An EII could help summarize complex data into an easily understood presentation. While it is not the purpose of the monitoring plan to produce basic research on ecological indicators, the data should be interpreted in an ecological context that allows assessment of the project's success or failure. The EII should be developed as part of the final synthesis and integration of component data into a final report.

Annual progress reports should be prepared and presented at meetings which include both the sponsoring organizations and those performing work for the project. Annual progress reports should be limited to data presentation and interpretation of the individual component projects.

A final report should be prepared at the end of the project based on the entire 4-year field monitoring data set. The final report should contain additional, cross-component analyses to synthesize data from different components. A synthesis is essential to data interpretation in the context of ecosystem dynamics. The final report should be prepared during a fifth project year.

Annual Report Schedule

It is recommended that the Rincon Bayou project adopt the same reporting schedule as the Allison WWTP Effluent Diversion Demonstration project, starting October 1 of each fiscal year. A Component/Data Workshop should be held each year to review previous year data. The CBBEP has volunteered to coordinate the annual data presentation workshop. Monitors will present synthesized data and provide recommendations and possible changes for the monitoring program. The project could then progress on the following schedule (Table 3).

Table 3. Project time line for field sampling years.

Date	Deliverable and/or Event
June 1	Budgets for new year to sponsors
August 1	Budgets and projects approved
September 1	Contract awarded, New Fiscal Year begins
November 1	Annual Component Report due on previous years data
November 15	Workshop with presentations on previous years data
February 1	Draft Annual Report due to reviewers (2 week review)
February 28	Annual Report due
March 1	Submit Annual Report to TNRCC and NEAC
March 31	Draft comment period ends

Final Integrated Report

It is recommended that a final report integrating components of the monitoring plan be prepared only once at the end of the project. The large number of components and complex nature of this project require this approach. It is simply not practical, from a cost standpoint, to prepare annual integrated reports. The integrated report will be more than simply a compilation of component reports. The integrated report should also contain synthesis of the entire data set, with additional chapters performing this function. The synthetic report has to be prepared in conjunction with the components, but is an additional task. It will take and additional year to prepare an adequate report based on four years worth of data. It is recommended that a fifth year be funded to prepare the final report and that a lead agency be chosen to take responsibility for preparing the synthesis chapters.

COSTS AND FUNDING

The City of Corpus Christi (CCC) currently funds approximately $250,000/year for the Allison WWTP monitoring project. A portion of that funding will be used in the recommended Plan, thus field component costs for the first two years are lower than for the last two years of monitoring (Table 4). The Coastal Bend Bays & Estuaries Program (CBBEP) will provide the Center for Coastal Studies (CCS) approximately $20,000/year for ichthyoplankton studies, which will be done in cooperation with the TPWD. The Nueces River Authority (NRA) will provide approximately $6,000 for the bathymetry study in the Nueces River. Thus items 1 - 10 are currently funded at a cost of $1,468,000 over a five year period.

After the Allison WWTP project ends collections in year 2 (August 2003), part of the Allison WWTP funding can be transferred to the Rincon Project for years 3 through 5 to continue monitoring historical stations from that project, which are used in the current project.

The modeling and data integration components (Tasks 11 - 17) for years 3 - 5 lack identified funding sources. Existing funds could be used as matching money for these projects. Although the subcommittee is adamant that modeling and integration of component data is necessary, organizations or agencies to fund these components could not be identified at the present time. Thus, a total of $554,000 of additional funding is required to ensure program success.

The proposed Plan is initially designed as a five year project, with field monitoring for four years and a fifth year for the field monitoring final report (Table 5). Two components, i.e., the ichthyoplankton and short-term event monitoring (tasks 5 and 15) will occur over two annual periods. Three components, i.e., the bathymetry, aerial photography and integrated/final reports, (tasks 8, 9, 10, and 17) will occur only once. The Final Report for field monitoring and data integration may be written as one or two documents depending on funding and need. Final Report(s) should be written only once in year 5.

The current monitoring plan assumes an initial field program lasting four years. However, previous studies have shown that demonstrating ecological changes due to inflow changes can take a long time, perhaps more than 10 years and up to 30 years. The long time is required because natural variation in climate causes natural variation in ecological responses. Thus, several wet and dry cycles have to occur to define the range of responses that are normal or typical, before changes due to restored effects can be separated from changes due to natural ecological variation. As part of the adaptive management plan, it is likely that an efficient long-term monitoring program can be designed as a result of the current recommended monitoring plan.

Table 4. Projected costs by component (task). Costs are new costs in addition to the Allison WWTP project for years 1 and 2. It is assumed the WWTP ends in year 3, thus those costs are added to these tasks for years 3 and 4. Costs for tasks 6 and 7 included in task 2, but other blanks indicate the task is not funded that year.

Task	Component	Year 1 (FY2002)	Year 2 (FY2003)	Year 3 (FY2004)	Year 4 (FY2005)	Year 5 (FY2006)
1	Water	$50,000	$50,000	$100,000	$100,000	
2	Benthos	$24,000	$53,000	$119,000	$119,000	
3	Vegetation	$44,000	$44,000	$73,000	$73,000	
4	Gauge	$67,000	$26,000	$65,000	$65,000	
5	Ichthyoplankton	$20,000	$20,000			
6	Epifauna					
7	Avian					
8	Aerial				$50,000	
9	Nueces Bathymetry	$6,000				
10	Final Field Report					$300,000
	Funded Subtotal	$211,000	$193,000	$357,000	$407,000	$300,000
11	Physical Model			$40,000	$40,000	$40,000
12	Ecological Model			$30,000	$30,000	$30,000
13	Rincon Bathymetry			$40,000		
14	Atmosphere			$8,000	$8,000	$8,000
15	Event			$40,000	$40,000	
16	Net Ecosystem Prod.			$60,000	$20,000	$20,000
17	Final Modeling Report					$100,000
	Unfunded Subtotal			$218,000	$138,000	$198,000
	Total	$211,000	$193,000	$575,000	$545,000	$498,000

Table 5. Project annual task schedule.

Task	Component	Year 1 (FY2002)	Year 2 (FY2003)	Year 3 (FY2004)	Year 4 (FY2005)	Year 5 (FY2006)
1	Water	✓	✓	✓	✓	
2	Benthos	✓	✓	✓	✓	
3	Vegetation	✓	✓	✓	✓	
4	Gauge		✓	✓	✓	
5	Ichthyoplankton	✓	✓	✓	✓	
6	Epifauna	✓	✓	✓	✓	
7	Avian	✓	✓	✓	✓	
8	Aerial				✓	
9	Nueces Bathymetry	✓				
10	Final Field Report					✓
11	Physical Model			✓	✓	✓
12	Ecological Model			✓	✓	✓
13	Bathymetric Survey			✓		
14	Atmosphere			✓	✓	✓
15	Event			✓	✓	✓
16	Net Ecosystem Prod.			✓	✓	✓
17	Final Modeling Report					✓

Appendix A. Summary of All Monitoring Programs in Nueces Bay and Nueces Delta.

Program listed for institution, sponsor, location, and parameters measured. Taken from CCBNEP report.

Project Name and Performing Party	Program Description
TAMU-CC, Center for Coastal Studies (CCS)	Army Corps of Engineers Mitigation Site studies (1989 on)
Allison WWTP Effluent Diversion Demonstration Project (UTMSI, CCS, CBI, City)	Nueces Estuary; 20 primary stations; water quality, phytoplankton, zooplankton, benthos, nekton, avian surveys, marsh vegetation, soil chemistry, weekly status check on diversion site facilities. (1997 on)
Long-term freshwater inflow studies (UTMSI)	2 stations in Nueces Bay and 2 stations in Corpus Christi Bay (1987 on)
99.1.3 Atmospheric Deposition Study (TAMU – GERG) (FY 99) 0004 Atmospheric Deposition Study (TAMU – GERG) (FY 00) 0110 Atmospheric Deposition Study (TAMU – GERG) (FY 01)	Wet and dry atmospheric deposition monitoring program was amended after the first year to provide data that can be included in EPA's National Atmospheric Deposition Program (NADP). Samples currently collected weekly at two sites, one on the north shore of Nueces Bay at White Point and the other at TAMU-CC on Ward Island. Each station collects wet and dry deposition as well as meteorological data. Samples are analyzed for conductivity, calcium, magnesium, potassium, sodium, ammonium, nitrate, total phosphate, chloride, sulfate, copper, zinc, lead, cadmium, titanium, vanadium, chromium, nickel, arsenic, selenium, and manganese.
CBBEP 0002 Surface Water Quality Monitoring & Assessment Project, Phase II (CBBEP, Center for Coastal Studies TAMU-CC, NRA)	Corpus Christi and Nueces Bay sampled quarterly for TNRCC routine field, conventional water chemistry, metals in water, and benthic macroinfauna using EMAP design for station selection.
CBBEP 0109 Bay Sediment Chemistry Monitoring and Assessment (CBBEP, Center for Coastal Studies, TAMU-CC)	EMAP Surface Water Quality Monitoring project sites from Corpus Christi and Nueces Bay measured once for standard TNRCC sediment conventionals and for microbiological organisms in the sediment.
Surface Water Quality Monitoring (TNRCC)	Nueces River and Bay Sites (4 in Nueces Bay, 1 in Nueces River tidal segment) sampled 1 – 4 times per year for depth, DO, pH, temperature, conductivity, salinity, fecal coliform, nutrients, chlorophyll a, dissolved and suspended solids, metals in water, metals in sediment, organics in water, and fish tissue.
Coastal 2000 (EPA, TPWD)	Nueces and Corpus Christi Bay - Stations sampled as part of this program. Water quality parameters that will be measured include routine field parameters, nutrients, TSS, light, DO, ph, salinity, and temperature. Sediment surveys, benthic surveys, and fish trawls utilizing TPWD stations. Sediments will be analyzed for metals, organics, TOC, grain size, and sediment toxicity. Fish tissue will be analyzed for contaminants. Sampling will take place annually from 2000-2005, although the design may change in years 3 through 5.

Project Name and Performing Party	Program Description
TMDL/Oyster Water Use Impairment due to Zinc (TNRCC, GLO, TDH)	Nueces Bay - TDH will be conducting a public health risk assessment project in Nueces Bay to re-assess oyster water use impairment due to zinc contamination. Collect oyster, fish, and crab tissue and analyze for metals (arsenic, cadmium, copper, lead, mercury and zinc) as well as PCBs, pesticides, and volatile and semivolatile organic compounds. This study is a follow-up to a 1994 tissue study looking at heavy metals in oyster, fish, and crab tissue in Nueces Bay.
Mussel Watch Project (NOAA)	Corpus Christi Bay monitored under this nationwide project that has monitored chemical contaminants in sediments and bivalve mollusks since 1986. Bivalves are collected every other year and sediments every fifth year. Samples are analyzed for PAHs, PCBs, DDT, DDD, DDE, 16 other chlorinated pesticides, tributyl-tins, 3 major elements, and 11 trace elements.
Ecological Influence of Treated Wastewater Diversions on Delta Habitats in a Semiarid Climate (TAMU-CC, Center for Coastal Studies)	14 sites sampled monthly (from 1997-2003) for TNRCC routine field parameters, benthic macroinfauna, epifaunal invertebrates and nekton macrofauna, and birds.
Nueces Bay Salinity Monitoring Project (TAMU-CC Conrad Blucher Institute)	Nueces River, Delta, and Bay Hydrolab sites in the Nueces River, Delta, and Bay are monitored for routine field parameters, salinity, water temperature, DO, and pH at 30 minute intervals (1990 to present).
Ambient Water Quality Monitoring/Datasonde (TWDB- TPWD)	Corpus Christi Bay sites are currently monitored on an hourly basis for water temperature, conductance, pH, dissolved oxygen, and salinity. Up to 9 years of data are available for some historic and current sites. Data are used to establish relationships between freshwater inflows and salinity.
TCOON [Texas Coastal Ocean Observation Network] (TAMU-CC, Conrad Blucher Institute; TWDB; TGLO; USACE)	Corpus Christi Bay, Nueces Bay tide gauges are located in the CBBEP area collecting water level, wind speed, wind direction, and temperature data. Some gauges collect water quality data (*e.g.*, salinity, dissolved oxygen).
Pfisteria (TPWD)	Nueces River sites sampled approximately monthly for temperature, salinity, DO, pH, chlorophyll a, nutrients, and *Pfisteria* during 2000-2001.
Characterization of Trace Metals and Radionuclides in Lake and Coastal Sediments (TAMU-CC Conrad Blucher Institute)	Nueces Bay and Lake Corpus Christi - Sediment samples from Nueces Bay and Lake Corpus Christi are analyzed for metals, organics, and radionuclides; fresh water samples from Lake Corpus Christi are also analyzed for metals.
Radar Water Velocity Project (TAMU-CC Conrad Blucher Institute)	Corpus Christi Bay - Surface current velocities are measured periodically throughout the year in Corpus Christi Bay
Corpus Christi Ship Channel Improvement Project (USACE, PCCA)	Corpus Christi Bay and Ship Channel – exact sites to be determined An environmental assessment will be conducted as part of the ship channel improvement project which will include assessments of water and sediment quality, terrestrial and aquatic baseline surveys, recreational uses, and cumulative impacts in Corpus Christi Bay within the vicinity of the ship channel.
Bay Water (Corpus Christi/Nueces County Health Department)	Corpus Christi Bay sites are sampled on a monthly basis for fecal coliform and enterococcus.
Texas – USGS Cooperative Program, Water Resources Investigations (TWDB)	Nueces River sites are monitored daily for stream flow volume.

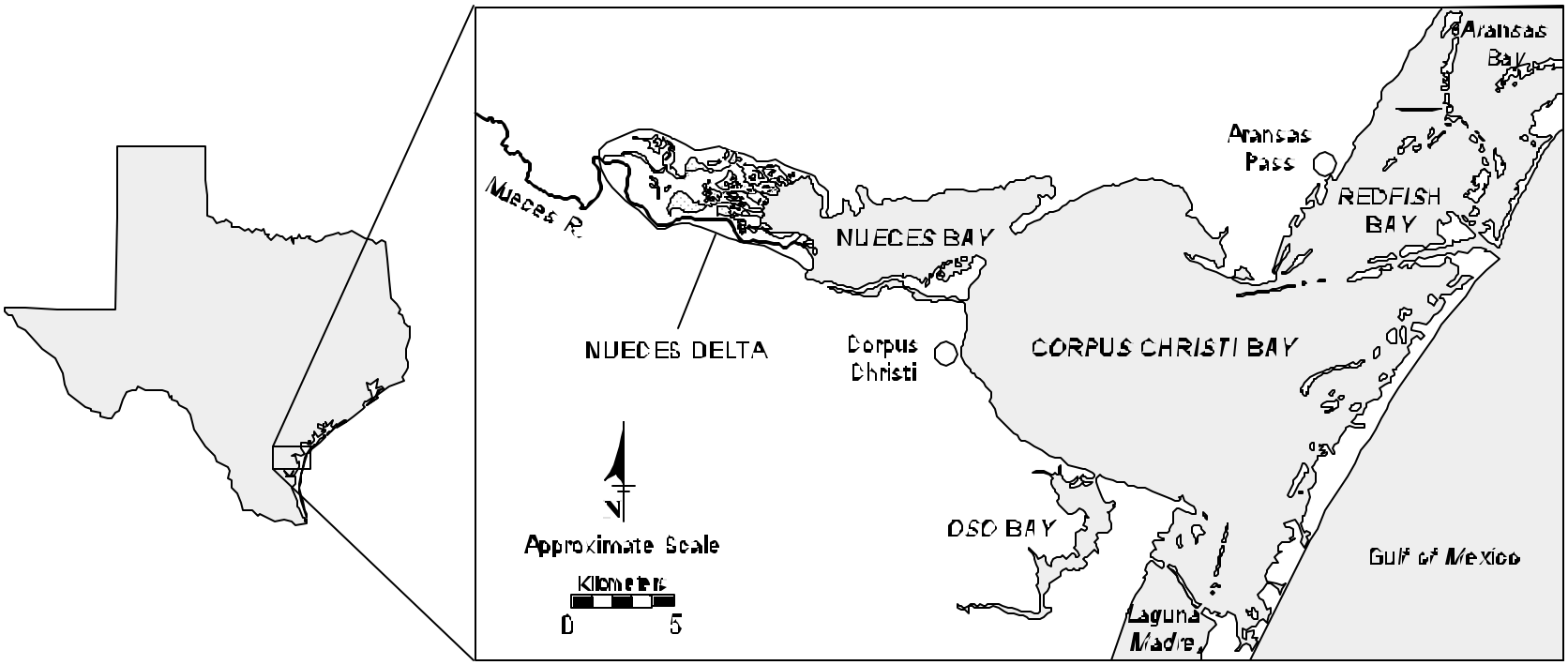
Project Name and Performing Party	Program Description
Rincon Bayou Water Level (TPWD)	Rincon Delta two sites sampled hourly measuring the water level in Rincon Delta, April 2000 to present.
Rincon Bayou Demonstration Project (UTMSI)	Three station in Upper Rincon Bayou sampled quarterly for vegetation composition and abundance and sediment salinity and nutrients since April 1995. Six stations sampled for benthic infauna, and eight stations sampled for water column quality and phytoplankton.
Nueces Bay Ichthyoplankton (TPWD)	Nueces Bay 4 sites sampled bi-monthly from February through May (1999, 2000 and 2002) for temperature, salinity, DO, pH, fish and plankton.
Ichthyoplankton Collection (UTMSI)	UTMSI pier, Port Aransas Daily data collection from UTMSI pier in Port Aransas from September through November since 1994 (data for all sciaenid fishes and notes about other taxa).
Benthos Sampling (UTMSI, TWDB, Sea Grant, GLO, US Bureau of Reclamation)	Site locations include Nueces Bay (2), Corpus Christi Bay (3), Rincon Bayou (6.) Sampled quarterly for benthic invertebrates, nutrients, DO, and salinity.
Sport-Harvest Monitoring Program (TPWD Coastal Fisheries Division)	Corpus Christi Bay sites sampled throughout Corpus Christi Bay, In all areas, intercept surveys are conducted for a combined total of 408 days annually at boat ramps and marinas. On 48 days/year roves are made to count the number of trailers at boat ramps. Parameters measured are: sport-boat harvest, fishing pressure, CPUE, size of fish, and other data as needed. 1974 to present.
Resource Monitoring Program (TPWD Coastal Fisheries Division)	Throughout Corpus Christi Bay Samples are collected throughout Corpus Christi Bay, collecting relative abundance and size of marine organism data. Samples are collected using gill nets (45 overnight sets in each of spring and fall in each bay system), bag seines (20/month in each bay system), bay trawls (20/month in Aransas Bay and Corpus Christi Bay
Shrimp Virus Sampling (TPWD Coastal Fisheries Division)	Corpus Christi Bay 240 each of brown shrimp, white shrimp, and pink shrimp were sampled annually for 3 years (1997-2000) for virus analysis in Corpus Christi Bay
Genetics Sampling (TPWD Coastal Fisheries Division)	Corpus Christi Bay; Various species of fish and invertebrate are sampled each year for electrophoresis, mtDNA, and microsatellite data in Corpus Christi Bay
Nueces Estuary Trawl Survey (TPWD)	Nueces Estuary ; Fish trawls are conducted at 10 fixed stations in the Nueces Estuary monthly during the summer and every other month in the winter for a total of 9 months per year from 1996 – 2000. In addition to species counts, routine field parameters are measured for water, including temperature, pH, DO, salinity, conductivity, and percent saturation.
Age/Growth Study (TPWD)	Corpus Christi Bay; Otoliths are collected in Aransas Bay, Corpus Christi Bay, Upper Laguna Madre, and Gulf of Mexico for determination of age of select finfish species. Sample number varies by species studied and year. Items subject to change each year. 1975 to present.
Commercial Harvest Program (TPWD)	Corpus Christi Bay Seafood dealers self-report on a monthly basis. Data include species, pounds, and price/pound for Corpus Christi Bay
Distribution of Seagrass Meadows and Wintering Redheads in Eastern Nueces Bay, Texas (TAMU-CC Center for Coastal Studies)	Nueces Bay 52 one-time emergent marsh surveys and 10 one-time seagrass surveys will be conducted along the western shoreline of Indian Point Peninsula in Nueces Bay to measure salinity, seagrass distribution, site elevation, and vegetation cover. Redhead abundance and behavior data will be collected every three weeks from October through March (2000-2001).

Project Name and Performing Party	Program Description
National Mussel Watch Program (NOAA)	Corpus Christi Bay Annual collection of oysters and *in situ* data (temperature, DO, salinity, pH). Oysters analyzed for PCBs, pesticides, and metals.

Appendix B. Historical and Current Station Designations

Stations included in the Rincon Bayou, Allison WTTP and BOR monitoring programs are included in this list to cross-reference different station names in each project.

Current	Historical		
City	UTMSI	CCS	CBI
104	4	4	
104A	4A	4A	
104B	4B		
106			6
168			68
168A			
168B			
202		NDMP 2	
206		NDMP 6	
252	52	52	7
254	54	54	4
271	71	NDMP 4	
301	1	NB 1	
302	2	NB 2	
304			1
400F	F		
450	50	50	8
451	51	51	
461E	61, E		
463	3, 60, G		
465D	65, D		
466C	66, C		
501	Ref		
562	2, 62		



Appendix C. Location of the Nueces Estuary

The Nueces Estuary, which includes the Nueces River, Nueces Delta, Nueces Bay, Corpus Christi Bay, Oso Bay, Redfish Bay, Aransas Bay, Upper Laguna Madre, and Aransas Pass to the Gulf of Mexico. Modified from Volume II Findings: Rincon Bayou Demonstration Project Concluding Report, Bureau of Reclamation, 2000.