

# **Point and Non-Point Source Pollution**

# Status and Trends of Water Quality, Sediment Quality, and Point Source Loadings in Galveston Bay

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For many years, data relating to the quality of water and sediment in the Galveston Bay system have been collected by a variety of organizations and individual researchers. The objectives of data collection have been equally varied, including the movement and properties of water, the biology of the bay, waste discharges and their impacts, navigation, geology and coastal processes, and fisheries. Some of this information dates back more than a century. While the specific purposes of the individual data collection projects have limited each Galveston Bay project in time and space, the data have great potential value to the Galveston Bay National Estuary Program (GBNEP) if they can be combined into comprehensive data bases yielding a historical depiction of the quality of the bay environment. As a part of the GBNEP, work is underway to compile and evaluate these data, and to employ these data in a quantitative assessment of alterations of bay quality and influences from point source loads.

The key objectives for these projects are:

1. Compilation of comprehensive data bases in machine-manipulable format;
2. Analysis of time and space variation (including "trends"); and
3. Identification of causal mechanisms to explicate the observed variations.

Specific parameters addressed are: nutrients (organic and inorganic carbon, phosphorus, and nitrogen); heavy metals (total and dissolved); pesticides, herbicides, and priority pollutants; chlorophyll *a* and pheophytin; pH; salinity/conductivity/TDS; turbidity/TSS; dissolved oxygen; fecal coliforms; temperature; biochemical oxygen demand (BOD); oil & grease; volatile solids; grain size (for sediments, especially sand fraction); secchi depth; chlorides; and total coliforms. Point source loads are considered to include both permitted discharges and riverine influxes. Loading is, of course, a calculated quantity, based upon the point source concentration and flow rate. Good estimates of loading can be calculated when there is simultaneous sampling of flow and concentration, as is generally the case for permitted point sources into the bay. For other point source loads such as major tributaries (including reservoir discharges), flow data are generally available on a daily basis, but constituent concentrations are not, and various statistical techniques have to be employed to estimate loadings, e.g., concentration vs. flow and load vs. flow relationships. Especially for longer term time periods, we anticipate significant gaps in both

ambient data and pollutant loading, especially priority pollutants.

A principle to be observed in the data compilation is differentiating the *primary* data base from *derivative* data bases. The primary data base codifies (in machine format) the measurements as reported by the originating agency, i.e., exactly the information implicit in the original: nothing is lost or added. Even the original units of measurement are preserved (because an apparently innocuous conversion of measurement units can introduce a distortion, by altering the implicit level of precision). For various analytical purposes, however, these data will be modified, for instance converted to common units, averaged in the vertical, aggregated, or screened out according to some criterion. The data set so processed is a *derivative* data base. Any number of derivative data bases can be created according to the needs of a scientific investigation; however, the primary data base, once established, should remain inviolate and sacrosanct.

A part of this work is the determination of the "reliability" of historical data so that measurements may be discounted that are judged to be "unreliable." The general problem of establishing data quality involves assessment of differences among data sets arising from differing analytical methodologies, different agency objectives, and differences in field procedures. For recent data with well-established protocols, quantifying accuracy and threshold is straightforward. For older data, the methodologies and care of the observers must be judged.

Several straightforward evaluations of cause-and-effect hypotheses are possible within the scope of these projects, especially the association of historical variations with large-scale controls, such as major structural modifications to the system (e.g., Houston's Northside STP, major dredge-and-fill projects, operation or enlargement of power plants, and imposition of internal barriers, such as the Texas City Dike), and with system transport.

Several reports will be produced from this project. One will address the data base itself, documenting the sources for the data, formatting of the data, methodology, quality, and spatio-temporal coverage. This will function as a Users Guide to the data base, to form the foundation for use of the data base by other researchers. This report will also include an assessment of the historical data base and the data collection programs that have produced it, with gaps and inadequacies identified, and specific recommendations for future monitoring programs in Galveston Bay. A separate document will employ the data base to characterize the Galveston Bay system, including statistical analyses of the data for key water-quality areas and all TWC segments, identification of water-quality problems, and an analysis of apparent mechanisms for the variation in space and time of water quality, and for the occurrence of water-quality problems.

## Shoreline Surveys for Unpermitted Point Source Discharges

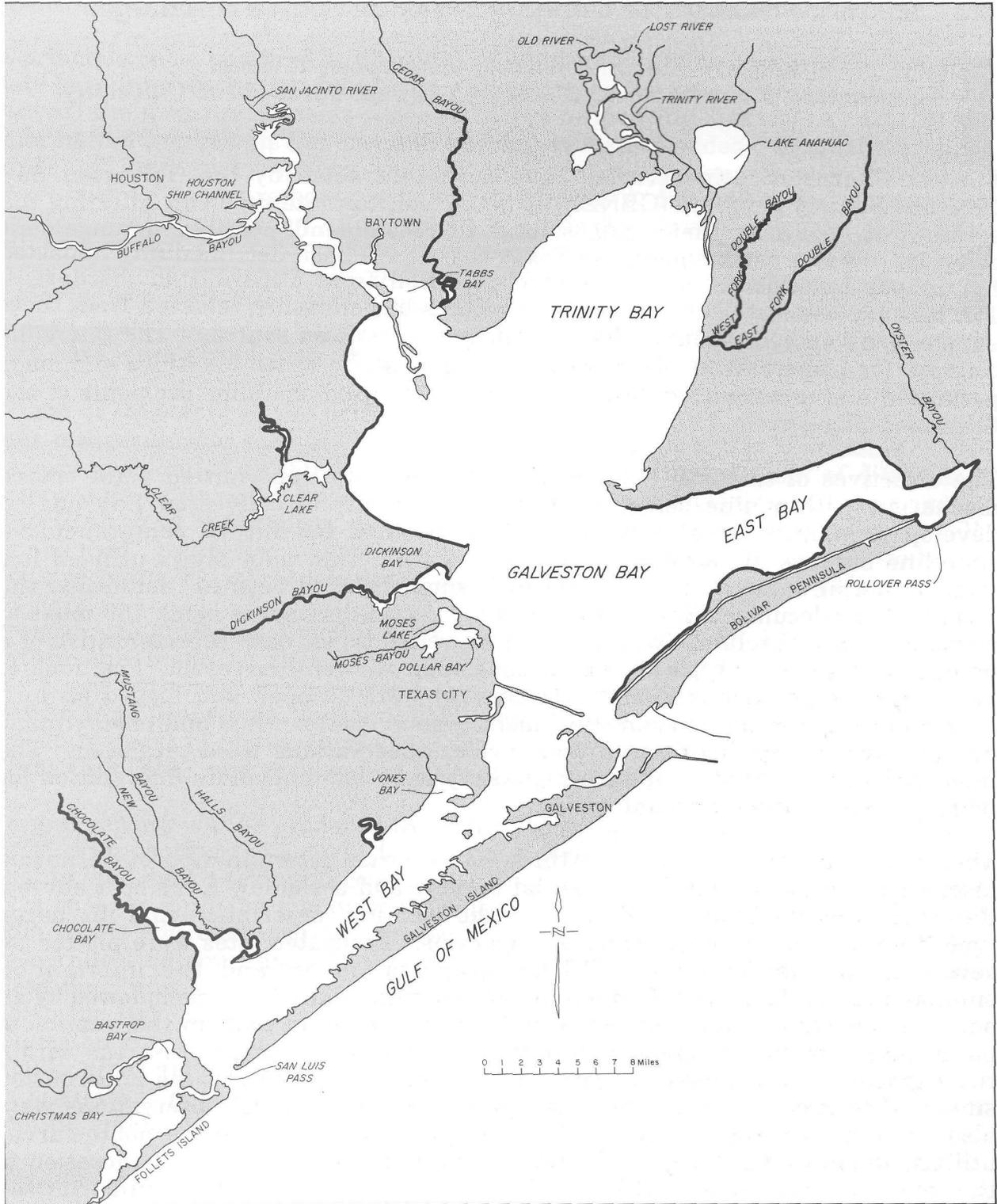
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Various Characterization studies have been contracted by the Galveston Bay National Estuary Program (GBNEP) to better substantiate problems affecting the estuary, to evaluate their causes, and to recommend possible management solutions. Water bodies along the Texas coast have been detrimentally impacted by various amounts of undocumented pollution from unpermitted discharges. Preliminary estimates are that the quantities of pollutants released from these sources may exceed amounts discharged from permitted sources. The Shoreline Surveys for Unpermitted Discharges is one such study which identifies and maps permitted and unpermitted discharges in nine selected shoreline segments of the Galveston Bay system.

The objectives of this study are to identify and map unpermitted point source discharges within nine selected shoreline segments of Galveston Bay and to develop a standard methodology and framework for future comprehensive shoreline surveys of the Galveston Bay system. This pilot study utilized low altitude aerial surveys and shallow draft small boat surveys to determine the extent of and document the location of unpermitted discharges along 159 miles of bayou and bay shoreline. Nine different shoreline types, each representative of a unique watershed or type of coastal development, were surveyed. Positions of discharges, both permitted and unpermitted were mapped and logged on to a personal computer data base management system (Reflex Plus) and photographic documentation from both aerial and surface observations were cataloged. The information was sorted to provide regulatory agencies immediate information for management and enforcement action.

The study was broken down into three basic parts: determination of permitted discharges within a segment, an aerial survey, and a shallow draft boat survey. Research was performed to determine the location, description and discharge type from the appropriate regulatory agencies. Permitted sites were plotted on seven-and-one-half-minute USGS topographical maps, and the information entered into the data base. Compilation of the initial data base was followed by an aerial photo-survey over each segment (still and video) to confirm the location of permitted sites, to document unpermitted discharges, to prioritize areas within the segment for the subsequent ground photo-survey, and to plot the unpermitted sites on the same map for use in the ground survey. Aerial observations were also entered into the database. The final part was the shoreline photo-survey utilized shallow-draft boats. This work was undertaken to verify the location of the plotted sites (using LORAN C), to search for additional unpermitted discharges, to plot these on the same map, and enter these observations into the database.

The initial cause for concern appears justified. For the study area, approximately 120 discharges are permitted by the Texas Water Commission (TWC) or the Railroad Commission (RRC). Based on the results of this project, an even greater



**Figure 1. Portions of the Galveston Bay shoreline addressed in this study.**

number of sites were identified as unpermitted with at least the potential for being an active unpermitted discharge. These include a surprising variety and magnitude of point sources and include, but are not limited to, oil production effluents, storm sewers, domestic sewage, industrial facilities, and unidentified sources.

A methodology was developed to allow a comprehensive Bay-wide survey to identify all sources of water-borne contaminant inputs to Galveston Bay, and which is applicable to all coastal waters. Some regions were better suited for aerial surveys (e.g., a shallow bayou) while others were better suited for ground surveys (e.g., a heavily foliated bayou or intensely developed shorelines). By combining both aerial and boat surveys, efficient and complete coverage was achieved.

Numerous concerns in regard to logistics, methodology, and conceptual criteria have arisen and been identified through this study. These need to be addressed in the scope of work before such a bay-wide comprehensive survey is undertaken. Further regulatory investigation by the responsible state and federal agencies will be required to determine the actual extent to which these unpermitted discharges contribute to the contaminant loading of the Galveston Bay system, and to implement corrective action as necessary.

# Characterization of Non-Point Sources and Loadings to Galveston Bay

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## Project Objectives

Non-point source (NPS) pollutants are an important factor in the management of water quality in Galveston Bay. In November, 1990 the Galveston Bay National Estuary Program (GBNEP) initiated a project to conduct a geographic analysis and priority ranking of possible NPS sources and impacts on the Bay. To perform this analysis, the Groundwater Services/Rice University project team will develop a computerized geographic information system (GIS) of the Galveston Bay watershed comprised of subwatershed boundaries, area land use, and other NPS environmental information. A comprehensive literature review, covering both national and local NPS projects, will be conducted to identify NPS loading data for several key water quality parameters. The loading data will be used in the GIS system to calculate of NPS loading rates for each subwatershed and rank each subwatershed according to the NPS contributions to the bay.

The final product will be a written report and a series of maps, delivered in both paper and electronic form, summarizing the location and relative contribution of different NPS areas to the bay. The maps will help identify NPS "hotspots" in the Galveston Bay watershed, and set the foundation for future NPS monitoring activities and development of management strategies. The expected project completion date is July, 1991.

## Project Design

As specified in the GBNEP project design, the primary elements for the NPS analysis will include watershed hydrology, NPS loading estimates, ranking of subwatersheds, upper watershed influences, and mapping. The approach to each element is discussed in more detail below.

- **Watershed Hydrology.** The entire drainage basin to Galveston Bay (excluding watersheds draining into Lake Houston and Lake Livingston) will be mapped and divided into approximately 15 major watersheds and approximately 100 subwatersheds. The delineation process will be based on the Texas water quality segments, land use patterns, and subwatershed delineations used in existing hydrologic models in the study area.
- **Land Use.** A detailed land cover/land use analysis will be developed to provide a basis for the NPS loading calculation. Two approaches for developing electronic versions of the land cover/land use maps are now being considered: interpretation of available LANDSAT imagery, and utilization of existing USGS

land cover maps augmented by analysis of aerial photos of critical areas.

- **Relative NPS Loading Estimates by Land Use Category and NPS Parameters.** Empirical data, collected from local studies when possible, will be used as the basis of the NPS loading data for this study, and representative Event Mean Concentrations (EMCs) will be compiled to quantify water quality of runoff from different land uses. Eight water quality parameters will be analyzed for the GBNEP NPS database: total phosphorus; nitrate + nitrite; oil and grease; one heavy metal (either lead, copper, or zinc); one organic compound (either phenol or pentachlorophenol); fecal coliform bacteria; and sediment (total suspended solids).

After developing representative EMCs for each parameter for the different land uses, NPS loads will be calculated by multiplying the EMCs by subwatershed runoff volumes. Runoff coefficients will be calculated using a simple rainfall/runoff algorithm, such as the SCS Curve Number Method (Technical Release TR-55), based on soil type, land cover, and land use. USGS stream gaging data, as well as detailed runoff coefficient data collected from previous NPS loading studies, will be utilized to verify the accuracy of the runoff coefficients used for the NPS loading calculation. Since the different water quality parameters impact the bay on different time scales, the calculation and mapping of NPS loading rates for each subwatershed will be repeated for three separate rainfall scenarios, such as annual runoff, a one-year frequency storm event, and a second individual storm event.

- **Ranking of Subwatershed NPS Loading Contributions.** On the basis of the relative loading estimates (developed as described above), subwatershed boundaries, and hydrologic features, each subwatershed will be assigned a total NPS loading contribution estimate using the GIS system. Each subwatershed will then be ranked relative to other subwatersheds for each of the eight NPS parameter categories. The subwatershed ranking procedure will evaluate the contributions of subwatershed land use and hydrology, as well as areal extent, in the determination of subwatershed loading contribution. Following completion of the ranking procedure, composite coded maps which display the assigned rankings from various subwatersheds will be developed using the GIS system.

- **Upper Watershed Influence.** Because NPS loadings entering Lake Houston and Lake Livingston are either greatly reduced or attenuated by the reservoirs, the upstream watersheds of the San Jacinto River and the Trinity River are excluded from this analysis. Existing water quality data, collected at regular periods below the reservoirs, will be statistically analyzed in detail and compared to the hydrologic record to estimate NPS loadings from the two reservoirs.

- **Mapping.** A GIS known as SYSTEM 9 will be used to process the land use and NPS loading data and prepare all final project maps. The SYSTEM 9 GIS has been used successfully at the Rice University Department of Environmental Science and Engineering for over a year to conduct well head protection mapping, and is well suited for the geographic interpretation and mapping requirements of this study. The SYSTEM 9 GIS is an advanced, object-oriented product based on the EMPRESS standard query language (SQL) database system. The spatial

correlation and querying capabilities of SYSTEM 9 will greatly enhance efficient data compilation and map production for the project. The SYSTEM 9 product includes a user interface, known as the Analytical Tool Box (ATB), that allows complex surface area and perimeter computations, geometric union and intersection calculations, and the performance of data retrieval and update functions. The final electronic versions of the GIS products will be delivered to the GBNEP in ARC/INFO format, a standard GIS file format, so that other researchers can utilize the maps for future projects.

### **Work Performed To Date**

A comprehensive literature review of local and national sources of NPS information has been completed. A detailed listing of local NPS EMC data has been compiled, and has been supplemented with national data for selected parameters, such as oil and grease. Electronic versions of USGS 1:24,000 topographic maps have been entered into the system, and a second GIS workstation has been purchased. Harris County Flood Control District watershed maps and Soil Conservation Service soil maps have been obtained, and digitizing of these maps into the System 9 software has been started. Options for constructing the land cover/land use maps have been developed, and are now being evaluated in detail.