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EXECUTIVE SUMMARY

ECOLOGICAL EFFECTS OF THE HOUSTON LIGHTING & POWER COMPANY CEDAR BAYOU GENERATING STATION ON THE ENVIRONMENTS OF TRINITY BAY AND VICINITY

FINAL REPORT
Project No. 01-5723

By

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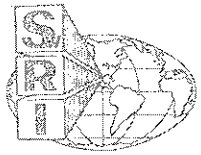

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I. INTRODUCTION

In the late 1960's and early 1970's, a new era of environmental awareness arose in the nation, and, in part, was focused on effects of electrical generating stations. The Houston Lighting & Power Company (HL&P) Cedar Bayou Generating Station became a target for that concern. The Cedar Bayou station was being built as one of the largest fossil fueled plants in the nation, and design allowed for expansion into even larger capacity. Concern about the environmental impacts of the project focused on the planned transport of cooling water from an area classified as industrial waters across six miles of land to another fresher, cleaner bay considered by regulators to be in a near pristine condition. The Houston Ship Channel was held as a national example of polluted water at its worst. Dredging plans for the new cooling water intake channel to Cedar Bayou showed the channel leading to near the Ship Channel. The perceived potential for degradation of the receiving waters, Trinity Bay, by the cooling waters resulted in intervention by the then newly formed Environmental Protection Agency in an effort to assess likely plant impacts and to incorporate controls.

After intensive agency review of the Cedar Bayou project, the discharge was designated as being potentially hazardous to the indigenous flora and fauna of the receiving waters, Trinity Bay. Houston Lighting & Power disagreed with the perceived harmful effects from construction and operation of the power plant and an impasse resulted. This led to suits being filed by both parties and a series of legal actions which resulted in an agreed judgement entered by the U.S. District Court, Galveston Division (Judgement 72-G049) establishing the requirement for monitoring of the Cedar Bayou Generating Station. The judgement required the monitoring program which was initiated on February 22, 1973 by Southwest Research Institute (SwRI) and is continuing at the present.

Southwest Research Institute reports an intensive analysis of the data generated during the monitoring program in the accompanying document. This report was modeled after previous analyses done in 1975 and 1976 by Drs. J. G. Mackin, Professor Emeritus, Texas A&M University, and E. G. Fruh, University of Texas (deceased), both widely respected scientists of Gulf of Mexico estuarine ecology.

The mission of the present analysis and report is to determine if the discharge of cooling waters from the Cedar Bayou station has had a detrimental

impact on the flora and fauna of the receiving waters. All statements made in this summary are from direct observations and conclusions made by the various scientists who analyzed data and, though the narrative may have changed, are as reflective of the overall data synthesis as the present writer can make them. The Project Manager takes sole responsibility for statements made in this summary.

II. BACKGROUND INFORMATION

At the time of construction of the Cedar Bayou Generating Station, Cedar Bayou itself was a grossly polluted stream, the recipient of high levels of poorly treated municipal sewage and oil field brine. Its normally sluggish flow allowed the buildup of these contaminants to seriously affect the bayou's capacity to develop a normal population. Immediately after the station commenced operation, reversal of flow in Cedar Bayou downstream from the Intake Structure and introduction of cleaner waters from Galveston Bay brought about an immediate improvement in water quality. The waters of upper Galveston Bay were, themselves, being cleaned up during this period of time by new requirements for improved quality in industrial discharges. In addition to state and federal requirements for cleaner effluents, the general area of the upper Texas coast has experienced a period of high rainfall over a number of years. The combination of extra dilution, flushing action of extra runoff, and better quality effluents has contributed to development of a much more desirable Galveston/Trinity Bay complex; thus, the water that has been transported through the Cedar Bayou station has a long history of becoming cleaner with time.

The cooling pond system of the station is large enough to not only cool the large amount of water used, but to also act as a treatment center, allowing assimilation and incorporation of excess nutrients in entrained water. It has been shown to function well in this capacity, at the same time allowing stabilization of the extra nutrients in "healthy" populations of plankton and desirable nekton such as shrimp and gamefish. In addition, the low levels of potentially toxic metals such as copper have been shown to be incorporated into the cooling pond sediments and "trapped", though not at levels high enough to cause concern.

All of these described happenings and conditions work together to enhance the quality of the effluent water from the Cedar Bayou station relative to the receiving waters of Trinity Bay. The following discussions of separate parameters of ecology of the plant environs will emphasize the technical findings of the accompanying report. These findings taken together demonstrate that Trinity Bay is not adversely affected by the discharge.

III. SIGNIFICANT FINDINGS

Results from this program are bulky and comprehension of all the information is quite difficult. Therefore, this summary does not give findings from every category of data examined. It will cover those which are significant in showing the presence or absence of generating station effects and for parameters which have been cited as particularly problematic by the EPA.

A. Water Quality

The hydrographic parameters measured during this study show that the primary physical change in the receiving waters after introduction of the cooling waters is a slight increase in salinity at the immediate discharge site. Higher salinity waters from the Cedar Bayou intake are different enough in density that they "duck under" the receiving waters and move to deeper areas of Trinity Bay in a bottom front that is not distinguishable beyond a few hundred meters. The temperature of the discharge waters declines to essentially ambient during residence in the pond and no problems of low dissolved oxygen, pH alteration, or excessive nutrient levels occur.

The most telling set of data on water quality are the nitrogen parameters, especially the changes in nitrogen species in the cooling water as it transits the cooling pond. Dr. Fruh's earlier analyses indicated that more information on nitrogen might show how effective the pond is in effecting what amounts to high level tertiary treatment of water. Results of subsequent studies indicate two important trends. First, the cooling pond served efficiently in reducing nitrogen levels of the water during the first five years of monitoring. A slight increase in nitrogen emanating from the pond in 1978 indicates that a stable condition may have been reached in which sediments and transient waters are reaching equilibrium. Second, the absolute levels of nitrogen are neither limiting to phytoplankton nor above what might be expected. At the same time, phosphorus levels have always decreased in the cooling pond and maintained a ratio with nitrogen of about 1 : 2, indicating that if other factors were not limiting, nitrogen would be the limiting element.

B. Sediment Chemistry

The single most important factor in determining the contaminant level of sediments in the study area is the grain size of the sediment. Where very fine clastics and higher organic content occur, higher absolute levels of all metals

and pesticides can be expected. The absorption of pollutants is due to the increased surface area available and electromagnetic charge associated with the extremely fine-grained particles. The data show that those stations in the study area nearest to potential pollutant sources, such as the Baytown sewage works and Trinity River, have shown higher levels, other factors being equal. The sediment type at the discharge is comparable in pollutant binding capacity with that nearer the Trinity River, but has shown less pollutant buildup. Thus the potential for incorporation of contaminants at the discharge has not been realized.

Copper has been shown to build up in the cooling pond over time. The level reached (≃ 7 ppb) is very low in comparison to the Houston Ship Channel and well below EPA stated acceptable levels for dredged material (50 ppb). Copper in clams has also shown a slight increase in the cooling pond though the levels are equal to those in the same species in San Antonio Bay, a "clean" area. Copper is one area of unequivocal increase in contaminants likely to have come from plant operation; however, the levels are apparently of no environmental significance.

Pesticides have been searched for in both sediments and bottom dwelling invertebrates (primarily clams) using extremely sensitive analytical techniques. Overall, pesticide occurrence is spotty and in extremely small amounts when found. Pesticides, apparently from the Baytown sewage and upstream rice fields, do enter the cooling pond and Trinity Bay. The absolute level of DDT, for example, in station C1 sediments in the discharge area is about 1 ppb. This is about the same as at the control line near the Trinity River. Organisms from the cooling pond and discharge area show levels of DDT lower than at the control site. Overall, pesticide data are difficult to use in forming conclusions because absolute levels are low, occurrence is spotty, and trends tend to contradict each other.

The physical measurements of water and sediments indicate that the water quality of effluent waters entering Trinity Bay are not degrading to the ecosystem.

C. Phytoplankton

It has been estimated that 94 percent of the primary productivity of Galveston Bay comes from the phytoplankton. This study has identified 225 species ranging from freshwater to primarily estuarine forms. Of these, the most numerically abundant are the diatoms, followed by the green and blue-green algae. This report focuses on these three important groups, discussing

species, total numbers, changes in populations, and importance to maintenance of a balanced ecosystem.

Of the primary divisions of phytoplankton, the diatoms are considered to be the most "desirable" as sources of food for zooplankton, larval invertebrates, and fish. Oysters, shrimp, and menhaden are among those important species in the present study area which are heavy grazers of diatoms. Diatoms occur both in the water column and on the surface of the sediments. In Trinity Bay, those from the sediments are frequently suspended in the water column, thus becoming a part of the population sampled as phytoplankton. Populations are capable of explosive growth, but do not produce toxic metabolic products. Findings from this study indicate that the diatom numbers range from one to twenty thousand cells/ml, with the most abundant populations being from the intake waters and the discharge area. Both show numbers higher than the receiving waters or control locations. The species makeup and absolute numbers indicate that healthy populations entering the system are either maintained or rejuvenated through the cooling pond, and provide a highly desirable source of nutrients at the discharge into Trinity Bay.

Blue-green algae are the anthithesis of diatoms in the consideration of the ecologist. They are not particularly desirable as food, produce toxic effects in blooms, and are usually indicative of an imbalance in the ecosystem such as might be brought about by an excess of nutrients. The blue-greens are a natural component of shallow sub-tropical estuaries, and are common in the Galveston Bay system. One of the primary concerns about the effects of the Cedar Bayou station has been that the cooling pond might offer just the right set of conditions to cause blooms of blue-greens and thus damage the receiving ecosystem. The long-term observation of this study is that blue-greens have never been a problem in the discharge waters and, in fact, show a trend to decrease in numbers between the intake site and discharge into the Bay.

The green algae contain three of the six most abundant species found in this study. Typically extremely small and not usually taken in standard phytoplankton sampling schemes, these "nanoplankton" have been shown to be a greater component of the phytoplankton in this study area than has been previously thought for Galveston Bay. The greens are desirable foodstuffs, especially for small organisms such as recently set oyster spat and other molluscs. They are also an important component of the food of shrimp and other larger organisms.

The consistent pattern shown in this investigation has been one of high productivity of desirable algae in the cooling waters of the station. There is evidence that the peak of productivity in species and numbers was realized in 1975, and that subsequent populations have either been lessened or equilibrated. This indicates that the cooling pond may have reached a steady state, or is declining slowly in overall nutrient availability.

D. Zooplankton Studies

An involved qualitative and quantitive study of zooplankton species and numbers reveals that patterns of succession and productivity in the environs of the Cedar Bayou station are highly variable. The variability is a reflection of the widely differing temperature, salinity, and productivity of a typical sub-tropical estuary and makes determination of any effects induced by the power plant hard to identify. In general, it can be shown that a diverse set of plankters is pulled into the plant from freshwaters coming down Cedar Bayou and from saltier water from upper Galveston Bay. These stocks are relatively euryhaline, and those that survive thermal shock are readily capable of producing rapid blooms in the relatively benign environment of the cooling pond. Thus, graphs of populations consistently show cooling pond diversity equitable with the Trinity Bay receiving waters and numbers of individuals usually higher in the pond.

Examination of the plankton near the discharge shows that these stations are very similar to the control stations in number of species and individuals. In both summer and winter, the effluent was comparable to the receiving waters in both species and numbers and exerted no significant influence on the balance of Trinity Bay fauna. There is no indication that higher temperatures during the warmer months cause a decline in zooplankton abundance in the cooling pond, though actual numbers are lower than the control sites. It is likely that other factors acting with temperature play important roles in controlling abundance. Correlating temperature and salinity with abundance at the intake structure and the discharge indicates neither is a limiting factor. In addition to the physical factors and their direct effect on zooplankters, the incorporation of available nutrients into phytoplankton as food is a paramount control over zooplankton populations. This is readily seen in the yearly spring bloom of algae followed shortly by a zooplankton increase.

E. Benthos

The benthos is cited as the best indicator of stress on the marine environment. Because they are sessile as adults and cannot escape the pollution or physical change causing the stress, benthic populations can be monitored periodically to ascertain when and where actual stresses have occurred. In addition, their ability to biomagnify certain contaminants and incorporate them into the food chain causes concern should any buildup of these contaminants take place. Therefore, the benthos have played a primary part in the present analysis and final determination of the effects of the Cedar Bayou station.

The present study identified approximately 336 taxa typical of the Gulf of Mexico shallow bayheads. They are characteristically euryhaline and opportunistic and thus capable of exploiting any situation in which stress from change in salinity or other factor has caused a dieoff of resident fauna. This analysis examined the species and numbers at stations representative of the intake, cooling pond, discharge, and control areas of the Cedar Bayou station environment. Most of the effort was to document change and determine why it occurred.

As with the other biological parameters, the long-term trend in benthic populations in the cooling pond has been toward an increase over the first two to three years of the study, then a decrease in numbers. Other stations varied considerably over the timespan of the study. The trend at the discharge site was typical, with an increase in both total species and individuals until 1976, then a decline to an apparent equilibrium, apparently in response to the nutrient levels and recruitment coming from the cooling pond. At the G control stations, near significant Trinity River outflow, numbers and species diversity were greater than at other sites. This was apparently from significant nutrient (sediment, detritus) inputs from the river, and also the drastic changes in population structure when a set of species which live under one salinity regime are excluded after a significant salinity change and another species regime moves in. No clear pattern of increase or decrease with distance from the discharge could be found at other stations.

Investigation of the productivity of all stations over the seasons showed that winter productivity was consistently the highest, a reflection of higher recruitment of young to the resident populations as is expected in Texas bays. The hot months of summer showed consistently lowered productivity, and the most significant decreases were seen in the cooling canal carrying heated water to

the cooling pond. The populations in the canal show a virtual dieoff during the summer, only to repopulate rapidly as soon as absolute temperatures fall to a tolerable level in the fall.

Beyond the immediate effects of the original scouring of the bottom in the discharge area when the power plant was started up, no effects to the resident benthic biota of Trinity Bay can be ascribed to Cedar Bayou station operations.

F. Nekton Analysis

It is commonly accepted that nekton data are usually inadequate for use in drawing conclusions about environmental effects because of the difficulty in catching adequate numbers of representative species, and due to the wide variability in populations geographically and temporally. The long term of this study and the large number of trawl samples taken has alleviated part of the problem and the fact of significant transport of water from one area to another at some distance removed further increases the chances of detecting effects. When the results of data summaries are made graphic, definite indicators of nekton success in the area of the Cedar Bayou station are seen.

During the hottest months of the year, significant mortality occurs to nekton subjected to the elevated temperatures of the cooling canal. This two-three month period occurs from late June to early September and is bracketed by a month to six weeks of stressful conditions both before and after. During the remaining seven months of the year, no heat effects are demonstrable by the catch in the cooling canal. When considered on an annual basis, the overall productivity of the cooling pond is high due to the periods of the year when survival of entrained and impinged organisms is sufficient to lead to a balanced population in the pond. Both numbers of species and individuals in cooling pond catches demonstrate the productivity level, and high numbers of organisms in catches at the discharge show the attraction which discharged waters have for Trinity Bay fauna. Species of nekton which represent foragers on phytoplankton, zooplankton, and baitfish as well as top carnivores confirm the balanced web of biota exiting the system.

The history of the cooling pond shows that numbers in the pond increased rapidly in the first years of plant operation and reached highest levels of individuals in 1976. While in subsequent years the numbers of species and

individuals have varied, and been slightly lower in some years, the totals have continued to remain higher than other stations surveyed.

There is no avoidance of the discharge site at any time of the year, and the attraction for all forms is further documented by the consistent high usage by and success of sportfishermen. Trinity Bay itself remains a heavily fished estuary with no indication of decline in either sport or commercial fishing.

IV. CONCLUSIONS

As is readily evident from perusal of this document, the scientists who have been monitoring the Cedar Bayou Generating Station for over six years and have done a thorough summary of the data are convinced that operation of the plant has not significantly affected the balance of indigenous flora or fauna in the receiving waters of Trinity Bay. As exemplified by the increase of life in the Cedar Bayou Channel from nearly nil to highly abundant and the overall health of the populations exiting the cooling pond into Trinity Bay, it may be considered that the plant has been helpful in restoring to a better condition areas which have previously been degraded by man.

As a convenience to readers, conclusions of the investigators in each research area reported are listed below.

A. Water Quality

- The physical and chemical data indicate that the effect of the operation of the generating station on Trinity Bay is very small, and where detectable, confined to the stations in the immediate vicinity of the discharge.
- The preliminary conclusions and trends noted by Fruh are essentially the same today.

B. Phytoplankton

- The diatoms were more important numerically than blue-green algae by a factor of ten at station DS and were more abundant there than at Trinity Bay control stations.
- The green algae were important numerically, comprising three of the six most abundant phytoplankton species in the entire study.
- Phytoplankton data on abundance and species composition do not indicate the phytoplankton community to be adversely affected by cooling pond effluent.

C. Zooplankton

- The operation of Cedar Bayou Generating Station had no adverse effect on zooplankton in Trinity Bay.
- The cooling canal and cooling pond stations had higher zooplankton abundance than the Trinity Bay stations most of the time.

- o Although summer months showed decreased plankton productivity in recent years, no adverse effect was observed on Trinity Bay plankton productivity.
- o Zooplankton species coming out of the cooling pond were comparable to those in Trinity Bay.
- o Food availability might be a more significant limiting factor on zooplankton abundance than temperature and salinity in the study area.

D. Nekton

- o There is no evidence indicating that the nektonic population in the study area has been adversely affected by the operation of Cedar Bayou Generating Station.
- o The immediate discharge site serves as an attractant to fishes and crustacea and is superior to the surrounding area in terms of productivity.
- o Seasonal cycles are the dominant factor in changes of numbers of species and abundance in the study area.
- o The temperature in the cooling pond and discharge site permit the maintenance of species diversity characteristic of Trinity Bay.

E. Benthos

- o The benthic population immediately beyond the discharge site is not harmed by the cooling pond discharge.
- o Productivity (in terms of number of species and number of individuals) in the cooling pond and at the discharge site tends to be as high or higher than most localities in the bay.
- o Productivity in the cooling pond and at the discharge site appears to be related to the year round maintenance of moderate temperatures and other factors conducive to growth.

V. RECOMMENDATIONS

It is the considered opinion of the research team monitoring the Cedar Bayou Generating Station that the years covered and intensity of sampling in this program has allowed coverage of all likely environmental perturbations from the plant within economic reason to ascertain. Further study of the power plant environment is not likely to result in findings of detrimental impact from operation. Therefore, we recommend that this program be stopped as soon as practicable.