NUECES COUNTY STORMWATER MANAGEMENT MASTER PLAN

SOUTH TEXAS WATER AUTHORITY

OCTOBER 1986

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A Centerra Company

NAISMITH ENGINEERS, INC.
Consulting Engineers

NUECES COUNTY

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The development of a master plan to control stormwater within the unincorporated areas of Nueces County, Texas, has required the assistance and cooperation of a number of capable individuals. HDR Infrastructure, Inc., and Naismith Engineers, Inc., would like to express their appreciation for this help to Mr. Tom Brown of the South Texas Water Authority, to Messrs. Bob Wear, Gary Laneman and Jim Fries of the Texas Water Development Board, and to the Nueces County Commissioners.

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EXECUTIVE SUMMARY

Nueces County is susceptible to flooding because some of its defined drainageways and creeks are constricted by inadequate channel capacities and man-made barriers such as road and railroad embankments, and because its flat topography and low soil permeability create poor drainage and ponding. Two feasible solutions to flooding problems in the County are (1) to identify areas of inadequate drainage and limit development in these areas, and (2) to upgrade drainage channels and replace constrictive barriers in existing developed areas.

There are nine drainage basins that must be analyzed in order to develop a stormwater masterplan for the unincorporated areas of Nueces County. Such analyses should include development plans and causes of specific area flooding. Maintenance program requirements, environmental impacts, and cost estimates are other critical factors in the viability of the masterplan.

Hydrology studies for the area are based on determining the instantaneous peak discharge values at key points along the nine drainageways in the County. Peak discharge is a function of precipitation magnitude and intensity, drainage area, topography, soil type, soil-moisture conditions, channel conveyance and other factors. Because the streams of Nueces County lack sufficient historical storm event records, a method selected as best applicable to the County is the USGS Method from the U. S. Geological Survey, except for one basin where the Cypress Creek Method from the Agricultural Research Service was used. The hydraulics were then determined using the Corps of Engineers HEC-2 Model, which computes and plots the water surface profiles for all flow conditions, including the effects of bridges, culverts, weirs, embankments and dams. The program can determine water surface profiles for various frequency floods for both natural and modified conditions.

The masterplan aims to reduce flood damages through both structural and non-structural measures. Possible non-structural measures include floodplain regulation, floodproofing, flood forecasting, on-site detention of stormwaters, clearing and snagging existing streams, and buyout and relocation of structures in the existing floodplain. Possible structural measures include storing flood waters in reservoirs, enlarging and straightening the channels, enlarging the bridge openings, and constructing flood protection levees.

The flooding potentials and recommended alternative solutions for each of the nine drainageways are outlined in the following list. In all cases, development in the areas should be carefully controlled within the 100-year flood boundaries to insure adequate flood protection and to meet FEMA requirements.

BASIN DESCRIPTION	NEEDED IMPROVEMENTS
1. Nueces River -- No planned development.	(a) None proposed (b) Study recommended for efficient flood flow passage.
2. Oso Creek -- High development expected near Corpus Christi. Backs up to influence Robstown area.	(a) Replace bridge at FM 763; raise roadway. (b) Replace bridge at St. Hwy. 44. (c) Replace bridge at Tex-Mex R.R. (d) Widen channel from St. Hwy. 44 to Co. Rd. 44. (e) Replace bridge on West Oso Creek at FM 665. (f) Investigate and clean ditches from Oso Basin to Petronila Creek.

BASIN DESCRIPTION	NEEDED IMPROVEMENTS
3. Petronila Creek -- Upstream flooding problems; downstream of FM 665 has few problems.	(a) Widen channel from FM 665 to near Mo-Pac RR. (b) Replace bridge at FM 2826; raise roadway. (c) Construct diversion ditch along west side of Driscoll.
4. Pintas Creek -- Flooding adjacent to channel, becomes sheet flow toward Driscoll.	(a) Widen channel from Petronila Creek to Nueces-Jim Wells county line.
5. Agua Dulce Creek -- Flooding between U.S. 44 and FM 70, overflow from Banquete Creek.	(a) Replace bridge at FM 666; raise roadway. (b) Widen channel from St. Hwy. 44 to FM 70.
6. Banquete Creek -- Flooding problems only when Agua Dulce Creek overflows into Banquete Basin.	(a) None proposed.
7. Quinta Creek -- Backwater flooding from bridges and due to Agua Dulce Creek.	(a) Replace bridges at FM 1833 and Co. Rd. 95 with one bridge at FM 1833.
8. San Fernando Creek -- Limited development. Some overflow goes to Carreta Creek and then toward Bishop.	(a) Widen channel from Nueces - Kleberg county line to Nueces-Jim Wells county line. (b) Replace bridge at FM 1355.
9. Carreta Creek -- Few flooding problems except for some overflow from San Fernando Creek.	(a) None proposed.

A sensitivity analysis at the channel roughness parameters (n-values) indicate that maintenance of stream channels is critical in solving local flooding problems.

Estimated capital costs for the recommended improvements are itemized in the Masterplan Report. The total estimated costs for all the improvements are $106,146,900, with $6,823,700 for structures and $99,323,200 for channelization efforts. It should be noted that channelization of the San Fernando Creek, at the sum of nearly $27,000,000, is an effort that extends over into Kleberg County.

Priority for implementing the recommended improvements is based on these criteria: severity of flooding problem, development potential of the area, capital costs, maintenance costs, ease of implementation, environmental impacts and socio-economic benefits. Weighting factors were then applied to these criteria, and the following order ranks the priority of the improvements.

Rank	Basin	Activity	Amount ($1,000)
1	Oso	Bridge at FM 763	538.4
2	Oso	Bridge at S.H. 44	1,103.0
3	Oso	Bridge at FM 665	371.6
4	Oso	Bridge at Tex-Mex RR	844.~~0~~5
5	Quinta	Bridge at FM 1833	813.6
6	Petronila	Drainage ditch at Driscoll	1,300.6
7	Agua Dulce	Bridge at FM 666	1,066.5
8	Oso	Channel Improvement	1,062.4
9	Petronila	Bridge at FM 2826	1,039.7
10	San Fernando	Bridge at FM 1355	1,046.4
11	Petronila	Channel Improvement	18,495.6
12	San Fernando	Channel Improvement	26,945.0
13	Agua Dulce	Channel Improvement	33,636.0
14	Pintas	Channel Improvements	17,883.6

An environmental impact assessment was performed by an independent specialist to determine potential effects on downstream estuarine systems, given the improvements noted above. The conclusion reached is that there are not expected to be any significant impacts.

Financial plans to fund the floodway drainage improvements in Nueces County must project a necessary tax rate to support $100 million worth of bonds issued over a ten-year period. Proper application can slow the level of tax needed for debt service. By issuing short (ten year) maturities, low interest rate (7.5%) costs can reasonably be projected. Nueces County could issue serial issues for a maximum projected tax rate of 7 cents per $100 valuation. The County has a 30 cent taxing authority for roadway and flood control projects.

The legal orders required to implement the drainage requirements are already in place through the County's subdivision regulations. A modification to the existing subdivision order is proposed in the Masterplan. Separate deliverables that are part of the Masterplan Report are: Drainage Criteria and Design Manual, maps and profiles.

TABLE OF CONTENTS

Section	Page
1 - INTRODUCTION	1-1
2 - PURPOSE OF THE MASTER PLAN	2-1
3 - DESCRIPTION OF THE AREA	3-1
4 - BASIN ANALYSIS METHODOLOGIES	4-1
Hydrology	4-1
Hydraulics	4-17
Alternatives Considered	4-26
5 - NUECES COUNTY MASTER PLAN	5-1
Nueces River	5-1
Oso Creek	5-4
Petronila Creek	5-11
Pintas Creek	5-16
Agua Dulce Creek	5-20
Banquete Creek	5-24
Quinta Creek	5-28
San Fernando Creek	5-32
Carreta Creek	5-36
6 - CAPITAL COSTS	6-1
Financial Plan	6-5
7 - ENVIRONMENTAL IMPACT	7-1
Affected Drainage Areas	7-2
Proposed Drainage Improvements	7-4
Affected Estuarine Systems	7-6
Important Species and Habitats	7-12
Potential Impacts	7-17
8 - CAPITAL IMPROVEMENTS PROGRAM	8-1
9 - LEGAL REQUIREMENTS	9-1
REFERENCES	R-1

LIST OF TABLES

No.		Page
4-1	Summary of SCS Curve Number Estimation Analysis	4-9
4-2	Peak Discharge Estimates Computed by Alternative Methods	4-11
4-3	Recommended Methods of Peak Discharge Estimation	4-16
5-1	Modified Floodway - Nueces River	5-4
5-2	Oso Creek - Peak Discharge	5-7
5-3	Oso Creek and West Oso Creek - Structure Inventory	5-8
5-4	Summary of Structural Improvements for Oso Creek	5-10
5-5	Summary of Channel Improvements for Oso Creek	5-10
5-6	Petronila Creek - Peak Discharge	5-14
5-7	Petronila Creek - Structure Inventory	5-14
5-8	Summary of Structural Improvements for Petronila Creek	5-15
5-9	Summary of Channel Improvements for Petronila Creek	5-15
5-10	Pintas Creek - Peak Discharge	5-18
5-11	Pintas Creek - Structure Inventory	5-18
5-12	Summary of Channel Improvements for Pintas Creek	5-19
5-13	Agua Dulce Creek - Peak Discharge	5-22
5-14	Agua Dulce Creek - Structure Inventory	5-22
5-15	Summary of Structural Improvements for Agua Dulce Creek	5-23
5-16	Summary of Channel Improvements for Agua Dulce Creek	5-24
5-17	Banquete Creek - Peak Discharge	5-27
5-18	Banquete Creek - Structure Inventory	5-27
5-19	Quinta Creek - Peak Discharge	5-30
5-20	Quinta Creek - Structure Inventory	5-30
5-21	Summary of Structural Improvements for Quinta Creek	5-31
5-22	San Fernando Creek - Peak Discharge	5-34
5-23	San Fernando Creek - Structure Inventory	5-34
5-24	Summary of Structural Improvements for San Fernando Creek	5-35
5-25	Summary of Channel Improvements for San Fernando Creek	5-36
5-26	Carreta Creek - Peak Discharge	5-39
5-27	Carreta Creek - Structure Inventory	5-39
7-1	Endangered or Threatened Marine Species Known or Likley to Occur in the Project Area.	7-13

LIST OF TABLES
(Cont'd)

8-1	Weighting Factors for Evaluation Criteria	8-2
8-2	Alternatives Ranking Table	8-3
8-3	Priority Ranking	8-4

LIST OF FIGURES

No.		Page
4-1	Oso Creek at Corpus Christi Gage	4-13
4-2	Los Olmos Creek Near Falfurrias Gage	4-14
5-1	Nueces River - Basin Boundary	5-2
5-2	Oso Creek - Basin Boundary	5-5
5-3	Petronila Creek - Basin Boundary	5-12
5-4	Pintas Creek - Basin Boundary	5-17
5-5	Agua Dulce Creek - Basin Boundary	5-21
5-6	Banquete Creek - Basin Boundary	5-25
5-7	Quinta Creek - Basin Boundary	5-29
5-8	San Fernando Creek - Basin Boundary	5-33
5-9	Carreta Creek - Basin Boundary	5-37
7-1	Conceptual Hydrographs for a Given Location and Storm	7-19

SECTION 1 - INTRODUCTION

Nueces County is susceptible to three primary sources of flooding. One source is from the defined drainageways and creeks, wherein flooding occurs due to inadequate channel capacity, restrictions within the channels, and the construction of man-made barriers with inadequate capacity to pass the stormwater flows, such as roads and railroad embankments. During times of flooding, these man-made barriers act as small dams that retard the flow. The second major source of flooding is from poor drainage due to the flat topography within the County. During storm events, water tends to pond and then drain off or evaporate very slowly. Therefore, a large area can have water slowly moving across it in a sheet flow pattern rather than in defined drainageways. This problem is aggravated by the fact that the soils have a very low permeability rate and little water percolates into the ground. The third cause of flooding is from tidal sources, but the evaluation of flooding in tidal areas is beyond the scope of this study.

It is recognized that due to the topography of the land and the expense of providing adequate drainage, not all areas of Nueces County are suitable for development. One purpose of this study is to identify these areas and limit development in them, in recognition that the least expensive solution is to prevent drainage problems in the first place and this is best done by not allowing development in floodplain or flood prone areas. These areas can then be maintained in their present land use and provide a beneficial service to the County by providing natural storage and areas for passage of flood waters. Some existing developed areas are located where frequent flooding occurs. If possible, alternatives were evaluated to provide relief to these areas. In some cases, improvements to maintenance of existing drainage ditches have been recommended.

Nueces County is impacted by nine major drainageways:

Nueces River

Oso Creek

Agua Dulce Creek

Pintas Creek

Petronila Creek

Banquete Creek

Quinta Creek

Carreta Creek

San Fernando Creek

These streams and creeks are analyzed in this study to determine the causes of flooding and to find alternatives that will alleviate or minimize this flooding in developed or developing areas.

Ponding, or sheet flow, is analyzed here as a separate problem. If the ponding is due to man-made barriers, relief through construction of drainageways or culverts can be examined and existing channels and structures enlarged. If the problem is caused solely by flat topography, solutions such as specifying that floor slabs and roads be constructed above the anticipated flood levels can be looked at. Other solutions include storage or detention ponds in the upper part of the basins, and flood plain zoning.

In addition to the engineering aspects of the proposed improvements, the effects of the improvements on freshwater inflows to the affected bays and estuaries are important considerations. These factors include the change of timing of the inflows, variations expected in salinity and changes in sedimentation, pesticide, and nutrient loading and their effects on the sensitive habitat in the bays and estuaries.

Other non-engineering aspects are the consideration of local orders governing the drainage jurisdictions and platting requirements for developing areas. This report will include the draft of an order or modifications of an existing order to be considered by the Commissioners Court, and also provide and recommend financing options available to the County.

The present report provides for all phases in the development of a stormwater master plan for Nueces County. The following section will discuss the general purposes and goals for stormwater master plans, including FEMA flood control guidelines. Section 3 will describe the study area, along with the principal flooding and drainage problems of the area. The methodology used for basin analyses and hydrology studies as applied to Nueces County is defined in Section 4. After this preliminary information is presented, the specific master plan recommendations for Nueces County and their associated cost estimates are given in Sections 5 and 6, respectively. These recommendations, applicable to the unincorporated areas of Nueces County, will cover:

- Development plans for the nine basins
- Causes of specific area flooding
- Drainage system needs for improved flood control
- Master drainage plan, along with prepared maps and profiles showing the plan
- Maintenance program requirements for the plan

The environmental impact and its effects on bays and estuaries are described in Section 7. The plan for financing the proposed improvements is outlined in Section 8, and a draft set of drainage orders for consideration by the County is given in the final section.

SECTION 2 - PURPOSE OF THE MASTER PLAN

Development of a stormwater master plan for the County should adhere to the following criteria:

1. Technically sound. Use proven hydrologic and hydraulic procedures that are consistent with the County's objectives.
2. Community input. Input from local communities should be obtained at all levels of master plan development. A series of preliminary and follow-up meetings can identify problem areas and discuss alternatives. This allows community officials and the public to participate in development of the master plan.
3. Compatible. The masterplan must be compatible and coordinated with planned drainage improvements of the communities, developers and other governmental agencies or private groups planning drainage improvements.
4. Comprehensive. The master plan must integrate the solution of drainage problems with other development issues, including water quality, land use, salt water intrusion into the groundwater, tidal surges, and maintenance of environmentally sensitive areas.
5. Flexible. Nueces County is experiencing pressure for development. The master plan must be flexible enough to assure adequate drainage for planned land development, yet be capable of modification if development does not occur as planned.
6. Implementable. Consideration must be given to the ease of implementing the master plan, including acquisition of right-of-way, designation of effective floodways, ease of maintenance, permitting, and the use of conventional construction techniques.
7. Cost effective. The final master plan must be an economical solution to the drainage problems and still meet the above requirements. In some instances, the least costly alternative can not be chosen because of problems with the other criteria.

Conventional stormwater drainage master plans try to provide solutions for both existing flood problems and anticipated drainage problems based on future development in the watershed. The selection of drainage improvements is partially based on future development as envisioned at the present time. Any changes in the future development plans of a drainage basin or revision of the recommended master plan in the basin can render the traditional stormwater drainage master plan inadequate or obsolete.

A dynamic stormwater management program can be significantly impacted by the utilization of computer programs that analyze large amounts of data in a uniform manner and optimize solutions readily. Currently, hydrology is developed using computer programs such as the Corps of Engineers HEC-1 or the Soil Conservation Services TR-20, or through regionalized or standard procedures. The hydraulic analysis is done with programs such as the Corps of Engineers HEC-2 or the Soil Conservation Services WSP-2. Computers have become a key element in the development of dynamic stormwater management programs.

Standard hydrologic procedures were utilized to determine peak flow values for this study. Hydraulic models of the streams were developed. The strength of a dynamic master plan lies in its flexibility after the first master plan is submitted. The County is provided with the computer models used and copies of all input files. As development patterns change, the master plan can be updated and checked to see if the master plan alternatives or other proposed improvements are adequate. If the alternatives prove inadequate or other changes are proposed, they can be quickly evaluated and incorporated into the revised master plan. In this way, the County always has a current master plan that can be an effective tool for use in urban planning. The advantages of dynamic stormwater master plans include:

1. The ability to quickly evaluate proposed changes to the master plan at a specific location.

2. The ability to quickly evaluate downstream responses to changes in the master plan.

Initial and Major Drainage Systems

All local and regional planning must take into consideration both the initial and the major stormwater drainage systems. The initial drainage system will transport the runoff from various frequency design storms. The design frequency will vary according to type and use of facility. This system is necessary to reduce street maintenance costs, provide protection against regularly recurring damage from stormwater runoff, and provide convenience to the residents. Storm sewer systems consisting of swales, ditches, and underground pipes are a part of the initial storm drainage system, and offer protection, for purposes of this report, from storms with a frequency of occurrence of once in twenty-five years. The initial system must assure a minimum of future drainage problems within the ability of the community to afford drainage facilities.

The major drainage system is necessary to transport flow from extreme events, which is normally established as the runoff that can be expected to have a 1% chance of occurrence in any single year, or expected to be equalled or exceeded once every 100 years. The major drainage system may not carry this load, but must be designed to prevent loss of life and major damage to property and public facilities.

Every developed area needs these two drainage systems, and both systems should be planned and properly engineered to insure adequate drainage. Development proposals should receive full site planning and engineering analysis, and should protect not only the property being developed but downstream properties as well. In this regard, uniform professional considerations must be applied to each site, and these methods are defined in the area's drainage criteria manual.

Drainage Criteria Manual

In "Drainage Criteria and Design Manual, Nueces County, Texas" (Ref. 43), storm drainage design criteria and procedures are presented in order to achieve a uniform method of assuring adequate storm drainage as the County develops. The manual lists the reference information used and gives design factors and graphs for use as engineering guides in the planning and design of drainage facilities for the initial and major storm systems.

The manual can not be expected to cover extraordinary situations but should be adequate for most applications. It is not intended as a replacement for sound engineering judgment, but as a guide to providing adequate drainage. It is kept in loose-leaf form and should be reviewed and modified periodically in order to achieve a reliable and consistent design method for the analysis of storm drainage practices.

FEMA Floodplain Management Program

The Federal Emergency Management Agency (FEMA) encourages state and local governments to adopt sound floodplain management programs, and this is partly accomplished through the National Flood Insurance Program. Each Flood Insurance Study includes a flood boundary and floodway map (FBFM) designed to assist communities in developing sound floodplain management measures. Such a map was prepared for Nueces County and is unaffected by the present study results. The salient features of the maps are:

- Flood boundaries. In order to provide a national standard, the 100-year flood has been adopted by FEMA as the base flood for purposes of floodplain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100- and the 500-year floods have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:24,000 with a contour interval of 5 feet. In cases where the 100-year and the 500-year boundaries are close together, only the 100-year boundary is shown. For inland flooding, FEMA uses three flood zone designations: A or numbered A zones indicate areas inundated by the 100-year flood, B zones are areas between the 100-year and 500-year flood boundaries, and C zones are areas outside the 500-year flood boundary. Other map details involve coastline determinations and other boundaries designating special flood layouts or areas not subject to flooding.

o Floodways. Encroachment on floodplains, such as artificial fill, reduces the flood-carrying capacity and increases the flood heights of streams and the flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment in order that the 100-year flood may be carried without substantial increases in flood heights. Minimum standards of FEMA limit such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced. These floodways are presented to local agencies as minimum standards that can be adopted or used as a basis for additional studies. Floodways are not delineated in coastal high hazard areas.

- Base Flood Elevations. Base flood elevations have been established in areas of special hazards (A and V zones) by detailed engineering methods. In coastal areas affected by wave action, base flood elevations are generally maximum at the normal open shoreline. These elevations generally decrease in a landward direction at a rate dependent on the presence of obstructions capable of dissipating the wave energy. Where possible, changes in base flood elevations have been shown in 1-foot increments on the Flood Insurance Rate Maps. Base flood elevations shown in the wave action areas represent the average elevation within the zone. Current program regulations generally require that all new construction be elevated such that the first floor, including basement, is above the base flood elevation in A and V zones.

- Velocity Zones. The U.S. Army Corps of Engineers has established the 3-foot wave as the criterion for identifying coastal high hazard zones, and this has been adopted by FEMA for the determination of V zones. Because of the additional hazards associated with high-energy waves, the National Flood Insurance Program requires much more stringent floodplain management measures in these areas, such as elevating structures on piles or piers.

SECTION 3 - DESCRIPTION OF THE AREA

Field Reconnaissance and Surveying

The study area consisted of the unincorporated areas of Nueces County, excluding areas subject to flooding from tidal sources. A field reconnaissance survey was conducted within the study area in order to determine the condition of the channels and structures on the streams, identify roughness factors (Manning's "n" values) for the channels and overbanks, identify channel constrictions and constraints, and determine basin boundaries. A photo log of a majority of the structures in the study area was compiled to assist in the development of the hydraulic models for the study. FEMA survey data, when available, were used in the study.

In areas where FEMA survey data were not available, cross sections were determined from USGS quad maps. In addition, the County Engineers office provided survey data on the location and elevation (both top of road and channel invert) for structures included in the hydraulic models. As part of this process, a tabulation of benchmarks found and set was made. This tabulation of benchmarks is included as Appendix A and the locations are shown on the Stormwater Master Plan Maps.

Description

Nueces County is located along the Texas Gulf Coast extending from the Nueces River and the western tip of St. Joseph Island to approximately 10 miles south of Corpus Christi Bay. The central portion of the county is approximately 145 miles southeast of San Antonio and 210 miles southwest of Houston. Nueces County has a land area of 536,360 acres. The County extends 25 miles from north to south and about 50 miles from the western boundary to the eastern shore of Mustang Island. Corpus Christi, the county seat and largest town, is on Corpus Christi Bay.

Nueces County is one of several counties that form an almost uniform curve on the western coast of the Gulf of Mexico. This curve is known locally as the Coastal Bend of Texas. Nueces County is in about the center of this curve. Its mainland is part of a nearly level coastal plain that is about 40 miles wide and is made up mainly of heavy, blackland soils. The topography of Nueces County is generally flat, with elevations ranging from sea level to 146 feet. The offshore islands and tidal lands of the County make up less than 10 percent of the land area. About three-fourths of the land area consists of a nearly level, fairly smooth coastal terrace that, on the average, falls about 3 feet in a mile. About 73 percent of the land area in the county is cultivated, and about 13 percent is used for range. The rest is mostly urban land, dunes, or beaches. The principal crops are cotton and grain sorghum, but some flax, corn, and vegetables are grown.

About 17 percent of the county drains northward into the Nueces River and Nueces Bay. Drainage is mainly to the southeast through the shallow, narrow channels of Agua Dulce, Pintas, and Petronila Creeks. These creeks cross Kleberg County and empty into Baffin Bay. Oso Creek drains the northeastern quarter of the county and enters Corpus Christi Bay at a point southeast of Corpus Christi.

The climate of the County is intermediate between that of the humid, subtropical areas to the northeast along the coast and that of the semi-arid region to the west and southwest. The average rainfall ranges from about 25 inches in the southwestern part of the County to about 28 inches near the coast. The average monthly temperatures range from about 84 deg F. in August to 57 deg F. in January.

Severe tropical storms occur about once in every 10 years, and less severe storms occur about once in 5 years. When storms strike the coast 100 miles to the east or south, Nueces County receives beneficial rains and there is little wind. Hurricanes strike chiefly in August and September, though tropical storms have occurred as early as June and as late as October. Several tropical storms and hurricanes have been encountered in and near Nueces County (see Refs. 27-31).

Development Standards

According to records in the Nueces County Tax Appraisal District Office, eleven subdivisions in the county are unplatted. These developments were built prior to platting and subdivision controls being implemented within the County. They would not meet minimal standards if they were to be submitted for platting now.

At the time these subdivisions were started, the County was powerless to force developers to comply with the County's platting requirements since the County had no enforcement authority. Through its subdivision requirements, the County now has the authority to require adequate drainage be provided. For further details on the County's subdivision requirements, see Section 9.

Existing Flood Protection Measures

Numerous channels have been constructed throughout the study area in an attempt to alleviate flooding problems and to drain low-lying areas in a reasonable amount of time. Several drainage ditches in the upper portion of Oso Creek, in the Robstown area, have been constructed in an attempt to divert water around and drain water away from Robstown.

Existing hurricane flood protection within the study area is limited to a few locally constructed seawalls and flood gates in the more populated urban areas, as well as several earthen and concrete dikes constructed by private industries. The northern portion of the City of Corpus Christi is protected to an elevation of 14 feet above mean sea level (msl) by an approximately 2-mile long concrete seawall constructed in 1942. Although Corpus Christi has not been battered by a major hurricane since construction of the seawall, the structure minimized the effects of high tides associated with Hurricane Carla, which made landfall farther up the coast, as well as those of less intense storms in the Corpus Christi vicinity. In addition, flood gates have been installed at the harbor bridge and at several downtown locations to afford protection up to 14 feet msl.

Apart from these publicly financed flood protection works in Corpus Christi and Aransas Pass, various private industries near the coast have constructed levees. Refineries in the Corpus Christi area have constructed 6- to 10-feet high levees around storage tanks primarily to contain potential spills; however, these levees also afford protection against hurricane surge waters to some extent. Similarly, the Dupont Company and, to a lesser extent, Brown and Root in Aransas Pass have constructed 5- to 7-foot high earthen and concrete dikes around storage tanks and equipment areas. Most industries along the waterfront operate under hurricane protection plans when the need arises.

SECTION 4 - BASIN ANALYSIS METHODOLOGIES

In analyzing solutions to the flooding and drainage problems, principles of hydrology, hydraulics, and economics are employed. This section discusses the methodologies applicable for a basin analysis of Nueces County and neighboring Kleberg County. These methods are then used in Section 5 for providing the master plan recommendations for Nueces County.

HYDROLOGY

A significant component of the drainage studies performed for Nueces and Kleberg Counties involves the determination of instantaneous peak discharge values for key points located along each of the 15 defined drainage-ways (excluding the Nueces River) considered. Peak discharge values at each key point are determined for return periods ranging from 2 to 100 years. For example, the estimated 50-year peak discharge is likely to be equalled or exceeded only once in a typical fifty-year period, that is, a 2 percent chance of occurrence in any given year. Peak discharge values are used in the computation of water surface profiles which, in turn, delineate the floodplain or inundated region surrounding the primary drainage-way during a flood event.

Peak discharge at any given point in a watershed may be a function of precipitation magnitude and intensity, drainage area, topography, general soil type, antecedent soil-moisture conditions, channel conveyance, and numerous other factors. Due to the diversity of factors whose interrelationships determine the maximum runoff for a particular storm event, a number of methods have been developed to estimate instantaneous peak discharge. One method for estimating peak discharge for storm events associated with various return periods is based on frequency analysis of measured historical peak streamflows in the watershed of interest. Unfortunately, none of the streams passing through Nueces and Kleberg Counties have records of sufficient length to facilitate this procedure. Therefore, alternative hydrologic methods were required for the selected watersheds of this study.

Several Flood Insurance Studies (Refs. 5, 6, 7, 8, and 9) of the Nueces and Kleberg County area sponsored by the Federal Emergency Management Agency have utilized hydrologic methods developed by the U.S. Geological Survey (USGS Method, Ref. 16) and the Agricultural Research Service (Cypress Creek Method, Ref. 20) in the determination of 10-, 50-, 100-, and 500-year flood flows. The District 16 office of the Texas Highway Department, located in Corpus Christi, generally uses the USGS Method for rural watersheds and the Rational Method for smaller urban watersheds in the hydrologic design of bridges and highway drainage. The Texas Department of Water Resources (now the Texas Water Development Board), on the other hand, applied hydrologic methods developed by the Soil Conservation Service (SCS Method, Ref. 17) in the performance of their bay and estuary studies, which included the Laguna Madre estuary (Ref. 22) and the Nueces and Mission-Aransas estuaries (Ref. 23). Of the four hydrologic methods named above, three methods for the estimation of peak discharge were considered applicable to the current study: the SCS, USGS, and Cypress Creek Methods.

Methods for Peak Discharge Estimation

1. Soil Conservation Service Method

The first peak flow estimation method considered was the Soil Conservation Service (SCS) Method, which is described at length in the SCS National Engineering Handbook, Section 4, "Hydrology" (Ref. 17). To summarize briefly, peak discharge for typical applications is estimated by the SCS method based on the following equation:

$$q_p = \frac{484\ AQ}{T_p} \qquad (1)$$

where: q_p = Peak discharge in cubic feet per second (cfs)

A = Watershed area, sq. mi.

Q = Depth of effective precipitation, in.

T_p = Time to peak discharge, hr.

The depth of effective precipitation or direct runoff, Q, is a function of total depth of precipitation, watershed curve number, and the initial rainfall abstraction. The initial abstraction is the sum of rainfall before runoff begins and is comprised of interception by trees and vegetation, evaporation, and soil water storage. It is normally assumed to be two-tenths of the potential maximum retention, S, which is a function of the curve number, CN.

$$S = \frac{1000}{CN} - 10 \qquad (2)$$

The potential maximum retention, S, is the maximum amount of rainfall that can be retained and/or infiltrated into the soil. The watershed curve number, CN, is an indicator of runoff potential and is based on hydrologic soil groups and land use classes defined by the SCS. The watershed curve number varies with the soil type, land use, the hydrologic condition of the cover, and the antecedent moisture conditions. Soils with a low curve number will have less total runoff from the same storm event as soils with a higher curve number. Note that the initial abstraction as well as the potential maximum retention is a particularly difficult quantity to estimate without intensive field studies. Time to peak discharge, T_p, is generally approximated by the sum of six-tenths of the time of concentration plus one-half of the duration of precipitation excess, with the time of concentration being the time it takes a particle of water from the most hydrologically distant point in the watershed to reach the point where the peak flow rate is being estimated.

One problem expected to arise in the use of the SCS Method for the estimation of peak discharge involves the value of the constant, 484, in equation (1), which is based on a time of recession to time to peak ratio of 1.67 to 1.00 using a triangular hydrograph approximation. The SCS Handbook (p. 16.7) states: "This constant has been known to vary from about 600 in steep terrain to 300 in very flat swampy country." As the terrain in Nueces, Kleberg, and surrounding counties is generally very flat, it is probable that a constant value less than 484 will prove appropriate.

2. U.S. Geological Survey Method

The second method considered for applicability to the Nueces and Kleberg County area was developed by the U.S. Geological Survey (USGS) in: "Technique for Estimating the Magnitude and Frequency of Floods in Texas" (Ref. 16). This study incorporated annual peak discharge data from 289 sites throughout the state using procedures outlined by the Hydrology Committee of the U.S. Water Resources Council in 1976. Multiple regression techniques were used to develop equations for predicting the peak discharge for various return periods. Independent variables considered in the multiple regression analyses included drainage area, slope, channel length, elevation, mean annual precipitation, evaporation, and the 24-hour rainfall intensity with a 2-year recurrence interval. The state was subsequently divided into six regions on the basis of the distribution of the residuals from a single statewide regression of the 10-year flood.

The present study covers a region of the state in which flood-frequency relationships were considered by the USGS to be undefined. Nueces County, however, is immediately adjacent to Flood-Frequency Region 1 as delineated by the USGS in the referenced report. In Region 1, the only independent variables found to be significant at the 95 percent confidence level were slope and drainage area. Equations and nomographs are provided from which the 2-, 5-, 10-, 25-, 50-, and 100-year peak discharge values can be determined given watershed slope and drainage area.

3. Cypress Creek Method

The Cypress Creek Method as applied by Stephens and Mills (Ref. 20) of the Agricultural Research Service (ARS) is the third alternative method of peak discharge estimation to be considered for the South Texas study area. Stephens and Mills applied the method to three rural watersheds in the Southern Florida Flatwoods major land resource area. The experimental watersheds range in size from 15.6 to 98.6 square miles and typically have sandy soils and slopes in the 0 to 2 percent class. According to the referenced report (p. 3), the three watersheds are "judged to be representative in many ways of the Gulf Coast and Atlantic Coast Flatwoods, and of level, sandy parts of the Southern Coastal Plain." Given the similarities in watershed size, topography, coastal proximity and meteorological influence, and soil type between the experimental watersheds and those in Nueces and Kleberg Counties, applicability of the Cypress Creek Method was considered for the present study.

The general governing equation defining the peak 24-hour average runoff rate in the Cypress Creek Method is as follows:

$$Q_a = CM^x \quad (3)$$

where: Q_a = Peak 24-hour average runoff rate, cfs

C = Coefficient related to rainfall excess

M = Drainage area, sq. mi.

x = Exponent defining the impact of drainage area on discharge

Once the peak 24-hour average runoff rate, Q_a, is determined, it is multiplied by a ratio that varies with drainage area to compute instantaneous peak discharge. Analysis of the data for this study showed a defined relationship between the average runoff rate of a watershed and the true instantaneous peak flow generated, based on the drainage area of the basin. Based on a graphical analysis of annual maximum 24-hour average runoff plotted versus watershed area for a total of 20 events affecting the three experimental watersheds, Stephens and Mills found the best estimate of the exponent, x, to be 0.83. The coefficient, C, is assumed to be linearly related to rainfall excess, R_e, by the equation:

$$C = 16.39 + 14.75R_e \quad (4)$$

This equation was derived by least squares regression based on 20 runoff events, and the coefficient of determination, r^2, associated with the equation was found to be 0.823. Once the peak 24-hour average runoff rate has been determined by equations (3) and (4), it must be multiplied by a ratio that varies with drainage area to obtain instantaneous peak discharge.

Application of Peak Discharge Estimation Methods

Each of the three methods for estimating peak discharge discussed in the preceding sections was applied to the Oso Creek and Los Olmos Creek watersheds in Nueces and Kleberg Counties, respectively. These were the only two watersheds in the area for which an adequately lengthy sequence of unregulated historical gaged streamflow and annual peak discharge measurements could be obtained from the U.S. Geological Survey (USGS) to confirm the applicability of a particular method. In addition, these two watersheds more or less typify the geographic and soil type extremes to be found in the study area. The Oso Creek watershed is located in northern Nueces County and has soil-cover complexes that are predominantly clay with low infiltration rates (Ref. 18). Los Olmos Creek, on the other hand, forms a portion of the southern boundary of Kleberg County, and the soil-cover complexes found within its watershed are predominantly sands with somewhat higher infiltration rates (Ref. 19).

In order to apply the SCS Method, hourly flow rates from three independent historical storm events for Oso Creek at Corpus Christi (USGS Gage #08211520) and two independent historical storm events for Los Olmos Creek near Falfurrias (USGS Gage #08212400) were computed from stage records using rating curves provided by the USGS. Drainage areas above the gages are 90.3 and 480 square miles for Oso Creek and Los Olmos Creek, respectively. Precipitation measurements at the following locations were obtained for the selected storm events from National Weather Service records.

Uso Creek Watershed:

Hourly Rainfall Station: Corpus Christi Airport

Daily Rainfall Stations: Robstown, Chapman Ranch

Los Olmos Creek Watershed:

Hourly Rainfall Stations: Corpus Christi Airport, Hindes, Sarita 7E, Cotulla, Zapata

Daily Rainfall Stations: Benavides, Hebbronville, Falfurrias, Freer 18WNW

Analysis of precipitation data and runoff hydrographs yielded estimates of effective rainfall depth, Q, and total precipitation depth, P, for each storm event which, in turn, were used to estimate the appropriate SCS curve number for each of the two watersheds. The resulting curve numbers adjusted to antecedent soil moisture condition II, which is considered the average moisture condition of the soil, as defined by the SCS are presented in Table 4-1.

The data presented in Table 4-1 are by no means comprehensive; however, they do indicate that the rainfall-runoff characteristics of the two watersheds are quite different. This is apparent in the disparity of the average estimated curve number for each of the watersheds: approximately 74 for Uso Creek and 43 for Los Olmos Creek. A much smaller portion of the total storm rainfall contributes to basin runoff or becomes effective rainfall in the Los Olmos Creek watershed where sandy soils are more dominant than in the Uso Creek watershed where the soils contain more clays. It is also noted that these curve numbers are substantially lower than those determined solely on the basis of the soil type and land use guidelines published by the SCS. The Texas Department of Water Resources (now the Texas Water Development Board), however, has estimated curve numbers of 73 and 35 for the respective portions of the Oso Creek and Los Olmos Creek watersheds above the USGS gage locations (Refs. 22 and 23).

TABLE 4-1

SUMMARY OF SCS CURVE NUMBER ESTIMATION ANALYSES

Stream	Event	Observed Peak Hourly Discharge (cfs)	Total Precip. (Inches)	Effective Rainfall (Inches)	SCS* Curve Number
Oso Creek	Apr. 1977	2,240	3.69	1.26	86
	Aug. 1980	10,630	11.77	5.20	71
	Feb. 1982	5,596	4.67	2.67	64
Los Olmos Creek	Aug. 1980	1,342	7.73	0.15	45
	May 1982	3,019	5.09	0.36	43

* Curve numbers are shown for antecedent soil moisture condition II.

Analysis of the observed storm runoff hydrographs using a triangular hydrograph approximation indicated time of recession to time of peak ratios somewhat greater than the 1.67 to 1.00 ratio generally assumed in the SCS Method. Analysis of the three storm hydrographs for Oso Creek yielded an average ratio 1.94 to 1.00, which implies that the constant in the peak discharge equation could equal 440 rather than 484. The corresponding average ratio for Los Olmos Creek was found to be 2.76 to 1.00, yielding a constant of approximately 343. These modified constants were used along with 24-hour precipitation estimates obtained from the "Rainfall Frequency Atlas of the United States, TP-40" (Ref. 14) in the computation of peak discharge for various return period events. Peak discharge estimates for Oso and Los Olmos Creeks for return periods of 2-, 5-, 10-, 25-, 50-, and 100-years computed using the SCS Method are presented in Table 4-2.

Required parameters for the computation of peak discharge estimates for various return periods using the USGS Method Region 1 equations included slope and drainage area. Slope in this method is defined as the average slope of the streambed between points 10 and 85 percent of the distance along the main-stream channel from the site to the basin divide. The resulting peak discharge estimates for Oso and Los Olmos Creeks are presented in Table 4-2.

The Cypress Creek Method was also applied to the Oso and Los Olmos Creek watersheds so that the results might be compared with those obtained by SCS and USGS peak discharge estimation techniques (Table 4-2). Total 24-hour precipitation for return periods ranging from 2 to 100 years was obtained from TP-40, and the effective precipitation, R_e, was computed by

TABLE 4-2

PEAK DISCHARGE ESTIMATES
COMPUTED BY ALTERNATIVE METHODS

Oso Creek at Corpus Christi (USGS #08211520):

	Return Period (Years)					
Method *	2	5	10	25	50	100
SCS	3,440	6,350	8,150	10,500	12,600	15,050
USGS	1,900	3,700	5,200	7,200	9,000	11,000
CC	2,110	3,220	3,900	4,800	5,590	6,530

Los Olmos Creek Near Falfurrias (USGS #08212400):

	Return Period (Years)					
Method *	2	5	10	25	50	100
SCS	1,330	5,260	8,840	13,900	18,750	26,050
USGS	6,000	15,000	23,000	36,000	48,000	62,000
CC	3,670	5,050	6,300	8,070	9,770	12,350

* SCS = Soil Conservation Service Method (Ref. 17)
USGS = U.S. Geological Survey Method (Ref. 16)
CC = Cypress Creek Method (Ref. 20)

the SCS Method using the previously estimated average curve numbers of 74 and 43 for Oso and Los Olmos Creeks, respectively. The ratio of peak instantaneous discharge to peak 24-hour average discharge was assumed to be 1.145 to 1.00 for Oso Creek and 1.14 to 1.00 for Los Olmos Creek to account for watershed size.

Selection of Peak Discharge Estimation Method

The peak discharge estimates for the Oso and Los Olmos Creek watersheds presented in Table 4-2 are plotted versus return period in Figures 4-1 and 4-2. The individual points shown in Figure 4-1 correspond to observed historical annual maximum discharge values of 12,100 cubic feet per second (cfs) and 6,110 cfs occurring in 1980 and 1973, respectively, at the Oso Creek gage location. Discharge records prior to 1972 are nonexistent; however, USGS publications (Ref. 38) indicate that the instantaneous peak discharge of 6,110 cfs on October 12, 1973 was the maximum attained since 1919. The plotting position of these points with respect to return period or frequency is based on the Weibull plotting position relationship (Ref. 12). It is possible that the 1980 discharge (associated with Hurricane Allen) actually has a return period greater than the indicated plotting position, as the 2-day precipitation total recorded at the Corpus Christi Airport was 13.27 inches. This depth is in excess of the 100-year, 2-day precipitation depth of approximately 12.8 inches based on data from TP-49 (Ref. 42) and TP-40. Given these historical points of reference, it would appear that the USGS Method yields the most reasonable peak discharge estimates for the Oso Creek watershed.

As in Figure 4-1, two observed historical annual maximum discharge values are plotted for reference in Figure 4-2 for the Los Olmos Creek

FIGURE 4-1

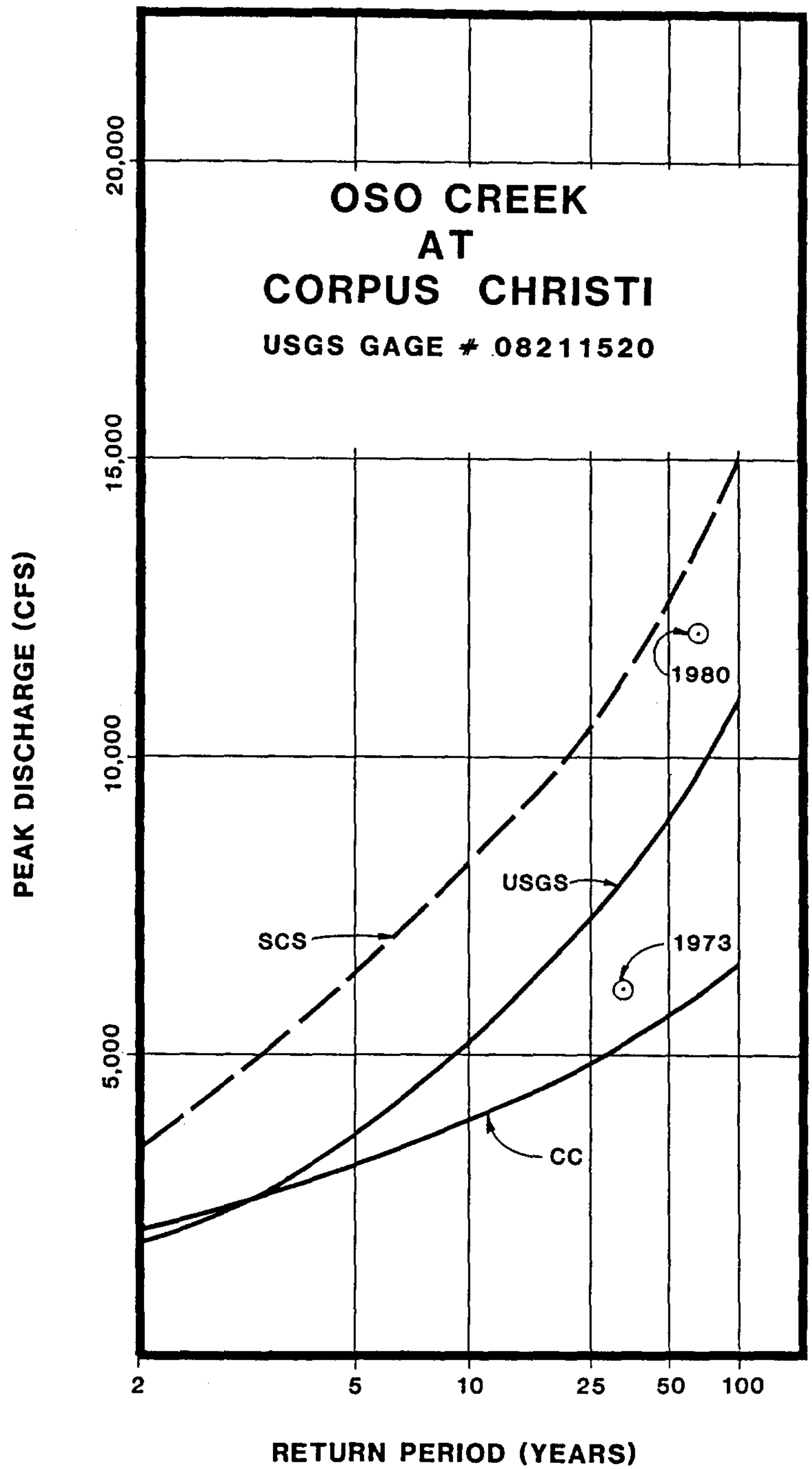
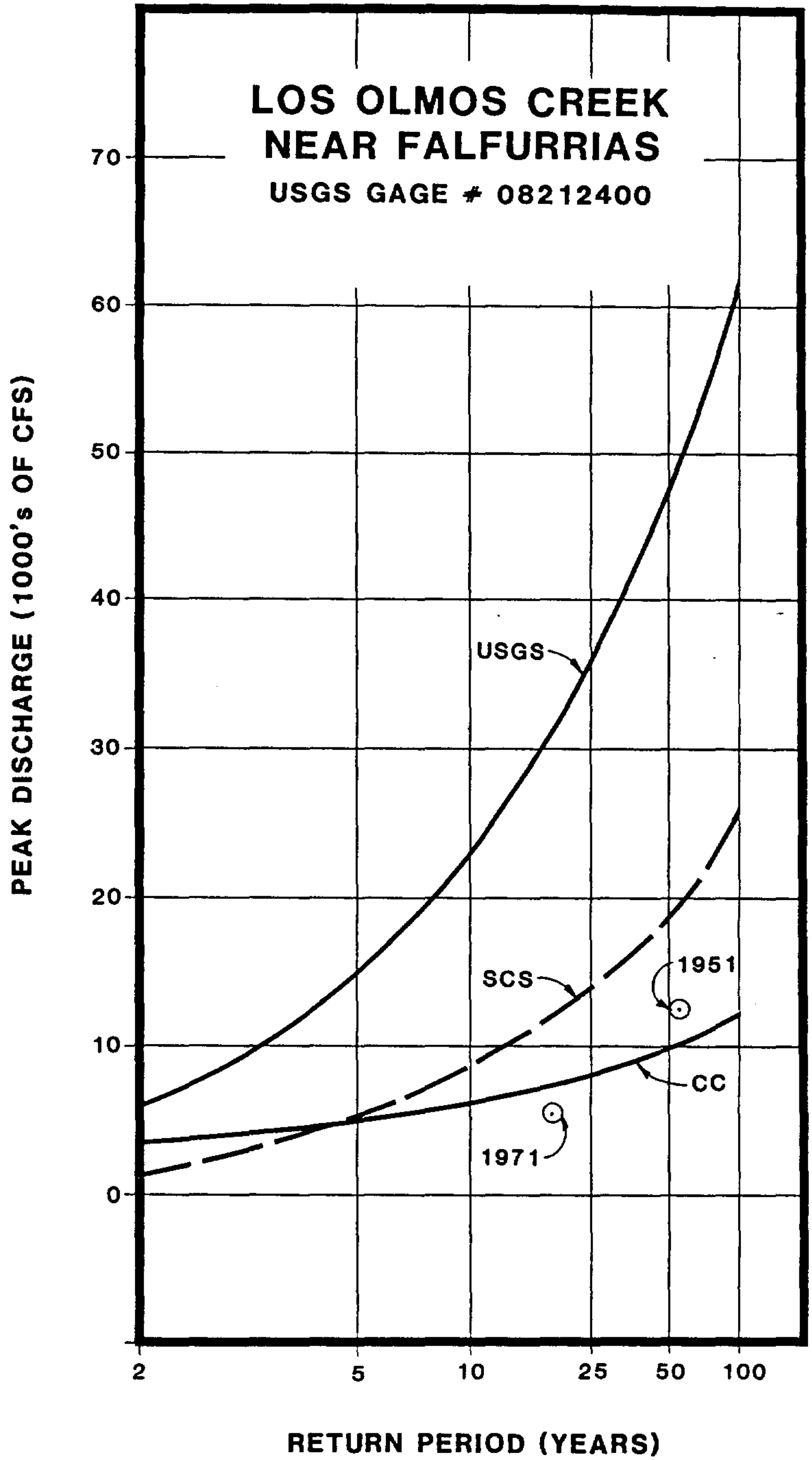

OSO CREEK
AT
CORPUS CHRISTI
USGS GAGE # 08211520
PEAK DISCHARGE (CFS)
20,000
15,000
10,000
5,000
1980
USGS
SCS
1973
CC
2
5
10
25
50
100
RETURN PERIOD (YEARS)

FIGURE 4-2


LOS OLMOS CREEK
NEAR FALFURRIAS
USGS GAGE # 08212400
70
60
50
40
30
20
10
0
PEAK DISCHARGE (1000's OF CFS)
USGS
SCS
1951
CC
1971
2
5
10
25
50
100
RETURN PERIOD (YEARS)

watershed. An estimated peak discharge of 12,500 cfs occurred on September 13, 1951 and the stage attained during this event is known to have been the highest since at least 1929. Precipitation on September 13, 1951 was measured at 13.21 inches at Alice, Texas. This depth of precipitation is, in fact, well in excess of the 100-year, 24-hour precipitation depth shown for the watershed in TP-40. The indicated peak discharge of 5,300 cfs that occurred in 1971 during Hurricane Fern is plotted as the maximum measured discharge that has occurred since installation of the USGS streamflow gage in 1966. Figure 4-2 indicates that the Cypress Creek Method yields suitable estimates of peak discharge for various return periods for the Los Olmos Creek watershed.

It is apparent in the two figures that peak discharge estimates for the Oso Creek and Los Olmos Creek watersheds could not be obtained by the same method. The SCS Method appears to generate values that are too high in both watersheds. While the peak discharge estimates based on the USGS study appear adequate for Oso Creek, they are much too high for Los Olmos Creek. The Cypress Creek Method, on the other hand, generates reasonable values for the Los Olmos Creek watershed, but appears to underestimate peak discharge for the Oso Creek watershed. Peak discharge estimates for various return periods were obtained by the USGS Method for streams in Nueces County, since the geologic and soil survey maps (Ref. 18) indicate that the clay soils found in the Oso Creek watershed are typical of both Nueces County and adjacent coastal areas assigned to Region 1 in the USGS study. The Cypress Creek Method was utilized for streams in Kleberg County because the soil map (Ref. 19) shows that the sandy soils found in the Los Olmos Creek watershed are common in the Kleberg County area. Each of the 15 streams selected for analysis in the current study is noted in Table 4-3 along with the adopted method of peak discharge estimation.

TABLE 4-3

RECOMMENDED METHODS OF PEAK DISCHARGE ESTIMATION

Stream	Method *	County
Uso Creek	USGS	Nueces
Agua Dulce Creek	USGS	Nueces
Pintas Creek	USGS	Nueces
Petronila Creek	USGS	Nueces
Banquete Creek	USGS	Nueces
Quinta Creek	USGS	Nueces
Carreta Creek	CC	Nueces & Kleberg
San Fernando Creek	CC	Nueces & Kleberg
Tranquitas Creek	CC	Kleberg
Santa Gertrudis Creek	CC	Kleberg
Escondido Creek	CC	Kleberg
Jaboncillos Creek	CC	Kleberg
Ebanito Creek	CC	Kleberg
Velederos Creek	CC	Kleberg
Arania Creek	CC	Kleberg
Salado Creek	CC	Kleberg
Los Olmos Creek	CC	Kleberg

* USGS = U.S. Geological Survey Method (Ref. 16)

CC = Cypress Creek Method (Ref. 20)

HYDRAULICS

HEC-2 Computer Program - Water surface profiles have often been determined using normal depth calculations or standard step backwater methods. The standard step backwater method is a common procedure for use in computer programs such as HEC-2 and WSP2 and should be used in flat terrain. The key input requirement for these computer programs is stream channel cross sections that adequately describe the hydraulic properties of the stream and bridge and culvert geometry. On streams where FEMA survey data were available, these were used as a part of this study. Where FEMA data were not available, cross sections were determined from USGS quad maps, county survey data of structures, and the field reconnaissance survey. Criteria for selection of the location of cross sections include

- Upstream and downstream face of hydraulic structures
- Typical section in channel 50 feet upstream and 50 feet downstream of hydraulic structures
- Centerline of hydraulic structures
- Changes in channel geometry and grade

Cross sections, channel reach, Manning "n" values and peak discharge rates are all coded for use in the backwater model. The use of a computer program to perform the backwater analysis has several advantages:

- Large volumes of field data can be easily handled.
- Multiple water surface profiles for varying frequencies can be computed at the same time.
- Subcritical, supercritical, and critical flow regimes can be calculated.
- Computer plotted cross sections and profiles may be obtained.
- Impacts of channel improvements and bridge replacements are easily assessed.

The Corps of Engineers HEC-2 Water Surface Profiles Model was selected for use in the storm drainage basin study. The program computes and plots (by printer) the water surface profile for either subcritical or supercritical flow conditions. The effects of various hydraulic structures such as bridges, culverts, weirs, embankments, and dams may be considered in the computation. The principal use of the program is for determining profiles for various frequency floods for both natural and modified conditions. The latter may include channel improvements, levees and floodways. Input may be in either English or metric units.

The one-dimensional computational procedures used by HEC-2 are similar to Method 1 in the Corps of Engineers Manual "Backwater Curves in River Channels" (Ref. 25). This method applies Bernoulli's theorem for the total energy at each cross section and Manning's formula for the friction head loss between cross sections. In the program, average friction slope for a reach between two cross sections is determined in terms of the average of the conveyances at the two ends of the reach. Other losses are computed using one of several methods. The critical water surface elevation corresponding to the minimum specific energy is computed using an iterative process.

Calibration of HEC-2 - The output of any computer model is dependent on the quality, application, and proper understanding of the level of input data. At the beginning of the study, a sensitivity analysis on water surface profiles was performed using typical stream channel characteristics which represented flat channel slopes, high Manning "n" values, defined channels with flat overbanks and a range of discharges. For the channel characteristics selected it was concluded that for flat channel slopes, the water surface elevation was most sensitive to a change in n-values and less sensitive to changes in channel geometry and discharge. In addition, it was determined that backwater effects from structures impact water surface elevations for long stretches of channel upstream from the structure. The results of the sensitivity analysis were used as guidelines in establishing existing channel conditions and recommending drainage improvements.

The sensitivity of n-values indicates that maintenance of stream channels is critical to solving local flooding problems. Also, it shows that channel improvements resulting in lower n-values would be a good alternative for increasing conveyance efficiency. The n-values for HEC-2 were established using information published in "Open Channel Hydraulics" (Ref. 2) and verifying these values with conditions observed during the field reconnaissance. Typical values that were used include:

n	Channel Condition
.045	Improved grass channel
.45-.10	Natural channels
.06-.15	Overbank areas

The sensitivity of water surface elevations to discharge and channel geometry was low because of the flat overbank areas. As soon as the stormwater runoff exceeds bank capacity, the flow spills out into the flat overbank areas and establishes new flow patterns. In many instances the direction of overland flow is normal to the channel flow and would require more complex modeling procedures. In general, the capacity of overbank floodplain areas to store water is so unlimited that a large increase in discharge results in a small increase in flood elevations. When simulating these conditions in HEC-2, the effective flow area of a floodplain is determined and cross sections are extended at that point. When extended sections exceed one foot, the cross section and/or hydrology is modified. Channel geometry is fixed as per the field survey data. However, sections and overbank slopes are sometimes modified to provide for uniform flow regimes along a particular channel reach. In areas where it was difficult to obtain field survey data, upstream and downstream cross sections were used to interpolate the required section.

The backwater effects of undersized hydraulic structures are critical to the direction that recommended drainage improvements will take. Bridges and culverts are both difficult and costly to replace in most instances. The sensitivity analysis indicated that small backwater effects would be felt farther upstream. Application of the normal bridge routines contained in HEC-2 to structures throughout the County showed that outlet control governed the analysis.

Application of HEC-2 - The water surface profiles represent the bottom line of the hydraulic analysis. The water surface elevations computed by each cross section of the areas studied were drawn on enlargements (from 1" = 2000' to 1" = 900' to match aerial maps) of USGS 7-1/2 minute quad maps. The area between cross sections was interpolated based on the 5-foot contours on the enlarged quad maps to determine floodplain boundaries. In addition, water surface profiles, channel inverts and structures were plotted. From the floodplain mapping and profiles, areas of significant areal flooding, excess backwater at structures, and overtopping of roads were identified. Existing flood profiles were compared with available high water mark data to verify results and floodplain mapping.

Another level of hydraulic analysis was incorporated in the development of the drainage master plan. Alternatives were developed involving structural improvements, channel improvements, flood proofing, flood forecasting and warning, cleaning existing channels, relocation of structures within the floodplains, and floodway delineation. Impacts of these alternatives on the water surface elevation were determined using HEC-2. At each level of analysis, the model was further refined in order to more accurately simulate flow characteristics of the channels.

Shallow Flooding

Identification of areas subject to shallow flooding and ponding problems is a less quantifiable procedure than determining flood boundaries on defined drainageways. Several methods can be used to identify these areas, including review of topographic maps, soil survey maps and aerial photographs after severe rainfall events, and interviews with long-term residents. Topographic maps indicate areas that do not have defined drainageways or have depressions that would collect water. Soil survey maps show areas that have had standing water in them, which are identifiable by their undrained condition and by recent sedimentary type materials. The best ways to identify problem areas are to observe the area during severe rainfall events, which is normally not possible during the course of a study, or talk to people who have knowledge of the area. All these methods were used in identifying these areas within the unincorporated areas of Nueces and Kleberg Counties. By these procedures, areas identified as having shallow flooding or ponding problems were delineated and divided into two groups.

The locations identified on the masterplan maps as Zone 1 are comprised of areas subject to 12 inches or more of ponding or severe sheet flow. Due to the potential hazard, any development in these areas should provide adequate drainage and measures to protect roads and structures from damage. In the Zone 1 areas, an analysis of the flooding problems and corrective measures proposed should accompany drainage plans submitted to the County for approval. These requirements are outlined in the "Drainage Criteria and Design Manual" for the County (Ref. 43).

The locations identified as Zone 2 on the masterplan maps are comprised of areas subject to less than 12 inches of ponding or sheet flow. Development in these areas should account for this type of hazard by elevating roads and structures and by providing adequate drainage so that the flooding situation is not aggravated by development and the development itself is not ruined.

Flood Control and Drainage Alternatives

Plan Components - Components of the master plan for the basins in the County were selected from a broad series of alternatives available for each basin. These alternatives propose various solutions to solving flood problems, including structural improvements, channelization, storage, floodway zoning and minimum building elevations. These are summarized below:

- Structural Improvements. The master plan is designed to retain the 100-year flood within the channel banks, prevent overtopping of major roads and bridges, and prevent houses from being inundated, where possible. Each of the drainage structures listed in the structure inventory (see Section 5) for each basin was evaluated for capacity, setting and structural condition. Structures in potential developing areas that could not pass the 100-year flood without causing significant backwater or overtopping were recommended for replacement. Emphasis was placed on keeping Farm to Market roads, State highways, and U.S. highways free from overtopping. Also, structures in poor condition, structures that are heavily silted from poor invert setting and structures that create erosion problems from high velocities were recommended for improvements. Structural improvements include replacing or modifying bridges and culverts and replacing low water crossings with bridges or culverts.

- Channelization. Many of the existing developments have encroached into floodplains, creating flooding problems along the stream. In these locations it was necessary to provide additional channel capacity in order to reduce flooding potential. Whenever possible, the natural stream channel courses were retained in the master plan. In addition, some areas are extremely flat and when the floodwaters overflow the streams, they can pass into adjacent drainage basins, aggravating the flood problems in these areas. Channelization alternatives generally consisted of widening existing channels, providing 4:1 sideslopes, and providing a maintenance easement on both sides of the channel.
- Storage. Various forms of storage including retention, detention and natural storage were investigated. The primary purpose of storage is to reduce the peak flow rate by capturing a portion of the flow during high runoff periods and slowly releasing it as floodwaters recede. When it is desirable to preserve the ecology of environmentally sensitive low-lying areas, natural storage areas are designated. These areas do not require any excavation, yet are effective in their natural state for improving stormwater quality, providing aquifer recharge and reducing downstream impacts of flooding.

- Floodplain Zoning. Floodplain and floodway zoning allow non-structural alternatives to solve drainage problems. Zoning regulations usually restrict development in the 100-year floodplain. In areas that are not currently developed, zoning is an effective way to prevent development in the floodplains to avoid future problems.
- Minimum Building Elevations. Some portions of the County have historically had flood problems due to flat topography or inadequate drainage. While these areas are not on defined drainageways, they do pond water. Development can occur in these areas if floor slabs are raised to minimum elevations and drainage in a reasonable time is provided. While yards and open areas may flood, houses and roads should remain above the anticipated flood levels.

Other alternatives that were looked at included floodproofing, flood forecasting and warning, clearing of channels, and a buyout of existing flood-prone buildings. Most of the basin master plans utilize a variety of solutions involving the integration of the structural, non-structural and storage solutions. The process used to select the best solution involves a set of criteria which could compare the various alternatives that were generated.

Selection Criteria

The alternative solutions for each basin were evaluated and compared during the selection process. A set of criteria was established to evaluate the alternatives and provide guidance in selecting the final master plan. Throughout the course of the study, the priorities of each of the following criteria were established for each basin.

- Economics. Economic considerations include construction, land acquisition, right-of-way acquisition, and operation and maintenance costs. Less costly alternatives, taking into account maintenance costs, were given a higher priority.
- Hydrology. Reliability and performance of a drainage system vary, depending on the frequency of the selected design rainfall event. Typically, sound stormwater management accounts for initial drainage (25-year event) and for major drainage (100-year event). When analyzing alternatives to alleviate flood problems associated with a 25-year discharge, it is important to evaluate the performance of these alternatives subject to the 100-year flow.
- Environmental. Positive and negative impacts on water quality and the ecological balance of nature must be reviewed in master plan development. Typically, structural measures (channelization, structure replacement) may create adverse water quality effects and negative impacts on native wildlife and vegetation, while storage and non-structural measures imply positive water quality effects and preserve the natural environment of the area. Although this may be generally true, each situation was analyzed independently to determine the overall impacts of structural and non-structural measures on water quality and the natural environment of the area.
- Local Input and Coordination. Along with economics and costs, political and social acceptability are probably the most important criteria as to whether the master plan will be implemented. Thus, it is important that the recommended master plan reflect current attitudes. Input from local communities during the development of

the master plan helped insure coordination in development and eventual completion of the master plan. During the initial portions of the study, meetings were held with all communities, major landowners, developers and governmental agencies to solicit input for the study.

- Maintenance. Upkeep of structures, channels, and storage areas can be a jurisdictional headache and very time-consuming. Each alternative was analyzed as to its dependence on proper maintenance. A proper maintenance program for existing channels and structures would solve a great many of the existing flooding problems.

Types of alternatives that best meet all the previously discussed criteria include zoning the floodplain so there will be no development in flood-prone areas, and utilizing these same areas to generate more rapid conveyance of flood waters. Other alternatives that were considered in terms of the criteria include channelization, structure replacement, diversion, and inter-basin transfer.

ALTERNATIVES CONSIDERED

A full range of alternative flood damage reduction measures has been evaluated, and several alternatives for resolving flooding problems have been identified. Flood damages could be reduced by structural or non-structural measures or by a combination of both. Possible non-structural measures include floodplain regulation, floodproofing, flood forecasting and warning, on-site detention of stormwaters, clearing and snagging the existing stream, and buyout and relocation of all or part of the structures in the existing floodplain. Possible structural measures include storage of all or part of the flood waters in a reservoir or system of reservoirs, enlarging and straightening the channels, enlarging the bridge openings, and constructing of flood protection levees.

Implementation of more stringent floodplain regulations by the County would be effective in controlling development in the area subject to flooding and would, as a consequence, minimize future flood losses. There may be some limited opportunity to floodproof some structures, but, because of the general type of structures in the area, such measures are not suitable. Buyout and permanent evacuation is not an acceptable solution.

During the course of the study it became apparent that the construction of levees and channelization would be very expensive alternatives due primarily to the flat topography, and would require the acquisition of large amounts of land throughout the County. In the existing condition, once the capacity of the channel is exceeded, the flow tends to spread out over large areas. Further increases in the flow do not significantly affect the water surface elevation because of the large flow-carrying capacity of the overbanks. Construction of levees to confine the flow to the channels would increase the water surface elevation within the levees and cause backwater problems great distances upstream. Construction of channel improvements would generally require extremely large channels to pass design storms due to the slow velocities and the large increase in capacity required to accommodate flow that was previously overbank flow. In most cases the channels are relatively shallow with slopes that are too flat to allow them to be deepened. In addition, constructing levees and improving channel capacity have the detrimental effect of deleting natural storage in the overbanks. Storage, in most cases, did not prove to be a viable alternative due to the prohibitive size and lack of adequate topography for structures.

The existing floodplains play a very important role in the passage of floodwaters in the County, both from a storage and flow capacity standpoint. They should be maintained in their present use as much as possible. In light of the cost of providing adequate flood protection in these areas and the availability of land suitable for development, development within the floodplains should be discouraged.

Existing Flood Control Plans

During the initial coordination meetings with the communities, state and federal agencies, and others, no plans were indicated for major drainage improvements in the near future.

SECTION 5 - NUECES COUNTY MASTER PLAN

The master plan for Nueces County involves the delineation of floodway zones, channel improvements, and structural modifications and replacements. The plan is directed at each basin's unique problems.

The following pages describe each basin and its specific problem areas, present the method and results of the analysis used, and list the alternative improvements recommended. An area map showing the floodway boundaries for the watershed is given for each basin.

Basin 1: Nueces River

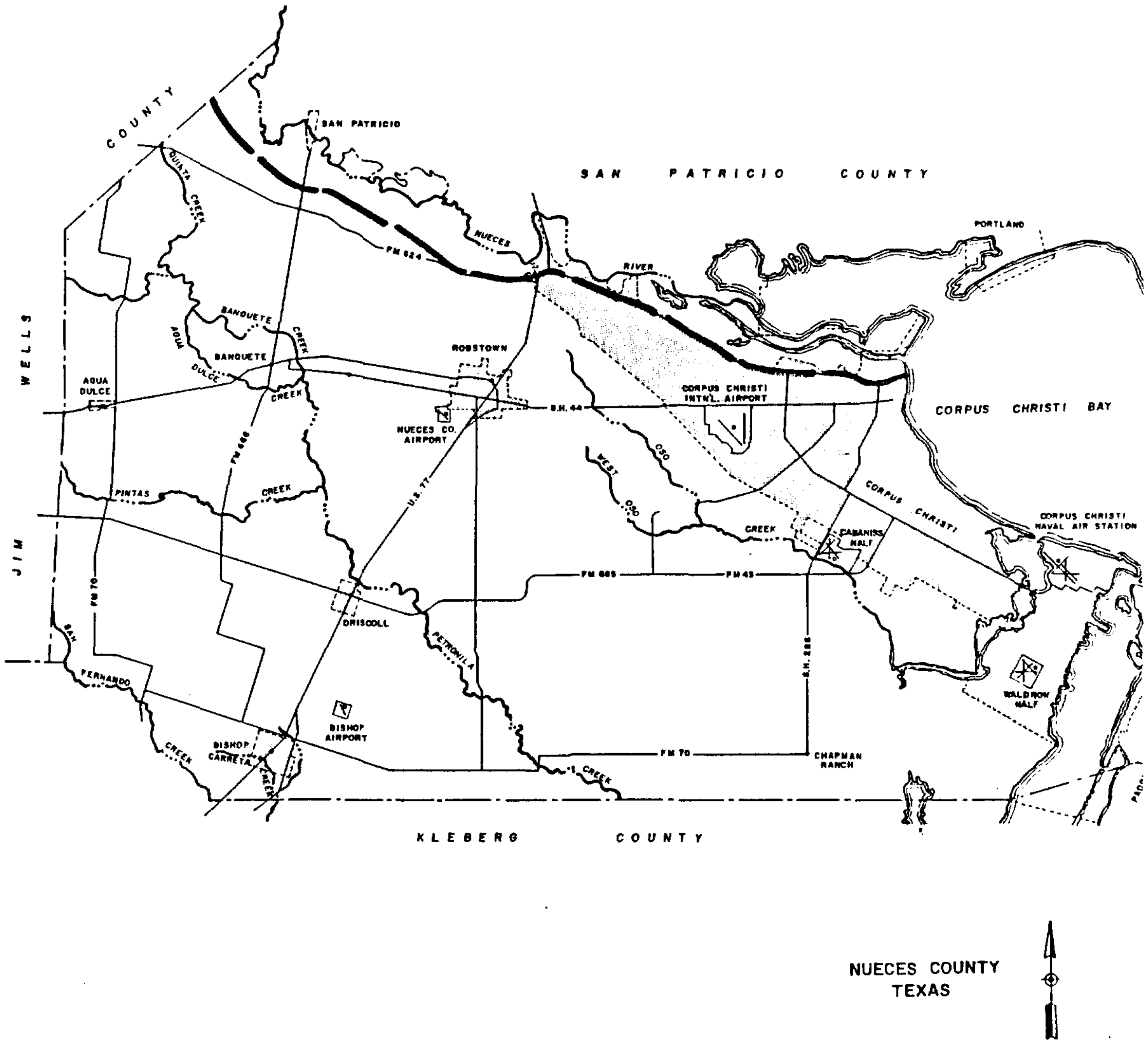
Description

The Nueces River Basin is located in the southern part of Texas and has a drainage area of 17,075 square miles. The basin extends to a length of about 235 miles and has a maximum width of 115 miles. With the exception of Corpus Christi, the other towns and even most of the counties affected by the basin have populations less than 20,000. The sparse population is indicative of a rural setting that characterizes most of the basin. For purposes of the present Master Plan, the Nueces River basin directly impacts the sliver of land along the north boundary of the County.

Geographically, the basin is divided into three segments. The upper basin, north of the town of Uvalde, is 3,100 square miles of rugged broken land known as the Texas Hill Country. About 90 percent of the land is used for grazing. The hill country is part of the Edwards Plateau, a geological province separated by a great uplift known as the Balcones Escarpment. South of the escarpment and continuing to within about 60 miles of the Gulf

FIGURE 5-1

NUECES RIVER - BASIN BOUNDARY



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Coast is a low rolling erosional plain known locally as the brush country. The area is used mainly for cattle ranching and leased hunting. Some local areas are intensively farmed. The 60-mile corridor adjacent to the Gulf Coast is the Coastal Prairie, and much of this land is under cultivation. Feed crops, sorghum, flax, cotton, and vegetables are the primary agricultural products. In addition, oil production and refining operations have led to significant industrial development. Shipping of goods is enhanced through the seaport at Corpus Christi.

Outside the corporate limits of Corpus Christi, very limited development has occurred within the flood boundaries of the Nueces River. The development that has occurred is mainly recreational type housing or cabins along the river. This type of construction is generally built on stilts or piers or is of such low value that floodproofing is not economically feasible.

Basin Analysis

While there is no planned development within the flood boundaries of the Nueces River, there has been some interest in how much of the floodplain could be developed by decreasing the overbank roughness values by clearing the land adjacent to the river, thereby providing a more hydraulically efficient section to pass flood flows. In order to evaluate this, the overbank "n" values for the Nueces River (as determined in the FEMA study, Ref. 5) were reduced to 0.04, reflecting a clean overbank. The floodway boundaries as determined in the FEMA study were then adjusted inward to a point where the water surface elevation matched the original FEMA water surface elevation for natural conditions. Table 5-1 summarizes the results of the analysis.

TABLE 5-1

MODIFIED FLOODWAY - NUECES RIVER

Section Number (From FEMA Study)	Distance From River Bank To Floodway Boundary In Feet: Original FEMA Report	Modified
24.10	5,003	4,003
24.21	9,164	8,588
24.24	9,218	8,588
24.30	8,599	6,606
24.40	982	0

Proposed Basin Improvements and Recommendations

1. No improvements on Nueces River are proposed.
2. Carefully control development in areas identified as being within the 100-year flood boundaries of Nueces River.

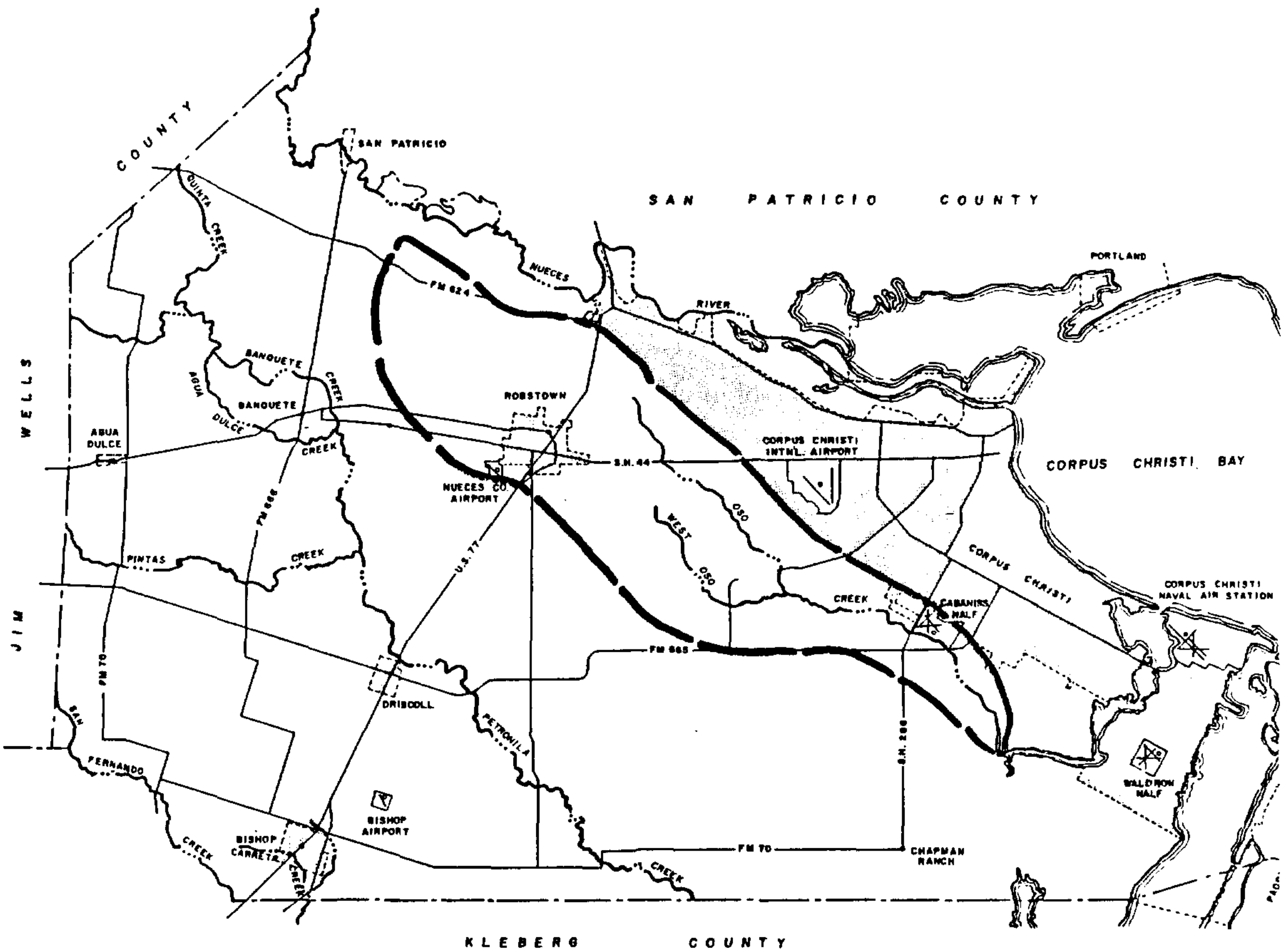
Basin 2: Oso Creek

Description

The Oso Creek watershed lies entirely within the boundaries of Nueces County. Elevations in the watershed range from about 100 feet above mean sea level (msl) at the western edge of the watershed to elevation 0 feet msl at Oso Bay. The headwater portion of the basin lies west of the town of Robstown, and Oso Creek drains into Oso Bay. The northern portion of the basin lies within the corporate limits of Corpus Christi. The headwater portion of the basin has no distinctive natural drainage channels, and runoff occurs as sheet flow. At FM 2444, Oso Creek has a drainage area of 144 square miles. For purposes of this study, the watershed was divided into three parts: Lower Oso Creek from Oso Bay to FM 763, Upper Oso Creek from FM 763 to FM 24, and West Oso Creek from its confluence with Oso Creek.

FIGURE 5-2

OSO CREEK – BASIN BOUNDARY



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Previous reports and studies of Oso Creek include the FEMA Flood Insurance Study (Ref. 5) and a Corps of Engineers Flood Hazard Information report (Ref. 26). The FEMA study covered Oso Creek from Oso Bay to FM 763.

Basin Analysis

Hydrology was performed using the USGS method (Ref. 16). The basin was divided into sub-basins, and the required parameters of drainage area and slope were computed. For the portions of Oso Creek that were included in the FEMA study, data directly from the study were used. The portion of the basin west of Robstown naturally drains towards Oso Creek, but drainage ditches have been constructed that divert water around Robstown and into Petronila Creek. For this reason, the majority of this area was considered non-contributing to the peak flow computations for Oso Creek. Table 5-2 shows the computed parameters of drainage area, slope, and discharge values for the 2-, 5-, 10-, 25-, 50-, and 100-year events.

Water surface profiles were calculated for Oso Creek and West Oso Creek using the Corps of Engineers Computer Backwater Model, HEC-2. Both natural channel sections and sections at structures were modelled. An inventory of existing structures is shown in Table 5-3. Section numbers correspond to the numbers found in the HEC-2 data, on the aerials, and on the profiles.

Problem Areas

The Oso Creek watershed has a high probability of development in certain areas due to the growth around Corpus Christi. Primary growth areas appear to be along the southern edge of Corpus Christi, particularly east of St. Hwy. 286 and around the Five Points area near U.S. 77 and FM 624.

TABLE 5-2

OSO CREEK - PEAK DISCHARGES

Location	Drainage Area (mi^2)	Slope (ft./mi.)	Discharge (cfs) 2-yr.	5-yr.	10-yr.	25-yr.	50-yr.	100-yr.
LOWER OSO CREEK*								
At FM 2444	144.0	4.14			12,500		19,400	23,700
3,200' Upstream of FM 2444					12,000		19,300	23,300
Above Confluence with Trib 6					11,900		19,200	23,200
Above State Hwy. 286					11,000		17,200	21,200
1,000' Below Confluence with Trib 10					10,500		16,000	19,400
Above Confluence with Trib 10					10,100		15,200	18,400
4,100' Above Confluence with Trib 10					10,000		15,100	18,200
UPPER OSO CREEK								
Above Confluence with West Oso	44.3	4.14	1,200	2,250	3,100	4,250	5,200	6,100
Above FM 24	3.53	2.86	225	350	450	550	650	700
WEST OSO CREEK								
At Confluence with Oso Creek	18.46	4.81	700	1,300	1,750	2,350	2,800	3,300
At Co. Road 28	11.77	5.29	550	1,000	1,300	1,750	2,100	2,400

* Discharges from FEMA Study (Ref. 5), values not generated for 2-, 5-, and 25-year events.

TABLE 5-3

OSO CREEK AND WEST OSO CREEK

STRUCTURE INVENTORY

Section No.	Road	Structure Type	Structure Size, ft.
16.02	FM 2444	17-span bridge	425 x 25
16.11	FM 43	9-span bridge	360 x 34
16.18	State Hwy. 286	19-span bridge	285 x 29
16.27	FM 763	4-span bridge	122 x 25
16.33	FM 665	3-span bridge	129 x 42
16.37	FM 2292	4-span bridge	100 x 25.5
16.44	Co. Rd. 57	5-span bridge	130 x 25
16.49	State Hwy. 44	2-span bridge	62 x 22
16.49	State Hwy. 44	4-span bridge	80 x 26
16.49	Tex-Mex R.R.	6-span bridge	78 x 15
16.54	FM 24	2-span bridge	40 x 23
16.58	Co. Rd. 44	3-span bridge	45 x 24
17.11	FM 665	2-span bridge	78 x 43
17.14	Co. Rd. 28	6-span bridge	90 x 22.5
17.31	Co. Rd. 30	4-span bridge	60 x 22

Neither of these areas experiences direct flooding from Oso Creek. The lower portion of Oso Creek has a very flat slope. Upstream of FM 2292 the channel invert experiences a rather abrupt increase in elevation of about 15 feet. The bridge at FM 763 is inadequate to pass the 100-year flood and is overtopped. Upstream of State Hwy. 44, the flooding increases significantly due to reduced channel capacity and the bridge constriction of State Hwy. 44 and the Texas-Mexican Railroad. The high backwater level in the stream also has an effect on the capacity of some of the drainage ditches in the Robstown area. By lowering the water level in this portion of Oso Creek, the drainage ditches from the Robstown area would have a higher capacity due to a decreased tailwater elevation.

West Oso Creek has a major constriction at the bridge at FM 665. This structure produces approximately 4.5 feet of backwater.

Proposed Basin Improvements

1. Replace the existing bridge on Oso Creek at FM 763 with a structure having the hydraulic characteristics of a 150 foot span structure. Raise the roadway approximately 1.5 feet.
2. Replace the existing bridges on Oso Creek at State Highway 44 and the Texas-Mexican RR with structures having the hydraulic characteristics of a 150-foot span structure.
3. Widen the channel on Oso Creek from State Highway 44 to County Road 44 to a 200-foot bottom width section.
4. Replace the existing bridge on West Oso Creek at FM 665 with a structure having the hydraulic characteristics of a 100-foot bridge.
5. The drainage ditches in and around Robstown divert water from the Oso Basin into Petronila Creek. As stated in the hydraulics section of this report, the condition of outlet channels is an important factor in the satisfactory performance of these facilities. These ditches now appear to have excess vegetation growth, which hinders passage of flood flows, and some siltation. These ditches must be maintained free of this excess vegetation and the silt buildup removed to operate as designed. It is recommended that these ditches be cleaned to their designed size and slope, and that an annual maintenance program be instigated by the drainage district at Robstown to meet these requirements. No cost has been associated with this because these ditches are controlled by the Robstown Drainage District. It has been noted

that there have been field crossings constructed across the drainage ditch south of U.S. 77. These have caused a partial blockage of the flow in the drainage ditch, thereby limiting their capacity. The drainage district should investigate these structures and remove or replace them.

6. Carefully control development in areas identified as being within the 100-year flood boundaries of Oso Creek.

Tables 5-4 and 5-5 summarize the structural and channel improvements for Oso Creek.

TABLE 5-4

SUMMARY OF STRUCTURAL IMPROVEMENTS FOR OSO CREEK

Location	Section	Station	Allowable Head Loss (ft)	Design Discharge (cfs)	Proposed Structure	Misc.
FM 763	16.27	25+80	0.7	18,000	Bridge with 150' span	Raise Road 1.5 feet
S. H. 44	16.49	504+00	0.2	6,100	Bridge with 150' span	
Tex-Mex RR	16.49	505+00	0.2	6,100	Bridge with 150' span	
FM 665	17.11	128+00	1.0	3,300	Bridge with 100' span	

TABLE 5-5

SUMMARY OF CHANNEL IMPROVEMENTS FOR OSO CREEK

Location	Station	Bottom Width (ft)	Design Discharge (cfs)
S. H. 44 to Co. Rd. 44	503+00 to 618+00	200	6100

Basin 3: Petronila Creek

Description

Petronila Creek has its origin at the confluence of Agua Dulce and Banquete Creeks. Petronila Creek has one major tributary, Pintas Creek, which joins Petronila Creek immediately downstream of FM 2826 near the Perry Foundation. Petronila Creek crosses into Kleberg County where it empties into the Cayo del Mazon, which is part of Baffin Bay. At its confluence with the Cayo del Mazon, Petronila Creek has a drainage area of approximately 624 square miles, and at FM 665 east of Driscoll it has a drainage area of approximately 381 square miles. Within Nueces County, the only community affected by flooding of the creek is Driscoll. The Matamoros Swale is a natural swale 1 to 2 feet deep that runs south of Petronila Creek and Driscoll and has been excavated to drain into Petronila Creek. U.S. Highway 77 and the Missouri-Pacific Railroad divide the watershed, running through Driscoll. The portion of the watershed in Nueces County is nearly flat coastal plain. The general slope of the ground is from the northwest to southeast at a rate of approximately 5 feet per mile.

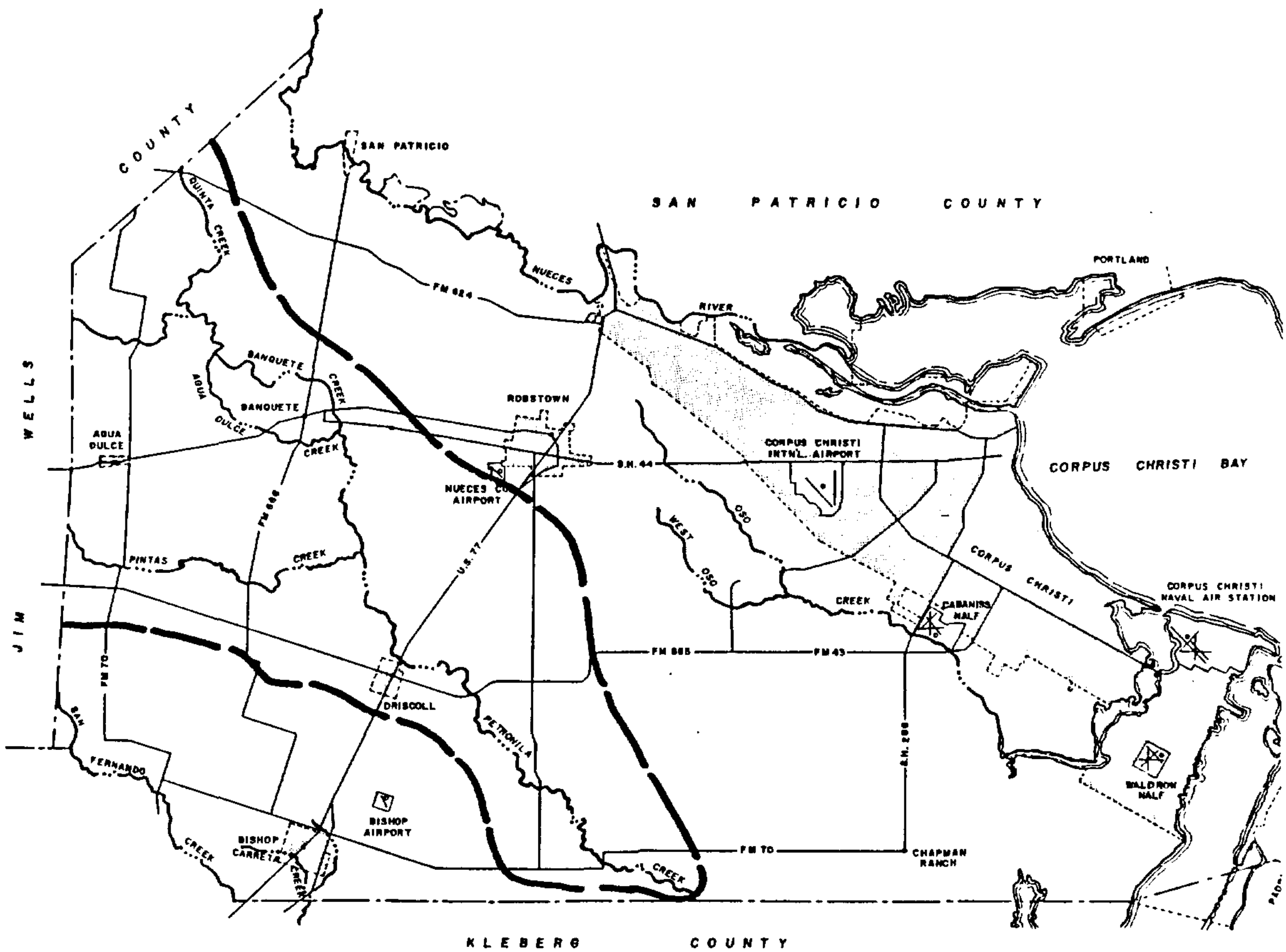
Basin Analysis

During the initial coordination meetings, it was decided to study Petronila Creek from downstream of FM 665 to its origin at the confluence of Agua Dulce Creek and Banquete Creek.

Hydrology for the Petronila watershed was performed using the USGS method (Ref. 16). The basin was subdivided, and the required parameters of drainage area and channel slope were measured. Table 5-6 shows the measured parameters and the computed peak discharge values.

FIGURE 5-3

PETRONILA CREEK - BASIN BOUNDARY



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Water surface profiles were calculated for Petronila Creek using the Corps of Engineers Computer Backwater Model, HEC-2. Both natural cross sections and sections at structures were modelled. While a FEMA study for the City of Driscoll has been completed, data from the study were not available from FEMA for use in this study. An inventory of the existing structures is shown in Table 5-7. Section numbers correspond to the numbers found in the HEC-2 data, on the aerials, and on the profiles.

Problem Areas

The primary flooding problems on Petronila Creek occur upstream of FM 665. Downstream of FM 665 there is a well defined and relatively deep channel. The land use downstream of FM 665 is predominantly agricultural, and potential for development is minimal. Between FM 665 and U.S. 77, the channel depth decreases significantly, thereby reducing the capacity of the channel to carry floodwater. This creates a backwater effect behind U.S. 77 and the Missouri-Pacific Railroad, which prevents drainage in and around Driscoll from entering the Creek. A previous report (Ref. 24) states that when the water surface elevation in Petronila Creek above U.S. 77 reaches 60 feet msl, flooding occurs in Driscoll. Another source of flooding in the Driscoll area is from the Matamoras Swale. Due to the flat topography of the area west of Driscoll, floodwater can break over the divide from Pintas Creek and San Fernando Creek into the Matamoras Swale. This water can enter the Driscoll area from the west as sheet flow. In addition, high water levels in Petronila Creek cause backwater up the Matamoras Swale.

TABLE 5-6

PETRONILA CREEK - PEAK DISCHARGE

Location	Drainage Area (mi^2)	Slope (ft./mi.)	Peak Discharge (cfs)					
			2-yr.	5-yr.	10-yr.	25-yr.	50-yr.	100-yr.
6,000 ft. South of Co. Rd. 18	407	4.76	4,800	10,650	15,650	23,400	30,200	37,100
FM 665	381	4.86	4,650	10,250	15,050	22,450	29,000	35,600
US 77	360	5.27	4,500	10,050	14,850	22,200	28,800	35,400
FM 2826	289	6.04	4,000	9,000	13,250	19,850	25,700	31,700

TABLE 5-7

PETRONILA CREEK - STRUCTURE INVENTORY

Section No.	Road	Structure	
		Type	Size, ft.
15.15	Co. Rd. 18	5-span bridge	125 x 26
15.30	FM 665	8-span bridge	240 x 44
15.70	US 77 (northbound)	16-span bridge	488 x 28
15.70	US 77 (southbound)	20-span bridge	440 x 50
15.70	Mo-Pac R.R.	26-span bridge	442 x 15
15.90	FM 2826	4-span bridge	160 x 28
15.94	Co. Rd. 38	5-span bridge	150 x 28

Proposed Basin Improvements

1. Widen the Petronila Creek channel from FM 665 to approximately 16,000 feet upstream of the Missouri-Pacific Railroad to a 300-foot bottom width section.
2. Replace the existing bridge on Petronila Creek at FM 2826 with a structure having the hydraulic characteristics of a 300-foot span structure. Raise the roadway approximately 0.8 feet.
3. Construct a diversion ditch along the west side of Driscoll with a bottom width of 15 feet.
4. Carefully control development in areas identified as being within the 100-year flood boundaries of Petronila.

Tables 5-8 and 5-9 summarize the structural and channel improvements for Petronila Creek.

TABLE 5-8

SUMMARY OF STRUCTURAL IMPROVEMENTS FOR PETRONILA CREEK

Location	Section	Station	Allowable Head Loss (ft)	Design Discharge (cfs)	Example Structure	Misc.
FM 2826	15.90	757+20	0.7	31,700	Bridge with 300' span	

TABLE 5-9

SUMMARY OF CHANNEL IMPROVEMENTS FOR PETRONILA CREEK

Location	Station	Bottom Width (ft)	Design Discharge (cfs)
FM 665 to Section 15.80	217+00 to 656+00	300	31,700

Basin 4: Pintas Creek

Description

Pintas Creek is a major tributary of Petronila Creek. The headwaters of Pintas Creek begin in Jim Wells County east of Alice. At its confluence with Petronila Creek, Pintas Creek has a drainage area of approximately 51.1 square miles. There are no incorporated areas within the watershed in Nueces County. The general slope of the ground is from west to east at a rate of approximately 6.5 feet per mile. The watershed area in Nueces County is nearly flat coastal plain area.

Basin Analysis

During the initial coordination meetings, it was decided to study Pintas Creek from its confluence with Petronila Creek to the Nueces-Jim Wells county line.

Hydrology for the Pintas Creek watershed was performed using the USGS method (Ref. 16). The basin was subdivided, and the required parameters of drainage area and channel slope were measured. Table 5-10 shows the measured parameters and the computed peak discharge values.

Water surface profiles were calculated for Pintas Creek using the Corps of Engineers Computer Backwater Model, HEC-2. Both natural cross sections and cross sections at structures were modelled. An inventory of the existing structures is shown in Table 5-11. Section numbers correspond to the numbers found in the HEC-2 data, on the aerials, and on the profiles.

FIGURE 5-4

PINTAS CREEK – BASIN BOUNDARY

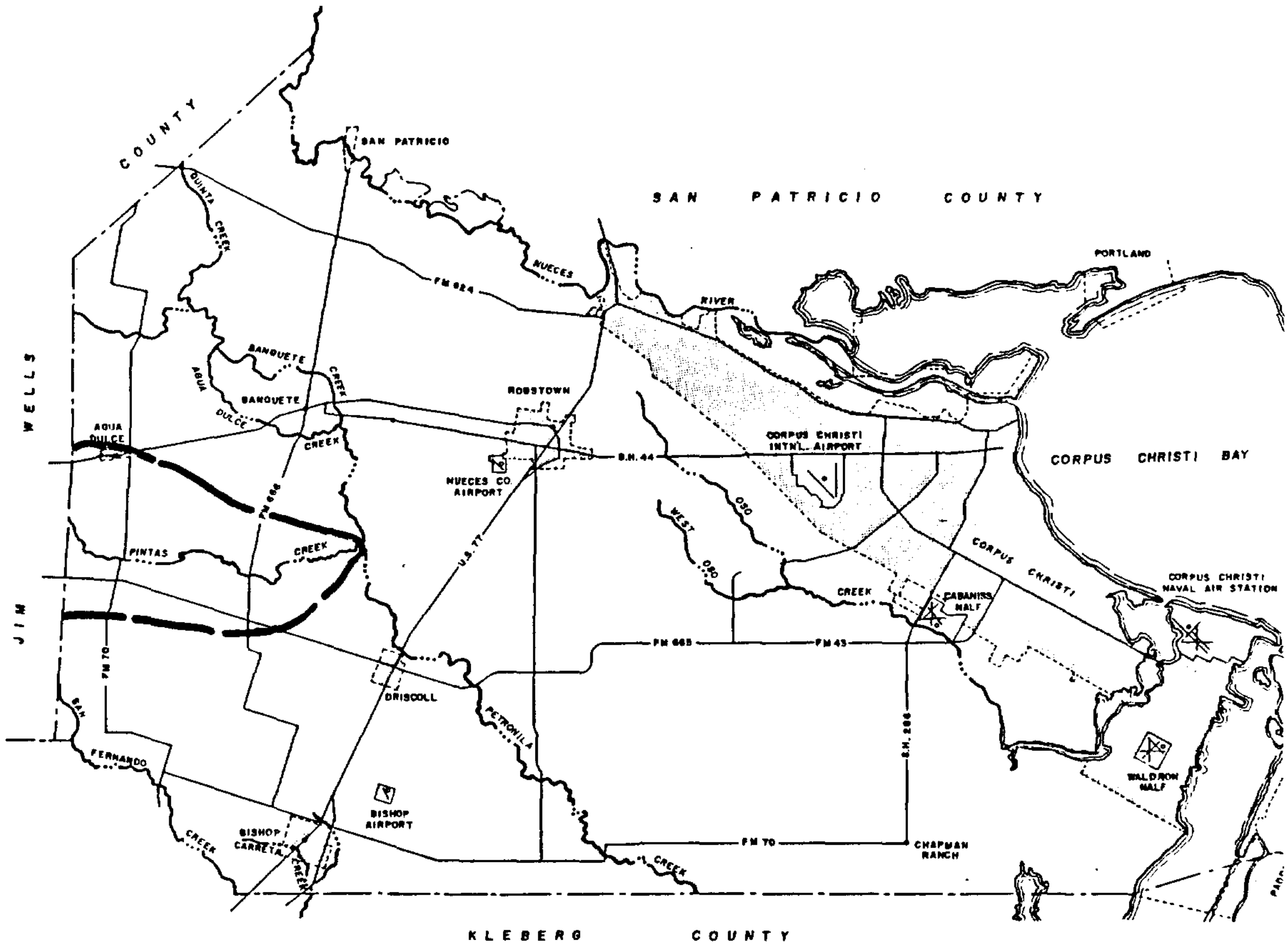

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TABLE 5-10

PINTAS CREEK - PEAK DISCHARGE

Location	Drainage Area (mi^2)	Slope (ft./mi.)	Discharge (cfs) 2-yr.	5-yr.	10-yr.	25-yr.	50-yr.	100-yr.
At Confluence with Petronila Creek	51.1	5.51	1,350	2,650	3,750	5,250	6,500	7,800
FM 666	43.0	6.26	1,200	2,450	3,450	4,850	6,000	7,200
FM 70	27.44	6.96	950	1,850	2,600	3,600	4,500	5,300
At County Line	14.77	7.11	650	1,200	1,650	2,300	2,800	3,300

TABLE 5-11

PINTAS CREEK - STRUCTURE INVENTORY

Section No.	Road	Structure Type	Size, ft.
11.01	Co. Rd. 85	5-span bridge	140 x 27
11.05	Co. Rd. 87	4-span bridge	100 x 25
11.10	FM 666	8-span bridge	120 x 26
11.15	Co. Rd. 93	6-span bridge	108 x 16
11.19	Co. Rd. 95	6-span bridge	108 x 16
11.26	FM 70	10-span bridge	150 x 26
11.31	Co. Rd. 105	6-span bridge	96 x 22

Problem Areas

Pintas Creek experiences extensive flooding adjacent to its channel. In addition, the high water levels in the channel prevent local drainage from entering the stream and being removed. While there is little development in the Pintas Creek watershed, floodwaters can overflow the basin boundary and enter the Matamoras Swale and proceed as sheet flow towards the City of Driscoll. In addition, the majority of the roads can be overtopped, thereby cutting off access to portions of the basin during storms.

Proposed Basin Improvements and Recommendations

1. Widen the Pintas Creek channel from its confluence with Petronila Creek to the Nueces-Jim Wells county line to a 200-foot bottom width section.
2. Carefully control development in areas identified as being within the 100-year flood boundaries of Pintas Creek.

Table 5-12 summarizes channelization improvements for Pintas Creek.

TABLE 5-12

SUMMARY OF CHANNEL IMPROVEMENTS FOR PINTAS CREEK

Location	Station	Bottom Width (ft)	Design Discharge (cfs)
Confluence with Petronila Creek to County Line	0+00 to 737+00	200	Varies - 3,300 to 7,800

Basin 5: Agua Dulce Creek

Description

Agua Dulce Creek has its origins in Jim Wells County. The major tributaries of Agua Dulce Creek are Banquete Creek in Nueces County, Quinta Creek in Nueces County, and Palo Hucco Creek in Jim Wells County. Agua Dulce Creek becomes Petronila Creek at its confluence with Banquete Creek. At its confluence with Banquete Creek, Agua Dulce Creek has a drainage area of 201 square miles. A portion of the Town of Banquete lies in the Agua Dulce watershed. The area of the watershed in Nueces County is nearly flat coastal plain. The general slope of the ground is from the northwest to the southeast at a rate of approximately 7.5 feet per mile.

Basin Analysis

During the initial coordination meetings, it was decided to study Agua Dulce Creek from its confluence with Banquete Creek to the Nueces-Jim Wells county line.

Hydrology for the Agua Dulce watershed was performed using the USGS method (Ref. 16). The basin was subdivided, and the required parameters of drainage area and channel slope were measured. Table 5-13 shows the measured parameters and the computed peak discharge values.

Water surface profiles were calculated for Agua Dulce Creek using the Corps of Engineers Computer Backwater Model, HEC-2. Both natural cross sections and sections at structures were modelled. An inventory of the existing structures is shown in Table 5-14. Section numbers correspond to the numbers found in the HEC-2 data, on the aerials, and on the profiles.

FIGURE 5–5

AGUA DULCE CREEK – BASIN BOUNDARY

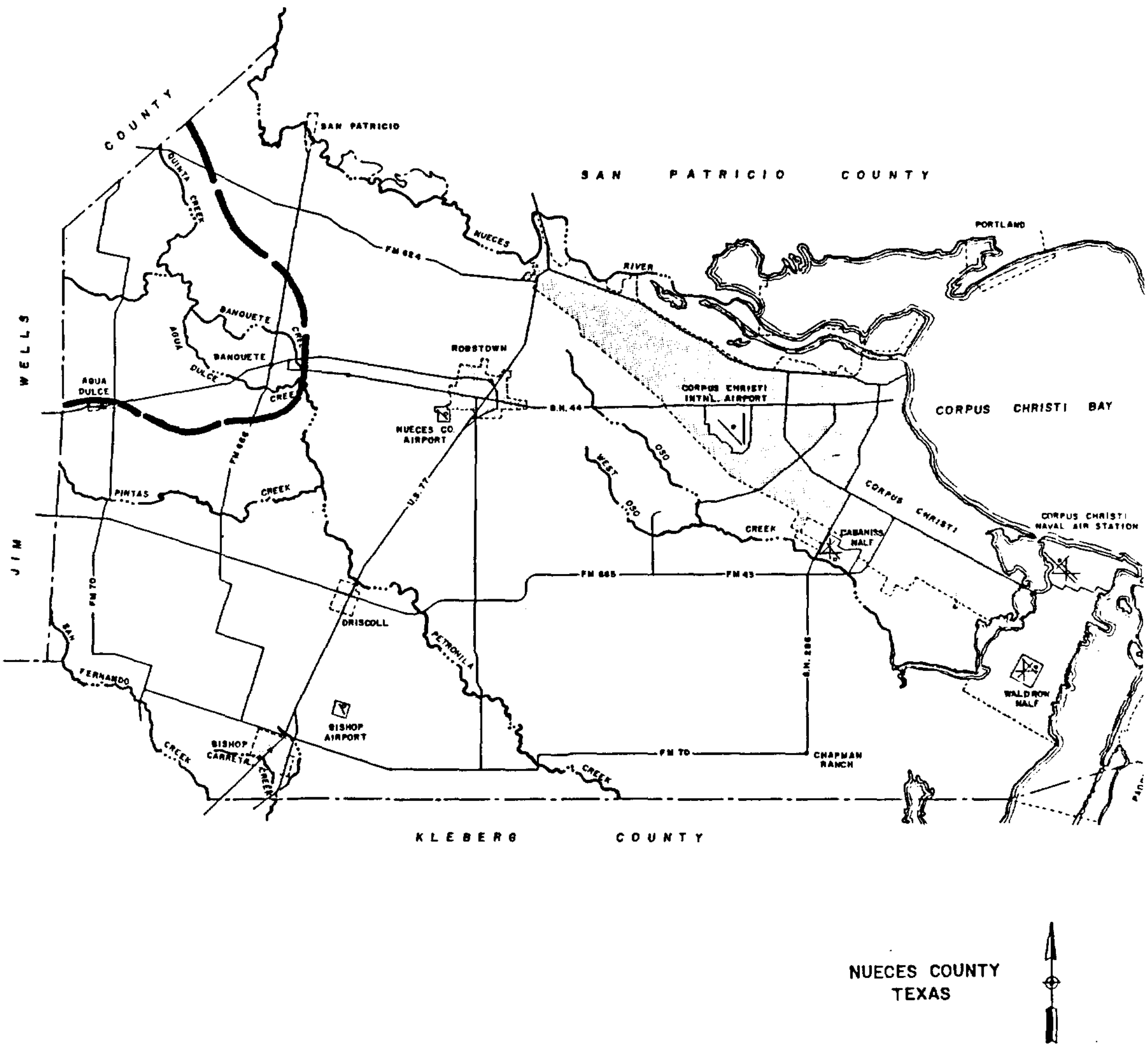


TABLE 5-13

AGUA DULCE CREEK - PEAK DISCHARGE

Location	Drainage Area (mi^2)	Slope (ft./mi.)	Discharge (cfs) 2-yr.	5-yr.	10-yr.	25-yr.	50-yr.	100-yr.
At Confluence with Banquete Creek	200.6	6.92	3,250	7,200	10,650	15,950	20,600	25,400
State Hwy. 44	190.1	7.32	3,150	7,050	10,450	15,650	20,300	25,000
FM 70	158.7	9.69	2,950	6,700	10,050	15,250	19,900	24,700
At County Line	150.9	9.79	2,850	6,500	9,700	14,750	19,200	23,900

TABLE 5-14

AGUA DULCE CREEK - STRUCTURE INVENTORY

Section No.	Road	Structure Type	Size, ft.
12.10	FM 666	7-span bridge	210 x 36
12.15	Tex-Mex R.R.		
12.20	State Hwy. 44 (eastbound)	8-span bridge	312 x 44
12.20	State Hwy. 44 (westbound)	8-span bridge	312 x 28
12.45	Co. Rd. 42	3-span bridge	48 x 20
12.60	FM 70	7-span bridge	196 x 27

Problem Areas

Primary flooding problems on Agua Dulce Creek occur between State Hwy. 44 and FM 70. The channel has inadequate capacity and this causes flooding adjacent to the channel. The headwaters of Banquete Creek are near the channel, and during periods of high flow, water can overflow the basin boundary into Banquete Creek. The high water levels in Agua Dulce Creek also cause extensive backwater up Quinta Creek. This backwater causes flooding of the low-lying areas near the confluence with Quinta Creek.

Proposed Master Plan Improvements and Recommendations

1. Replace the bridge at FM 666 with a structure having the hydraulic characteristics of a 300-foot span structure. Raise the roadway approximately 3.0 feet.
2. Widen the Agua Dulce channel from State Hwy. 44 to FM 70 to a 600-foot bottom width.
3. Carefully control development in areas identified as being within the 100-year flood boundaries of Agua Dulce Creek.

Tables 5-15 and 5-16 summarize the structural and channel improvements for Agua Dulce Creek.

TABLE 5-15

SUMMARY OF STRUCTURAL IMPROVEMENTS FOR AGUA DULCE CREEK

Location	Section	Station	Allowable Head Loss (ft)	Design Discharge (cfs)	Example Structure	Misc.
FM 666	12.10	117+70	0.3	25,400	Bridge with 300' span	Raise road 2.9 feet

TABLE 5-16

SUMMARY OF CHANNEL IMPROVEMENTS FOR AGUA DULCE CREEK

Location	Station	Bottom Width (ft)	Design Discharge (cfs)
S. H. 44 to FM 70	236+61 to 768+02	600	Varies - 24,700 to 25,000

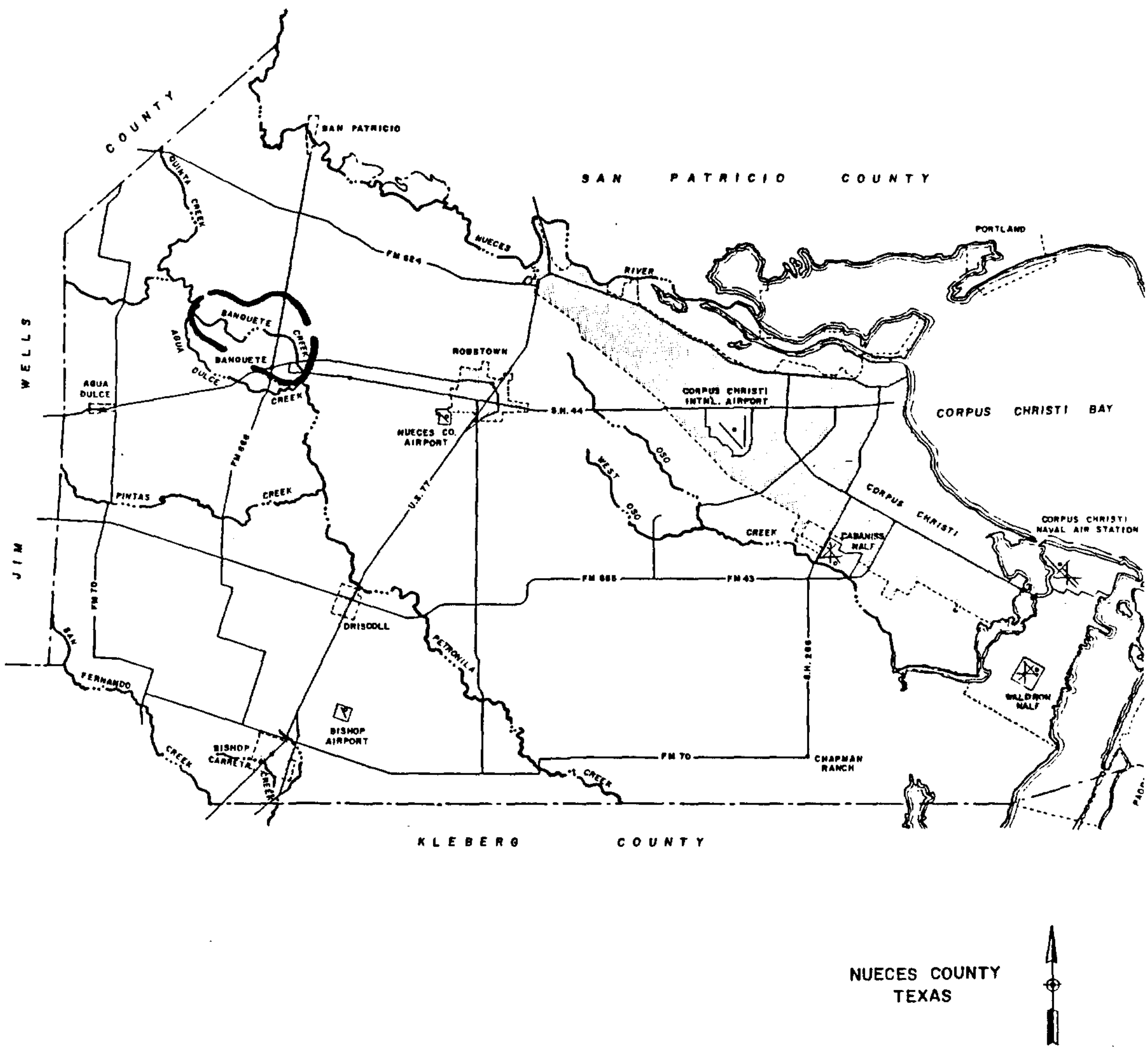
Basin 6: Banquete Creek

Description

The Banquete Creek watershed is located entirely within Nueces County. It has its origin near Agua Dulce Creek and discharges into Petronila Creek at its confluence with Agua Dulce Creek below the Texas-Mexican Railroad. At its confluence with Agua Dulce Creek, it has a drainage area of 10.9 square miles. A portion of the Town of Banquete is included in its watershed. The watershed is nearly flat coastal plain. The general slope of the ground is from the northwest to the southeast at a rate of approximately 2 feet per mile.

FIGURE 5-6

BANQUETE CREEK - BASIN BOUNDARY



Basin Analysis

During the initial coordination meetings, it was decided to study Banquete Creek from its confluence with Agua Dulce Creek to County Road 93, the limit of its defined channel.

Hydrology for the Banquete Creek watershed was performed using the USGS method (Ref. 16). The basin was subdivided, and the required parameters of drainage area and channel slope were measured. Table 5-17 shows the measured parameters and the computed peak discharge values.

Water surface profiles were calculated for Banquete Creek using the Corps of Engineers Computer Backwater Model, HEC-2. Both natural cross sections and sections at structures were modelled. An inventory of existing structures is shown in Table 5-18. Section numbers correspond to the numbers found in the HEC-2 data, on the aerials, and on the profiles.

Problem Areas

Due to the small drainage area and large structure sizes, Banquete Creek has little flooding problems from its own watershed. Problems can occur when Agua Dulce Creek overflows the basin boundary into Banquete Creek.

Proposed Basin Improvements and Recommendations

1. No improvements on Banquete Creek are proposed.
2. Carefully control development in areas identified as being within the 100-year flood boundaries of Banquete Creek.

TABLE 5-17

BANQUETE CREEK - PEAK DISCHARGE

Location	Drainage Area (mi^2)	Slope (ft./mi.)	Peak Discharge (cfs) 2-yr.	5-yr.	10-yr.	25-yr.	50-yr.	100-yr.
At Confluence with Agua Dulce Creek	10.9	2.53	450	750	1,000	1,250	1,450	1,600
FM 666	5.13	1.69	300	400	500	600	700	750
Co. Rd. 42A	0.62	8.45	100	150	200	225	250	300

TABLE 5-18

BANQUETE CREEK - STRUCTURE INVENTORY

Section No.	Road	Structure Type	Size, ft.
13.05	Tex-Mex R.R.	9-span bridge	121.5 x 15
13.10	Co. Rd. 40	3-span bridge	108 x 23
13.15	State Hwy. 44 (eastbound)	6-span bridge	240 x 44
13.15	State Hwy. 44 (westbound)	9-span bridge	180 x 26.5
13.30	FM 666	8-span bridge	160 x 28
13.50	Co. Rd. 93	7-span bridge	105 x 24

Basin 7: Quinta Creek

Description

Quinta Creek has its origin in Jim Wells County. The Creek is a major tributary of Agua Dulce Creek and discharges into Agua Dulce Creek downstream of FM 1833. At its confluence with Agua Dulce Creek, Quinta Creek has a drainage area of approximately 39.5 square miles. There are no incorporated areas within the watershed in Nueces County. The portion of the watershed in Nueces County is nearly flat coastal plain. The primary land use in the watershed is farming. The general slope of the ground is from the northwest to the southeast at a rate of approximately 7 feet per mile.

Basin Analysis

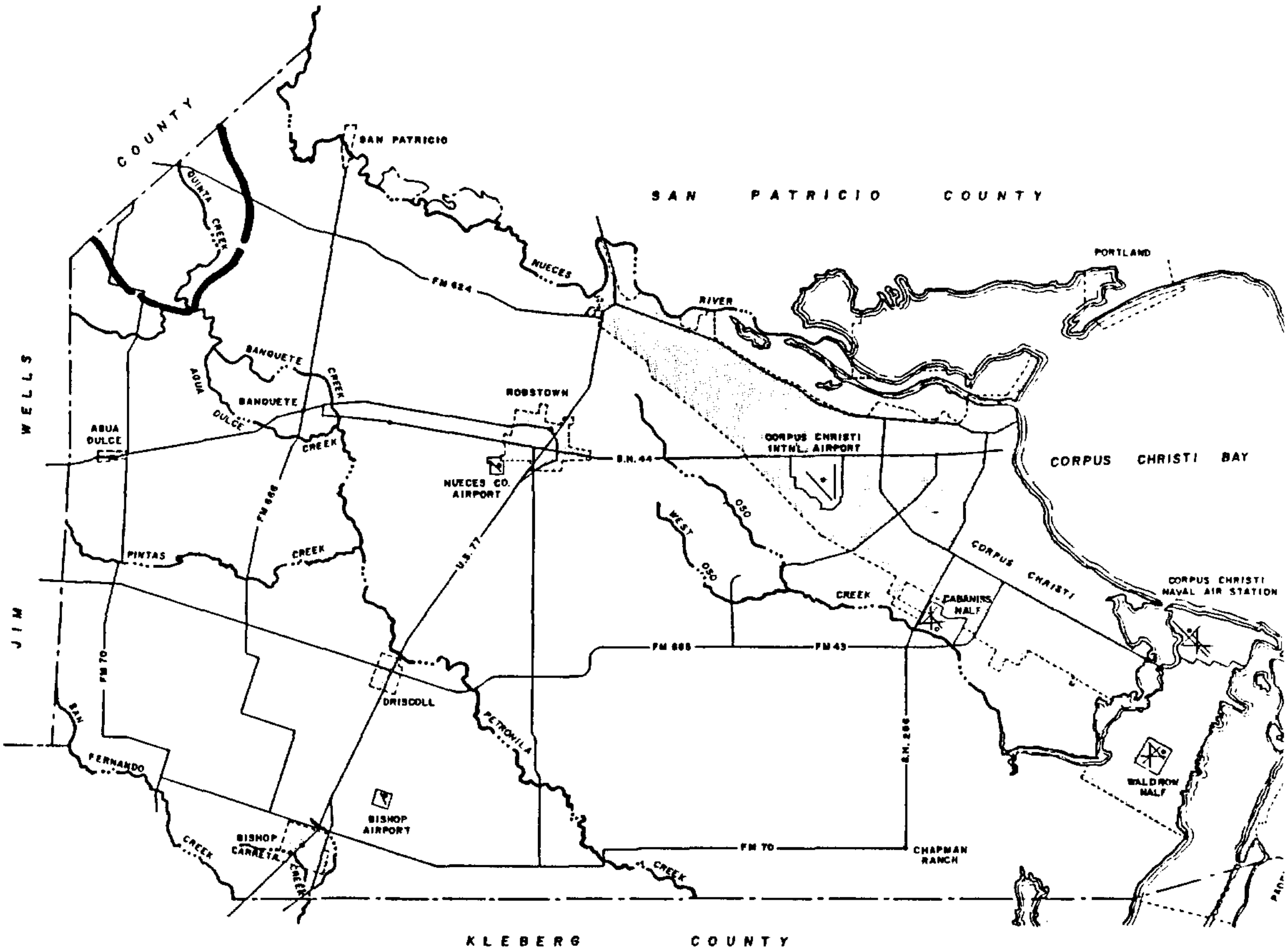
During the initial coordination meetings, it was decided to study Quinta Creek from its confluence with Agua Dulce Creek to the Nueces-Jim Wells county line.

Hydrology for the Quinta Creek watershed was performed using the USGS method (Ref. 16). The basin was subdivided, and the required parameters of drainage area and channel slope were measured. Table 5-19 shows the measured parameters and the computed peak discharge values.

Water surface profiles were calculated for Banquete Creek using the Corps of Engineers Computer Backwater Model, HEC-2. Both natural cross sections and sections at structures were modelled. An inventory of existing structures is shown in Table 5-20. Section numbers correspond to the numbers found in the HEC-2 data, on the aerials, and on the profiles.

FIGURE 5-7

QUINTA CREEK – BASIN BOUNDARY



NUECES COUNTY
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TABLE 5-19

QUINTA CREEK - PEAK DISCHARGE

Location	Drainage Area (mi²)	Slope (ft./mi.)	Peak Discharge (cfs) 2-yr.	5-yr.	10-yr.	25-yr.	50-yr.	100-yr.
At Confluence with Agua Dulce Creek	39.5	6.61	1,100	2,200	3,100	4,450	5,500	6,600
Co. Rd. 48	20.3	7.53	800	1,550	2,150	3,000	3,700	4,300
FM 624	14.0	9.27	650	1,250	1,750	2,450	3,000	3,600

TABLE 5-20

QUINTA CREEK - STRUCTURE INVENTORY

Section No.	Road	Structure Type	Structure Size, ft.
14.15	Co. Rd. 48	6-span bridge	90 x 24
14.21	FM 1833	6-span bridge	180 x 25
14.26	Co. Rd. 95	5-span bridge	100 x 24
14.35	Co. Rd. 101	5-span bridge	75 x 24

Problem Areas

The primary problem area in the Quinta Creek watershed is between the confluence with Agua Dulce Creek to upstream of FM 1833. A large part of the flooding problem can be attributed to excessive backwater at the bridges at County Road 48, FM 1833 and County Road 95, and also to the effects of Agua Dulce Creek. The flooding problem is aggravated by the fact that local drainage in the area cannot reach the stream due to these backwater problems.

Proposed Basin Improvements and Recommendations

1. Replace the bridges on FM 1833 and County Road 95 with one bridge on FM 1833. This bridge should have the hydraulic characterstics of a bridge with a 200-foot opening.
2. Carefully control development in areas identified as being within the 100-year flood boundaries of Quinta Creek.

Table 5-21 summarizes the structural improvements for Quinta Creek.

TABLE 5-21

SUMMARY OF STRUCTURAL IMPROVEMENTS FOR QUINTA CREEK

Location	Section	Station	Allowable Head Loss (ft)	Design Discharge (cfs)	Example Structure	Misc.
FM 1833 & Co. Rd. 95	14.21 & 14.26	205+00	0.5	4,300	Bridge with 200' span	

Basin 8: San Fernando Creek

Description

The San Fernando Creek watershed covers parts of four counties: Duval, Jim Wells, Nueces, and Kleberg. The Creek has its origin in the northern part of Duval County, passes through Jim Wells County into Nueces County where, for a distance, it forms the border with Kleberg County. It then passes into Kleberg County where it discharges into the Cayo del Grullo, an arm of Baffin Bay. San Fernando Creek has one tributary, Carreta Creek, that is partially in Nueces County. San Fernando Creek drains the extreme southwest portion of Nueces County, and at the point where it leaves Nueces County and enters Kleberg County, it has a drainage area of approximately 625 square miles. It has a total drainage area of approximately 1,260 square miles where it enters the Cayo del Grullo. There are no incorporated areas within the watershed in Nueces County. In Nueces County, the general slope of the ground is from the northwest to the southeast at a rate of approximately 4.8 feet per mile.

Basin Analysis

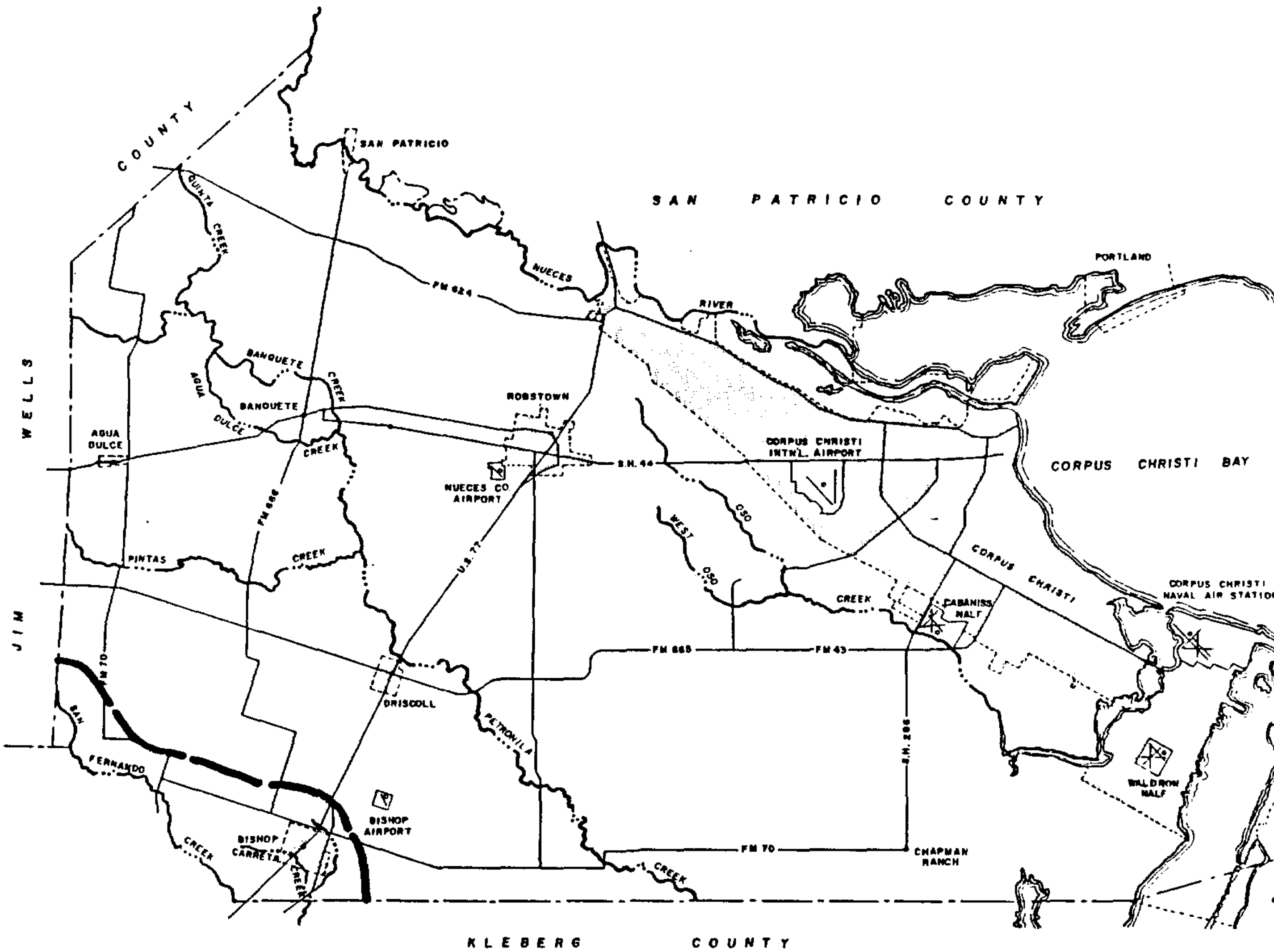
During the initial coordination meetings, it was decided to study the San Fernando Creek for its entire reach through Nueces County.

Hydrology for the San Fernando Creek watershed was performed using the Cypress Creek Method (Ref. 20). The basin was subdivided, and the required parameters of rainfall, curve number, and drainage area were determined. Table 5-22 shows the hydrologic parameters and peak discharge values used in the analysis.

Water surface profiles were calculated for the San Fernando Creek watershed using the Corps of Engineers Computer Backwater Model, HEC-2. Both natural cross sections and sections at structures were modelled. An

FIGURE 5-8

SAN FERNANDO CREEK – BASIN BOUNDARY



NUECES COUNTY
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TABLE 5-22

SAN FERNANDO CREEK - PEAK DISCHARGE

Location	Drainage Area (mi²)	Peak Discharge 10-year Rainfall (in.)	Q (cfs)	25-Year Rainfall (in.)	Q (cfs)	50-Year Rainfall (in.)	Q (cfs)	100-Year Rainfall (in.)	Q (cfs)
At Kleberg County Line	625	7.00	8,440	8.25	10,720	9.35	12,960	10.75	16,090
FM 1355	609	7.00	8,260	8.25	10,480	9.35	12,680	10.75	15,730
At Jim Wells County Line	544	7.00	7,510	8.25	9,540	9.35	11,530	10.75	14,310

TABLE 5-23

SAN FERNANDO CREEK - STRUCTURE INVENTORY

Section No.	Road	Structure Type	Size, ft.
8.15	FM 1355	3-span bridge	87 x 36

inventory of existing structures is shown in Table 5-23. Section numbers correspond to the numbers found in the HEC-2 data, on the aerials, and on the profiles.

Problem Areas

Direct flooding adjacent to the San Fernando Creek channel is not a severe problem due to the limited development in the watershed. During periods of high flows in San Fernando Creek, water can cross the basin divide and flow into Carreta Creek, which flows through a portion of the City of Bishop.

Proposed Basin Improvements and Recommendations

1. Widen the channel of San Fernando Creek from the Nueces-Kleberg county line to the Nueces-Jim Wells county line to a bottom width of 350 feet.
2. Replace the bridge on FM 1355 with a structure that has the hydraulic characteristics of a 300-foot span structure.
3. Carefully control development in areas identified as being within the 100-year flood boundaries of San Fernando Creek.

Tables 5-24 and 5-25 summarize the structural and channel improvements for San Fernando Creek.

TABLE 5-24

SUMMARY OF STRUCTURAL IMPROVEMENTS FOR SAN FERNANDO CREEK

Location	Section	Station	Allowable Head Loss (ft)	Design Discharge (cfs)	Example Structure	Misc.
FM 1355	8.15	360+00	0.5	15,727	Bridge with 300' span	

TABLE 5-25

SUMMARY OF CHANNEL IMPROVEMENTS FOR SAN FERNANDO CREEK

Location	Station	Bottom Width (ft)	Design Discharge (cfs)
Kleberg to Jim Wells county line	27+00 to 729+00	350	Varies - 17,266 to 14,311

Basin 9: Carreta Creek

Description

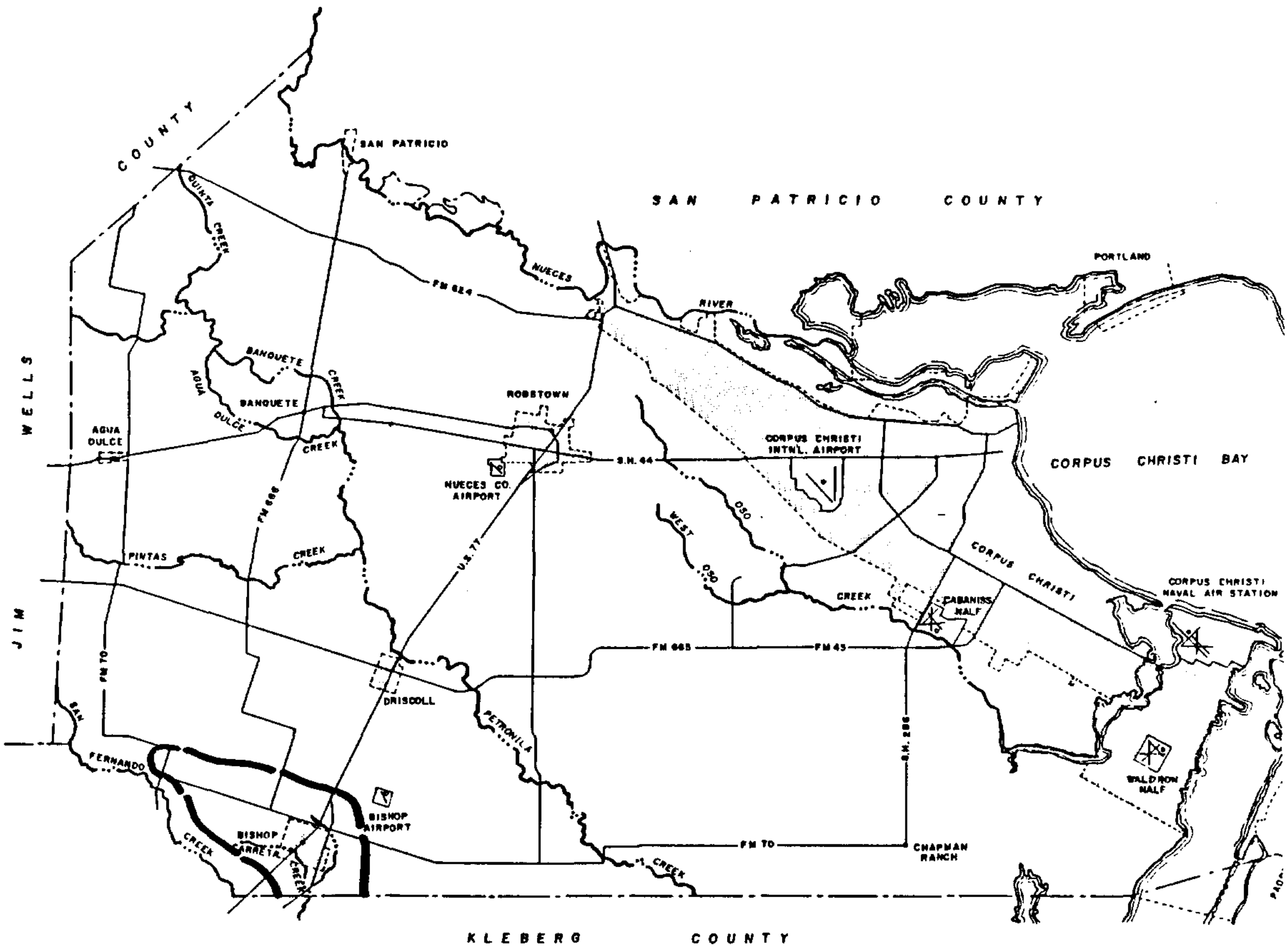
The Carreta Creek watershed covers a portion of the southwest corner of Nueces County. Carreta Creek has its origin in Nueces County near the Jim Wells County line. Carreta Creek travels in an easterly direction through the southern portion of the City of Bishop. Here it turns almost due south and crosses into Kleberg County where it joins San Fernando Creek. North Carreta Creek is a tributary of Carreta Creek. It drains the north and west portions of Bishop, and joins Carreta Creek immediately south of the Nueces-Kleberg county line. At its confluence with San Fernando Creek, it has a drainage area of approximately 37.4 square miles. At the Nueces-Kleberg county line, Carreta Creek has a drainage area of approximately 23.4 square miles. The general slope of the ground in the watershed is from the northwest to the southeast at a rate of about 6.3 feet per mile.

Basin Analysis

During the initial coordination meetings, it was decided to study Carreta Creek from the Nueces-Kleberg county line to upstream of FM 666, the limits of its defined channel.

FIGURE 5-9

CARRETA CREEK – BASIN BOUNDARY



NUECES COUNTY
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Hydrology for the Carreta Creek watershed was performed using the Cypress Creek Method (Ref. 20). The basin was subdivided, and the required parameters of rainfall, curve number, and drainage area were determined. Table 5-26 shows the hydrologic parameters and the peak discharge values used in the analysis.

Water surface profiles were calculated for Carreta Creek watershed using the Corps of Engineers Computer Backwater Model, HEC-2. Both natural cross sections and sections at structures were modelled. An inventory of existing structures is shown in Table 5-27. Section numbers correspond to the numbers found in the HEC-2 data, on the aerials, and on the profiles.

Problem Areas

No specific problem areas were identified in the Carreta Creek watershed. North Carreta Creek has been channelized through Bishop to control flooding. Primary flooding problems are due to the flat topography limiting the rate stormwater can reach the channels of Carreta and North Carreta Creeks. Carreta Creek is subject to overflow from San Fernando Creek during periods of high water levels in San Fernando Creek.

Proposed Basin Improvements and Recommendations

1. No improvements proposed.
2. Carefully control development in areas identified as being within the 100-year flood boundaries of Carreta Creek.

TABLE 5-26

CARRETA CREEK - PEAK DISCHARGE

Location	Drainage Area (mi^2)	Peak Discharge 10-year Rainfall (in.)	Q (cfs)	25-Year Rainfall (in.)	Q (cfs)	50-Year Rainfall (in.)	Q (cfs)	100-Year Rainfall (in.)	Q (cfs)
At Kleberg County Line	23.4	7.25	702	8.60	903	9.80	1,100	11.20	1,360
FM 666	16.4	7.25	543	8.60	700	9.80	853	11.20	1,050

TABLE 5-27

CARRETA CREEK - STRUCTURE INVENTORY

Section No.	Road	Structure Type	Size, ft.
10.35	US 77 Bypass (northbound)	4-span bridge	160 x 42
10.35	US 77 Bypass (southbound)	4-span bridge	160 x 40
10.40	Co. Rd. 4	4-span bridge	58 x 21
10.85	Co. Rd. 85	4-span bridge	60 x 24

SECTION 6 - CAPITAL COSTS

Selection of the final master plan is dependent on the costs of implementing its solution, which in turn are a function of the level of protection provided. These costs include both the capital costs to achieve the improvements and consideration of maintenance costs to sustain drainage capacity.

This report provides conceptual costs only. Consistent unit costs have been used throughout the County. These costs can be used as general guidelines in assessing improvement priorities and in budgeting long-range comprehensive stormwater management improvements.

Specific structure sizes and channel improvements are made here in order to define the hydraulic characteristics required to produce the water surface elevations of the master plan and to provide a basis for estimating the costs of the improvements. The final determination of these features and associated costs can not be made until a detailed engineering design has been completed.

The following summarizes the costs for the master plan improvements for the nine basins in Nueces County.

Nueces River

No improvements recommended.

Oso Creek

1. 150-foot bridge at FM 763

Demolition of existing bridge	$ 11,200
Construct new bridge	409,500
Earthwork	28,000
Subtotal Construction	$ 448,700
Engineering and legal at 20%	$ 89,700
Total	$ 538,400

2. 150-foot bridges at State Hwy. 44 (2 bridges)

Demolition of existing bridge	$ 35,000
Construct new bridges	819,000
Earthwork	65,000
Subtotal Construction	$ 919,000
Engineering and legal at 20%	184,000
Total	$ 1,103,000

3. 150-foot bridge at Texas-Mexican RR

Demolition of existing bridge	$ 6,500
Construct new bridge	247,000
Construct Shoefly	450,000
Subtotal Construction	$ 703,500
Engineering and legal at 20%	141,000
Total	$ 844,500

4. Channelize from station 503+00 to 618+00 with 200-foot bottom width channel

ROW (85 acres)	$ 170,000
Clearing	50,000
Earthwork	642,000
Seeding	23,400
Subtotal Construction	$ 885,400
Engineering and legal at 20%	$ 177,000
Total	$ 1,062,400

5. 100-foot bridge at FM 665 on West Oso Creek

Demolition of existing bridge	$ 16,700
Construct new bridge	273,000
Earthwork	20,000
Subtotal Construction	$ 309,700
Engineering and legal @ 20%	$ 61,900
Total	$ 371,600

6. Total for Oso Creek $ 3,919,900

Petronila Creek

1. Channelize from station 217+00 to 656+00 with a 300-foot bottom width channel

ROW (403 acres)	$ 806,000
Clearing	605,000
Earthwork	13,599,000
Seeding	403,000
Subtotal Construction	$ 15,413,000
Engineering and legal at 20%	$ 3,082,600
Total	$ 18,495,600

2. 300-foot bridge at FM 2826

Demolition of existing bridge	$ 22,400
Construct new bridge	819,000
Earthwork	25,000
Subtotal Construction	$ 866,400
Engineering and legal at 20%	$ 173,300
Total	$ 1,039,700

3. Diversion ditch around Driscoll

ROW (30 acres)	$ 60,000
Clearing	45,000
Earthwork	770,000
Bridges (2)	163,800
Seeding	45,000
Subtotal Construction	$ 1,083,800
Engineering and legal @ 20%	$ 216,800
Total	$ 1,300,600

4. Total for Petronila Creek $ 20,835,900

Agua Dulce Creek

1. 300-foot bridge at FM 666

Demolition of existing bridge	$ 37,800
Construct new bridge	819,000
Earthwork	32,000
Subtotal Construction	$ 888,800
Engineering and legal at 20%	$ 177,700
Total	$ 1,066,500

2. Channelize from station 236+61 to 768+02 with a 600-foot bottom width channel

ROW (854 acres)	$ 1,708,000
Clearing	1,281,000
Earthwork	24,187,000
Seeding	854,000
Subtotal Construction	$ 28,030,000
Engineering and legal at 20%	$ 5,606,000
Total	$ 33,636,000

3. Total for Agua Dulce Creek — $ 34,702,500

Pintas Creek

1. Channelize from station 0+00 to 737+00 with a 200-foot bottom width channel

ROW (492 acres)	$ 984,000
Clearing	734,000
Earthwork	12,693,000
Seeding	492,000
Subtotal Construction	$ 14,903,000
Engineering and legal at 20%	$ 2,980,600
Total	$ 17,883,600

Banquete Creek

No improvements recommended.

Quinta Creek

1. 200-foot bridge at FM 1833

Demolition of two bridges	$ 37,000
Construct new bridge	546,000
Earthwork	95,000
Subtotal Construction	$ 678,000
Engineering and legal at 20%	$ 135,600
Total	$ 813,600

San Fernando Creek

1. Channelize from station 27+00 to 729+00 with a 350-foot bottom width channel

ROW (652 acres)	$ 1,304,000
Clearing	1,630,000
Earthwork	18,868,000
Seeding	652,000
Subtotal Construction	$ 22,454,000
Engineering and legal at 20%	$ 4,491,000
Total	$ 26,945,000

2. 300-foot bridge at FM 1355

Demolition	$ 18,000
Construct new bridge	819,000
Earthwork	35,000
Subtotal Construction	$ 872,000
Engineering and legal at 20%	$ 174,400
Total	$ 1,046,400

3. Total for San Fernando Creek $ 27,991,400

Note: Bridge replacement at FM 1355 and channelization to station 599+00 is partially within Kleberg County.

Carreta Creek

No improvements recommended.

TOTAL MASTER PLAN IMPROVEMENTS $ 106,146,900

Financial Planning

In order to implement the recommended masterplan improvements, Nueces County will need to project the necessary tax rate to support the nearly $90 million worth of bonds required. By issuing short (ten year) maturities, the County would be able to complete the improvements in a reasonable amount of time with a maximum projected tax rate of $0.069 per $100 valuation. This is based on the presently available bond rate of 7.5%, available either through the Texas Water Development Board or on the open market. The County has the authority to tax at a maximum rate of $0.30 per $100 valuation for drainage improvements, road improvements, and maintenance.

The following cash flow analysis and debt service schedules show how the improvements could be financed over a ten-year period. This assumes the County will issue equal issues every year over a ten-year period. The issues can be arranged in any order equalling an average of 10% per year (i.e., two issues of $45 million five years apart) and not significantly affect the debt service requirements.

C A S H   F L O W   A N A L Y S I S

Rotan Mosle Inc.

NUECES COUNTY FLOOD CONTROL
SERIES 1986

YEAR	BEGINNING BALANCE	INTEREST EARNINGS	PREV. YEAR ASSESSED VALUATION	TAX RATE	COLL. FACT.	TAX REVENUE	AVAILABLE BALANCE	DEBT SERVICE	ENDING BALANCE
1987	$0	$0	$0	0.000%	95%	$0	$0	$0	$0
1988	$0	$0	$9,763,206,174	6.900%	95%	$6,399,782	$6,399,782	$1,455,000	$25,000,000
1989	$25,000,000	$1,250,000	$9,763,206,174	6.900%	95%	$6,399,782	$32,649,782	$2,912,125	$20,000,000
1990	$20,000,000	$1,000,000	$9,763,206,174	6.900%	95%	$6,399,782	$27,399,782	$4,367,250	$23,032,532
1991	$23,032,532	$1,151,627	$9,763,206,174	6.900%	95%	$6,399,782	$30,583,940	$5,826,250	$24,757,690
1992	$24,757,690	$1,237,884	$9,763,206,174	6.900%	95%	$6,399,782	$32,395,356	$7,284,250	$25,111,106
1993	$25,111,106	$1,255,555	$9,763,206,174	6.900%	95%	$6,399,782	$32,766,443	$7,286,375	$25,480,068
1994	$25,480,068	$1,274,003	$9,763,206,174	6.900%	95%	$6,399,782	$33,153,853	$8,740,250	$24,413,603
1995	$24,413,603	$1,220,680	$9,763,206,174	6.900%	95%	$6,399,782	$32,034,065	$10,201,500	$21,832,565
1996	$21,832,565	$1,091,628	$9,763,206,174	6.900%	95%	$6,399,782	$29,323,975	$11,653,750	$17,670,225
1997	$17,670,225	$883,511	$9,763,206,174	6.900%	95%	$6,399,782	$24,953,518	$13,111,375	$11,842,143
1998	$11,842,143	$592,107	$9,763,206,174	6.900%	95%	$6,399,782	$18,834,031	$11,657,250	$7,176,781
1999	$7,176,781	$358,839	$9,763,206,174	6.900%	95%	$6,399,782	$13,935,402	$10,201,250	$3,734,152
2000	$3,734,152	$186,708	$9,763,206,174	6.500%	95%	$6,028,780	$9,949,639	$8,742,875	$1,206,764
2001	$1,206,764	$60,338	$9,763,206,174	6.500%	95%	$6,028,780	$7,295,883	$7,287,000	$8,883
2002	$8,883	$444	$9,763,206,174	6.500%	95%	$6,028,780	$6,038,106	$5,828,500	$209,606
2003	$209,606	$10,480	$9,763,206,174	6.500%	95%	$6,028,780	$6,248,867	$5,828,000	$420,867
2004	$420,867	$21,043	$9,763,206,174	4.250%	95%	$3,941,894	$4,383,804	$4,372,000	$11,804
2005	$11,804	$590	$9,763,206,174	3.250%	95%	$3,014,390	$3,026,785	$2,912,750	$114,035
2006	$114,035	$5,702	$9,763,206,174	1.500%	95%	$1,391,257	$1,510,993	$1,456,625	$54,368
2007	$54,368	$2,718	$9,763,206,174	1.500%	95%	$1,391,257	$1,448,343	$2,641,975	($1,193,632)

NUECES COUNTY FLOOD CONTROL BONDS SERIES 1987
$10,000,000

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DEBT SERVICE SCHEDULE
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DATE	PRINCIPAL	COUPON	INTEREST	PERIOD TOTAL	FISCAL TOTAL	BONDS OUTSTANDING	BONDS PAID TO DATE
7/ 1/87			375,000.00	375,000.00		10,000,000.00	
1/ 1/88	705,000.00	7.500000	375,000.00	1,080,000.00	1,455,000.00	9,295,000.00	705,000.00
7/ 1/88			348,562.50	348,562.50		9,295,000.00	705,000.00
1/ 1/89	760,000.00	7.500000	348,562.50	1,108,562.50	1,457,125.00	8,535,000.00	1,465,000.00
7/ 1/89			320,062.50	320,062.50		8,535,000.00	1,465,000.00
1/ 1/90	815,000.00	7.500000	320,062.50	1,135,062.50	1,455,125.00	7,720,000.00	2,280,000.00
7/ 1/90			289,500.00	289,500.00		7,720,000.00	2,280,000.00
1/ 1/91	880,000.00	7.500000	289,500.00	1,169,500.00	1,459,000.00	6,840,000.00	3,160,000.00
7/ 1/91			256,500.00	256,500.00		6,840,000.00	3,160,000.00
1/ 1/92	945,000.00	7.500000	256,500.00	1,201,500.00	1,458,000.00	5,895,000.00	4,105,000.00
7/ 1/92			221,062.50	221,062.50		5,895,000.00	4,105,000.00
1/ 1/93	1,015,000.00	7.500000	221,062.50	1,236,062.50	1,457,125.00	4,880,000.00	5,120,000.00
7/ 1/93			183,000.00	183,000.00		4,880,000.00	5,120,000.00
1/ 1/94	1,090,000.00	7.500000	183,000.00	1,273,000.00	1,456,000.00	3,790,000.00	6,210,000.00
7/ 1/94			142,125.00	142,125.00		3,790,000.00	6,210,000.00
1/ 1/95	1,175,000.00	7.500000	142,125.00	1,317,125.00	1,459,250.00	2,615,000.00	7,385,000.00
7/ 1/95			98,062.50	98,062.50		2,615,000.00	7,385,000.00
1/ 1/96	1,260,000.00	7.500000	98,062.50	1,358,062.50	1,456,125.00	1,355,000.00	8,645,000.00
7/ 1/96			50,812.50	50,812.50		1,355,000.00	8,645,000.00
1/ 1/97	1,355,000.00	7.500000	50,812.50	1,405,812.50	1,456,625.00		10,000,000.00
	10,000,000.00		4,569,375.00	14,569,375.00			
ACCRUED							
	10,000,000.00		4,569,375.00	14,569,375.00			

DATED 1/ 1/87 WITH DELIVERY OF 1/ 1/87
BOND YEARS 60,925.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.093
N I C % 7.5000000 % WITH A BID OF 100.000

NUECES COUNTY FLOOD CONTROL BONS SERIES 1988
$10,000,000

DEBT SERVICE SCHEDULE

DATE	PRINCIPAL	COUPON	INTEREST	PERIOD TOTAL	FISCAL TOTAL	BONDS OUTSTANDING	BONDS PAID TO DATE
7/ 1/88			375,000.00	375,000.00		10,000,000.00	
1/ 1/89	705,000.00	7.500000	375,000.00	1,080,000.00	1,455,000.00	9,295,000.00	705,000.00
7/ 1/89			348,562.50	348,562.50		9,295,000.00	705,000.00
1/ 1/90	760,000.00	7.500000	348,562.50	1,108,562.50	1,457,125.00	8,535,000.00	1,465,000.00
7/ 1/90			320,062.50	320,062.50		8,535,000.00	1,465,000.00
1/ 1/91	815,000.00	7.500000	320,062.50	1,135,062.50	1,455,125.00	7,720,000.00	2,280,000.00
7/ 1/91			289,500.00	289,500.00		7,720,000.00	2,280,000.00
1/ 1/92	880,000.00	7.500000	289,500.00	1,169,500.00	1,459,000.00	6,840,000.00	3,160,000.00
7/ 1/92			256,500.00	256,500.00		6,840,000.00	3,160,000.00
1/ 1/93	945,000.00	7.500000	256,500.00	1,201,500.00	1,458,000.00	5,895,000.00	4,105,000.00
7/ 1/93			221,062.50	221,062.50		5,895,000.00	4,105,000.00
1/ 1/94	1,015,000.00	7.500000	221,062.50	1,236,062.50	1,457,125.00	4,880,000.00	5,120,000.00
7/ 1/94			183,000.00	183,000.00		4,880,000.00	5,120,000.00
1/ 1/95	1,090,000.00	7.500000	183,000.00	1,273,000.00	1,456,000.00	3,790,000.00	6,210,000.00
7/ 1/95			142,125.00	142,125.00		3,790,000.00	6,210,000.00
1/ 1/96	1,175,000.00	7.500000	142,125.00	1,317,125.00	1,459,250.00	2,615,000.00	7,385,000.00
7/ 1/96			98,062.50	98,062.50		2,615,000.00	7,385,000.00
1/ 1/97	1,260,000.00	7.500000	98,062.50	1,358,062.50	1,456,125.00	1,355,000.00	8,645,000.00
7/ 1/97			50,812.50	50,812.50		1,355,000.00	8,645,000.00
1/ 1/98	1,355,000.00	7.500000	50,812.50	1,405,812.50	1,456,625.00		10,000,000.00
	10,000,000.00		4,569,375.00	14,569,375.00			
ACCRUED							
	10,000,000.00		4,569,375.00	14,569,375.00			

DATED 1/ 1/88 WITH DELIVERY OF 1/ 1/88
BOND YEARS 60,925.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.093
N I C % 7.5000000 % WITH A BID OF 100.000

NUECES COUNTY FLOOD CONTROL BONDS SERIES 1989
$10,000,000

DEBT SERVICE SCHEDULE

DATE	PRINCIPAL	COUPON	INTEREST	PERIOD TOTAL	FISCAL TOTAL	BONDS OUTSTANDING	BONDS PAID TO DATE
7/ 1/89			375,000.00	375,000.00		10,000,000.00	
1/ 1/90	705,000.00	7.500000	375,000.00	1,080,000.00	1,455,000.00	9,295,000.00	705,000.00
7/ 1/90			348,562.50	348,562.50		9,295,000.00	705,000.00
1/ 1/91	760,000.00	7.500000	348,562.50	1,108,562.50	1,457,125.00	8,535,000.00	1,465,000.00
7/ 1/91			320,062.50	320,062.50		8,535,000.00	1,465,000.00
1/ 1/92	815,000.00	7.500000	320,062.50	1,135,062.50	1,455,125.00	7,720,000.00	2,280,000.00
7/ 1/92			289,500.00	289,500.00		7,720,000.00	2,280,000.00
1/ 1/93	880,000.00	7.500000	289,500.00	1,169,500.00	1,459,000.00	6,840,000.00	3,160,000.00
7/ 1/93			256,500.00	256,500.00		6,840,000.00	3,160,000.00
1/ 1/94	945,000.00	7.500000	256,500.00	1,201,500.00	1,458,000.00	5,895,000.00	4,105,000.00
7/ 1/94			221,062.50	221,062.50		5,895,000.00	4,105,000.00
1/ 1/95	1,015,000.00	7.500000	221,062.50	1,236,062.50	1,457,125.00	4,880,000.00	5,120,000.00
7/ 1/95			183,000.00	183,000.00		4,880,000.00	5,120,000.00
1/ 1/96	1,090,000.00	7.500000	183,000.00	1,273,000.00	1,456,000.00	3,790,000.00	6,210,000.00
7/ 1/96			142,125.00	142,125.00		3,790,000.00	6,210,000.00
1/ 1/97	1,175,000.00	7.500000	142,125.00	1,317,125.00	1,459,250.00	2,615,000.00	7,385,000.00
7/ 1/97			98,062.50	98,062.50		2,615,000.00	7,385,000.00
1/ 1/98	1,260,000.00	7.500000	98,062.50	1,358,062.50	1,456,125.00	1,355,000.00	8,645,000.00
7/ 1/98			50,812.50	50,812.50		1,355,000.00	8,645,000.00
1/ 1/99	1,355,000.00	7.500000	50,812.50	1,405,812.50	1,456,625.00		10,000,000.00
	10,000,000.00		4,569,375.00	14,569,375.00			
ACCRUED							
	10,000,000.00		4,569,375.00	14,569,375.00			

DATED 1/ 1/89 WITH DELIVERY OF 1/ 1/89
BOND YEARS 60,925.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.093
N I C % 7.5000000 % WITH A BID OF 100.000

NUECES COUNTY FLOOD CONTROL BONDS SERIES 1990
$10,000,000

DEBT SERVICE SCHEDULE

DATE	PRINCIPAL	COUPON	INTEREST	PERIOD TOTAL	FISCAL TOTAL	BONDS OUTSTANDING	BONDS PAID TO DATE
7/ 1/90			375,000.00	375,000.00		10,000,000.00	
1/ 1/91	705,000.00	7.500000	375,000.00	1,080,000.00	1,455,000.00	9,295,000.00	705,000.00
7/ 1/91			348,562.50	348,562.50		9,295,000.00	705,000.00
1/ 1/92	760,000.00	7.500000	348,562.50	1,108,562.50	1,457,125.00	8,535,000.00	1,465,000.00
7/ 1/92			320,062.50	320,062.50		8,535,000.00	1,465,000.00
1/ 1/93	815,000.00	7.500000	320,062.50	1,135,062.50	1,455,125.00	7,720,000.00	2,280,000.00
7/ 1/93			289,500.00	289,500.00		7,720,000.00	2,280,000.00
1/ 1/94	880,000.00	7.500000	289,500.00	1,169,500.00	1,459,000.00	6,840,000.00	3,160,000.00
7/ 1/94			256,500.00	256,500.00		6,840,000.00	3,160,000.00
1/ 1/95	945,000.00	7.500000	256,500.00	1,201,500.00	1,458,000.00	5,895,000.00	4,105,000.00
7/ 1/95			221,062.50	221,062.50		5,895,000.00	4,105,000.00
1/ 1/96	1,015,000.00	7.500000	221,062.50	1,236,062.50	1,457,125.00	4,880,000.00	5,120,000.00
7/ 1/96			183,000.00	183,000.00		4,880,000.00	5,120,000.00
1/ 1/97	1,090,000.00	7.500000	183,000.00	1,273,000.00	1,456,000.00	3,790,000.00	6,210,000.00
7/ 1/97			142,125.00	142,125.00		3,790,000.00	6,210,000.00
1/ 1/98	1,175,000.00	7.500000	142,125.00	1,317,125.00	1,459,250.00	2,615,000.00	7,385,000.00
7/ 1/98			98,062.50	98,062.50		2,615,000.00	7,385,000.00
1/ 1/99	1,260,000.00	7.500000	98,062.50	1,358,062.50	1,456,125.00	1,355,000.00	8,645,000.00
7/ 1/99			50,812.50	50,812.50		1,355,000.00	8,645,000.00
1/ 1/ 0	1,355,000.00	7.500000	50,812.50	1,405,812.50	1,456,625.00		10,000,000.00
	10,000,000.00		4,569,375.00	14,569,375.00			
ACCRUED							
	10,000,000.00		4,569,375.00	14,569,375.00			

DATED 1/ 1/90 WITH DELIVERY OF 1/ 1/90
BOND YEARS 60,925.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.093
N I C % 7.5000000 % WITH A BID OF 100.000

NUECES COUNTY FLOOD CONTROL BONDS SERIES 1991
$10,000,000

DEBT SERVICE SCHEDULE

DATE	PRINCIPAL	COUPON	INTEREST	PERIOD TOTAL	FISCAL TOTAL	BONDS OUTSTANDING	BONDS PAID TO DATE
7/ 1/91			375,000.00	375,000.00		10,000,000.00	
1/ 1/92	705,000.00	7.500000	375,000.00	1,080,000.00	1,455,000.00	9,295,000.00	705,000.00
7/ 1/92			348,562.50	348,562.50		9,295,000.00	705,000.00
1/ 1/93	760,000.00	7.500000	348,562.50	1,108,562.50	1,457,125.00	8,535,000.00	1,465,000.00
7/ 1/93			320,062.50	320,062.50		8,535,000.00	1,465,000.00
1/ 1/94	815,000.00	7.500000	320,062.50	1,135,062.50	1,455,125.00	7,720,000.00	2,280,000.00
7/ 1/94			289,500.00	289,500.00		7,720,000.00	2,280,000.00
1/ 1/95	880,000.00	7.500000	289,500.00	1,169,500.00	1,459,000.00	6,840,000.00	3,160,000.00
7/ 1/95			256,500.00	256,500.00		6,840,000.00	3,160,000.00
1/ 1/96	945,000.00	7.500000	256,500.00	1,201,500.00	1,458,000.00	5,895,000.00	4,105,000.00
7/ 1/96			221,062.50	221,062.50		5,895,000.00	4,105,000.00
1/ 1/97	1,015,000.00	7.500000	221,062.50	1,236,062.50	1,457,125.00	4,880,000.00	5,120,000.00
7/ 1/97			183,000.00	183,000.00		4,880,000.00	5,120,000.00
1/ 1/98	1,090,000.00	7.500000	183,000.00	1,273,000.00	1,456,000.00	3,790,000.00	6,210,000.00
7/ 1/98			142,125.00	142,125.00		3,790,000.00	6,210,000.00
1/ 1/99	1,175,000.00	7.500000	142,125.00	1,317,125.00	1,459,250.00	2,615,000.00	7,385,000.00
7/ 1/99			98,062.50	98,062.50		2,615,000.00	7,385,000.00
1/ 1/ 0	1,260,000.00	7.500000	98,062.50	1,358,062.50	1,456,125.00	1,355,000.00	8,645,000.00
7/ 1/ 0			50,812.50	50,812.50		1,355,000.00	8,645,000.00
1/ 1/ 1	1,355,000.00	7.500000	50,812.50	1,405,812.50	1,456,625.00		10,000,000.00
	10,000,000.00		4,569 [illegible]	[illegible]			
ACCRUED							
	10,000,000.00		4,569,375.00	14,569,375.00			

DATED 1/ 1/91 WITH DELIVERY OF 1/ 1/91
BOND YEARS 60,925.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.093
N I C % 7.5000000 % WITH A BID OF 100.000

NUECES COUNTY FLOOD CONTROL BONDS SERIES 1992
$10,000,000

DEBT SERVICE SCHEDULE

DATE	PRINCIPAL	COUPON	INTEREST	PERIOD TOTAL	FISCAL TOTAL	BONDS OUTSTANDING	BONDS PAID TO DATE
7/ 1/92			375,000.00	375,000.00		10,000,000.00	
1/ 1/93	705,000.00	7.500000	375,000.00	1,080,000.00	1,455,000.00	9,295,000.00	705,000.00
7/ 1/93			348,562.50	348,562.50		9,295,000.00	705,000.00
1/ 1/94	760,000.00	7.500000	348,562.50	1,108,562.50	1,457,125.00	8,535,000.00	1,465,000.00
7/ 1/94			320,062.50	320,062.50		8,535,000.00	1,465,000.00
1/ 1/95	815,000.00	7.500000	320,062.50	1,135,062.50	1,455,125.00	7,720,000.00	2,280,000.00
7/ 1/95			289,500.00	289,500.00		7,720,000.00	2,280,000.00
1/ 1/96	880,000.00	7.500000	289,500.00	1,169,500.00	1,459,000.00	6,840,000.00	3,160,000.00
7/ 1/96			256,500.00	256,500.00		6,840,000.00	3,160,000.00
1/ 1/97	945,000.00	7.500000	256,500.00	1,201,500.00	1,458,000.00	5,895,000.00	4,105,000.00
7/ 1/97			221,062.50	221,062.50		5,895,000.00	4,105,000.00
1/ 1/98	1,015,000.00	7.500000	221,062.50	1,236,062.50	1,457,125.00	4,880,000.00	5,120,000.00
7/ 1/98			183,000.00	183,000.00		4,880,000.00	5,120,000.00
1/ 1/99	1,090,000.00	7.500000	183,000.00	1,273,000.00	1,456,000.00	3,790,000.00	6,210,000.00
7/ 1/99			142,125.00	142,125.00		3,790,000.00	6,210,000.00
1/ 1/ 0	1,175,000.00	7.500000	142,125.00	1,317,125.00	1,459,250.00	2,615,000.00	7,385,000.00
7/ 1/ 0			98,062.50	98,062.50		2,615,000.00	7,385,000.00
1/ 1/ 1	1,260,000.00	7.500000	98,062.50	1,358,062.50	1,456,125.00	1,355,000.00	8,645,000.00
7/ 1/ 1			50,812.50	50,812.50		1,355,000.00	8,645,000.00
1/ 1/ 2	1,355,000.00	7.500000	50,812.50	1,405,812.50	1,456,625.00		10,000,000.00
	10,000,000.00		4,569,375.00	14,569,375.00			
ACCRUED							
	10,000,000.00		4,569,375.00	14,569,375.00			

DATED 1/ 1/92 WITH DELIVERY OF 1/ 1/92
BOND YEARS 60,925.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.093
N I C % 7.5000000 % WITH A BID OF 100.000

NUECES COUNTY FLOOD CONTROL BONDS SERIES 1993
$10,000,000

DEBT SERVICE SCHEDULE

DATE	PRINCIPAL	COUPON	INTEREST	PERIOD TOTAL	FISCAL TOTAL	BONDS OUTSTANDING	BONDS PAID TO DATE
7/ 1/93			375,000.00	375,000.00		10,000,000.00	
1/ 1/94	705,000.00	7.500000	375,000.00	1,080,000.00	1,455,000.00	9,295,000.00	705,000.00
7/ 1/94			348,562.50	348,562.50		9,295,000.00	705,000.00
1/ 1/95	760,000.00	7.500000	348,562.50	1,108,562.50	1,457,125.00	8,535,000.00	1,465,000.00
7/ 1/95			320,062.50	320,062.50		8,535,000.00	1,465,000.00
1/ 1/96	815,000.00	7.500000	320,062.50	1,135,062.50	1,455,125.00	7,720,000.00	2,280,000.00
7/ 1/96			289,500.00	289,500.00		7,720,000.00	2,280,000.00
1/ 1/97	880,000.00	7.500000	289,500.00	1,169,500.00	1,459,000.00	6,840,000.00	3,160,000.00
7/ 1/97			256,500.00	256,500.00		6,840,000.00	3,160,000.00
1/ 1/98	945,000.00	7.500000	256,500.00	1,201,500.00	1,458,000.00	5,895,000.00	4,105,000.00
7/ 1/98			221,062.50	221,062.50		5,895,000.00	4,105,000.00
1/ 1/99	1,015,000.00	7.500000	221,062.50	1,236,062.50	1,457,125.00	4,880,000.00	5,120,000.00
7/ 1/99			183,000.00	183,000.00		4,880,000.00	5,120,000.00
1/ 1/ 0	1,090,000.00	7.500000	183,000.00	1,273,000.00	1,456,000.00	3,790,000.00	6,210,000.00
7/ 1/ 0			142,125.00	142,125.00		3,790,000.00	6,210,000.00
1/ 1/ 1	1,175,000.00	7.500000	142,125.00	1,317,125.00	1,459,250.00	2,615,000.00	7,385,000.00
7/ 1/ 1			98,062.50	98,062.50		2,615,000.00	7,385,000.00
1/ 1/ 2	1,260,000.00	7.500000	98,062.50	1,358,062.50	1,456,125.00	1,355,000.00	8,645,000.00
7/ 1/ 2			50,812.50	50,812.50		1,355,000.00	8,645,000.00
1/ 1/ 3	1,355,000.00	7.500000	50,812.50	1,405,812.50	1,456,625.00		10,000,000.00
	10,000,000.00		4,569,375.00	14,569,375.00			
ACCRUED							
	10,000,000.00		4,569,375.00	14,569,375.00			

DATED 1/ 1/93 WITH DELIVERY OF 1/ 1/93
BOND YEARS 60,925.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.093
N I C % 7.5000000 % WITH A BID OF 100.000

NUECES COUNTY FLOOD CONTROL BONDS SERIES 1994
$10,000,000

DEBT SERVICE SCHEDULE

DATE	PRINCIPAL	COUPON	INTEREST	PERIOD TOTAL	FISCAL TOTAL	BONDS OUTSTANDING	BONDS PAID TO DATE
7/ 1/94			375,000.00	375,000.00		10,000,000.00	
1/ 1/95	705,000.00	7.500000	375,000.00	1,080,000.00	1,455,000.00	9,295,000.00	705,000.00
7/ 1/95			348,562.50	348,562.50		9,295,000.00	705,000.00
1/ 1/96	760,000.00	7.500000	348,562.50	1,108,562.50	1,457,125.00	8,535,000.00	1,465,000.00
7/ 1/96			320,062.50	320,062.50		8,535,000.00	1,465,000.00
1/ 1/97	815,000.00	7.500000	320,062.50	1,135,062.50	1,455,125.00	7,720,000.00	2,280,000.00
7/ 1/97			289,500.00	289,500.00		7,720,000.00	2,280,000.00
1/ 1/98	880,000.00	7.500000	289,500.00	1,169,500.00	1,459,000.00	6,840,000.00	3,160,000.00
7/ 1/98			256,500.00	256,500.00		6,840,000.00	3,160,000.00
1/ 1/99	945,000.00	7.500000	256,500.00	1,201,500.00	1,458,000.00	5,895,000.00	4,105,000.00
7/ 1/99			221,062.50	221,062.50		5,895,000.00	4,105,000.00
1/ 1/ 0	1,015,000.00	7.500000	221,062.50	1,236,062.50	1,457,125.00	4,880,000.00	5,120,000.00
7/ 1/ 0			183,000.00	183,000.00		4,880,000.00	5,120,000.00
1/ 1/ 1	1,090,000.00	7.500000	183,000.00	1,273,000.00	1,456,000.00	3,790,000.00	6,210,000.00
7/ 1/ 1			142,125.00	142,125.00		3,790,000.00	6,210,000.00
1/ 1/ 2	1,175,000.00	7.500000	142,125.00	1,317,125.00	1,459,250.00	2,615,000.00	7,385,000.00
7/ 1/ 2			98,062.50	98,062.50		2,615,000.00	7,385,000.00
1/ 1/ 3	1,260,000.00	7.500000	98,062.50	1,358,062.50	1,456,125.00	1,355,000.00	8,645,000.00
7/ 1/ 3			50,812.50	50,812.50		1,355,000.00	8,645,000.00
1/ 1/ 4	1,355,000.00	7.500000	50,812.50	1,405,812.50	1,456,625.00		10,000,000.00
	10,000,000.00		4,569,375.00	14,569,375.00			
ACCRUED							
	10,000,000.00		4,569,375.00	14,569,375.00			

DATED 1/ 1/94 WITH DELIVERY OF 1/ 1/94
BOND YEARS 60,925.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.093
N I C % 7.5000000 % WITH A BID OF 100.000

NUECES COUNTY FLOOD CONTROL BONDS SERIES 1995
$10,000,000

DEBT SERVICE SCHEDULE

DATE	PRINCIPAL	COUPON	INTEREST	PERIOD TOTAL	FISCAL TOTAL	BONDS OUTSTANDING	BONDS PAID TO DATE
7/ 1/95			375,000.00	375,000.00		10,000,000.00	
1/ 1/96	705,000.00	7.500000	375,000.00	1,080,000.00	1,455,000.00	9,295,000.00	705,000.00
7/ 1/96			348,562.50	348,562.50		9,295,000.00	705,000.00
1/ 1/97	760,000.00	7.500000	348,562.50	1,108,562.50	1,457,125.00	8,535,000.00	1,465,000.00
7/ 1/97			320,062.50	320,062.50		8,535,000.00	1,465,000.00
1/ 1/98	815,000.00	7.500000	320,062.50	1,135,062.50	1,455,125.00	7,720,000.00	2,280,000.00
7/ 1/98			289,500.00	289,500.00		7,720,000.00	2,280,000.00
1/ 1/99	880,000.00	7.500000	289,500.00	1,169,500.00	1,459,000.00	6,840,000.00	3,160,000.00
7/ 1/99			256,500.00	256,500.00		6,840,000.00	3,160,000.00
1/ 1/ 0	945,000.00	7.500000	256,500.00	1,201,500.00	1,458,000.00	5,895,000.00	4,105,000.00
7/ 1/ 0			221,062.50	221,062.50		5,895,000.00	4,105,000.00
1/ 1/ 1	1,015,000.00	7.500000	221,062.50	1,236,062.50	1,457,125.00	4,880,000.00	5,120,000.00
7/ 1/ 1			183,000.00	183,000.00		4,880,000.00	5,120,000.00
1/ 1/ 2	1,090,000.00	7.500000	183,000.00	1,273,000.00	1,456,000.00	3,790,000.00	6,210,000.00
7/ 1/ 2			142,125.00	142,125.00		3,790,000.00	6,210,000.00
1/ 1/ 3	1,175,000.00	7.500000	142,125.00	1,317,125.00	1,459,250.00	2,615,000.00	7,385,000.00
7/ 1/ 3			98,062.50	98,062.50		2,615,000.00	7,385,000.00
1/ 1/ 4	1,260,000.00	7.500000	98,062.50	1,358,062.50	1,456,125.00	1,355,000.00	8,645,000.00
7/ 1/ 4			50,812.50	50,812.50		1,355,000.00	8,645,000.00
1/ 1/ 5	1,355,000.00	7.500000	50,812.50	1,405,812.50	1,456,625.00		10,000,000.00
	10,000,000.00		4,569,375.00	14,569,375.00			
ACCRUED							
	10,000,000.00		4,569,375.00	14,569,375.00			

DATED 1/ 1/95 WITH DELIVERY OF 1/ 1/95
BOND YEARS 60,925.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.093
N I C % 7.5000000 % WITH A BID OF 100.000

NUECES COUNTY FLOOD CONTROL BONDS SERIES 1996
$10,000,000

DEBT SERVICE SCHEDULE

DATE	PRINCIPAL	COUPON	INTEREST	PERIOD TOTAL	FISCAL TOTAL	BONDS OUTSTANDING	BONDS PAID TO DATE
7/ 1/96			375,000.00	375,000.00		10,000,000.00	
1/ 1/97	705,000.00	7.500000	375,000.00	1,080,000.00	1,455,000.00	9,295,000.00	705,000.00
7/ 1/97			348,562.50	348,562.50		9,295,000.00	705,000.00
1/ 1/98	760,000.00	7.500000	348,562.50	1,108,562.50	1,457,125.00	8,535,000.00	1,465,000.00
7/ 1/98			320,062.50	320,062.50		8,535,000.00	1,465,000.00
1/ 1/99	815,000.00	7.500000	320,062.50	1,135,062.50	1,455,125.00	7,720,000.00	2,280,000.00
7/ 1/99			289,500.00	289,500.00		7,720,000.00	2,280,000.00
1/ 1/ 0	880,000.00	7.500000	289,500.00	1,169,500.00	1,459,000.00	6,840,000.00	3,160,000.00
7/ 1/ 0			256,500.00	256,500.00		6,840,000.00	3,160,000.00
1/ 1/ 1	945,000.00	7.500000	256,500.00	1,201,500.00	1,458,000.00	5,895,000.00	4,105,000.00
7/ 1/ 1			221,062.50	221,062.50		5,895,000.00	4,105,000.00
1/ 1/ 2	1,015,000.00	7.500000	221,062.50	1,236,062.50	1,457,125.00	4,880,000.00	5,120,000.00
7/ 1/ 2			183,000.00	183,000.00		4,880,000.00	5,120,000.00
1/ 1/ 3	1,090,000.00	7.500000	183,000.00	1,273,000.00	1,456,000.00	3,790,000.00	6,210,000.00
7/ 1/ 3			142,125.00	142,125.00		3,790,000.00	6,210,000.00
1/ 1/ 4	1,175,000.00	7.500000	142,125.00	1,317,125.00	1,459,250.00	2,615,000.00	7,385,000.00
7/ 1/ 4			98,062.50	98,062.50		2,615,000.00	7,385,000.00
1/ 1/ 5	1,260,000.00	7.500000	98,062.50	1,358,062.50	1,456,125.00	1,355,000.00	8,645,000.00
7/ 1/ 5			50,812.50	50,812.50		1,355,000.00	8,645,000.00
1/ 1/ 6	1,355,000.00	7.500000	50,812.50	1,405,812.50	1,456,625.00		10,000,000.00
	10,000,000.00		4,569,375.00	14,569,375.00			
ACCRUED							
	10,000,000.00		4,569,375.00	14,569,375.00			

DATED 1/ 1/96 WITH DELIVERY OF 1/ 1/96
BOND YEARS 60,925.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.093
N I C % 7.5000000 % WITH A BID OF 100.000

DEBT SERVICE SCHEDULE

DATE	PRINCIPAL	COUPON	INTEREST	PERIOD TOTAL	FISCAL TOTAL	BONDS OUTSTANDING	BONDS PAID TO DATE
7/ 1/87			375,000.00	375,000.00		90,000,000.00	
1/ 1/88	705,000.00		375,000.00	1,080,000.00	1,455,000.00	89,295,000.00	705,000.00
7/ 1/88			723,562.50	723,562.50		89,295,000.00	705,000.00
1/ 1/89	1,465,000.00		723,562.50	2,188,562.50	2,912,125.00	87,830,000.00	2,170,000.00
7/ 1/89			1,043,625.00	1,043,625.00		87,830,000.00	2,170,000.00
1/ 1/90	2,280,000.00		1,043,625.00	3,323,625.00	4,367,250.00	85,550,000.00	4,450,000.00
7/ 1/90			1,333,125.00	1,333,125.00		85,550,000.00	4,450,000.00
1/ 1/91	3,160,000.00		1,333,125.00	4,493,125.00	5,826,250.00	82,390,000.00	7,610,000.00
7/ 1/91			1,589,625.00	1,589,625.00		82,390,000.00	7,610,000.00
1/ 1/92	4,105,000.00		1,589,625.00	5,694,625.00	7,284,250.00	78,285,000.00	11,715,000.00
7/ 1/92			1,435,687.50	1,435,687.50		78,285,000.00	11,715,000.00
1/ 1/93	4,415,000.00		1,435,687.50	5,850,687.50	7,286,375.00	73,870,000.00	16,130,000.00
7/ 1/93			1,645,125.00	1,645,125.00		73,870,000.00	16,130,000.00
1/ 1/94	5,450,000.00		1,645,125.00	7,095,125.00	8,740,250.00	68,420,000.00	21,580,000.00
7/ 1/94			1,815,750.00	1,815,750.00		68,420,000.00	21,580,000.00
1/ 1/95	6,570,000.00		1,815,750.00	8,385,750.00	10,201,500.00	61,850,000.00	28,150,000.00
7/ 1/95			1,944,375.00	1,944,375.00		61,850,000.00	28,150,000.00
1/ 1/96	7,765,000.00		1,944,375.00	9,709,375.00	11,653,750.00	54,085,000.00	35,915,000.00
7/ 1/96			2,028,187.50	2,028,187.50		54,085,000.00	35,915,000.00
1/ 1/97	9,055,000.00		2,028,187.50	11,083,187.50	13,111,375.00	45,030,000.00	44,970,000.00
7/ 1/97			1,688,625.00	1,688,625.00		45,030,000.00	44,970,000.00
1/ 1/98	8,280,000.00		1,688,625.00	9,968,625.00	11,657,250.00	36,750,000.00	53,250,000.00
7/ 1/98			1,378,125.00	1,378,125.00		36,750,000.00	53,250,000.00
1/ 1/99	7,445,000.00		1,378,125.00	8,823,125.00	10,201,250.00	29,305,000.00	60,695,000.00
7/ 1/99			1,098,937.50	1,098,937.50		29,305,000.00	60,695,000.00
1/ 1/ 0	6,545,000.00		1,098,937.50	7,643,937.50	8,742,875.00	22,760,000.00	67,240,000.00
7/ 1/ 0			853,500.00	853,500.00		22,760,000.00	67,240,000.00
1/ 1/ 1	5,580,000.00		853,500.00	6,433,500.00	7,287,000.00	17,180,000.00	72,820,000.00
7/ 1/ 1			644,250.00	644,250.00		17,180,000.00	72,820,000.00
1/ 1/ 2	4,540,000.00		644,250.00	5,184,250.00	5,828,500.00	12,640,000.00	77,360,000.00
7/ 1/ 2			474,000.00	474,000.00		12,640,000.00	77,360,000.00
1/ 1/ 3	4,880,000.00		474,000.00	5,354,000.00	5,828,000.00	7,760,000.00	82,240,000.00
7/ 1/ 3			291,000.00	291,000.00		7,760,000.00	82,240,000.00
1/ 1/ 4	3,790,000.00		291,000.00	4,081,000.00	4,372,000.00	3,970,000.00	86,030,000.00
7/ 1/ 4			148,875.00	148,875.00		3,970,000.00	86,030,000.00
1/ 1/ 5	2,615,000.00		148,875.00	2,763,875.00	2,912,750.00	1,355,000.00	88,645,000.00
7/ 1/ 5			50,812.50	50,812.50		1,355,000.00	88,645,000.00
1/ 1/ 6	1,355,000.00		50,812.50	1,405,812.50	1,456,625.00		90,000,000.00
	90,000,000.00		41,124,375.00	131,124,375.00			
ACCRUED							
	90,000,000.00		41,124,375.00	131,124,375.00			

SECTION 7 - ENVIRONMENTAL IMPACT

An important aspect of the process of evaluating drainage improvements in Nueces County is to analyze the potential effects on downstream estuarine systems. This evaluation requires descriptions of potentially affected drainages and estuaries with regard to the proposed drainage improvements, and an estuarine impact assessment based on a literature review covering major data sources for the project area.

The principal improvements recommended in Section 5 involved enlarging channel sections, or reaches, that cause flooding due to inadequate capacity, and replacing drainage structures that presently retard flood flows or are overtopped during high water. The reaches recommended for improvement lie within the Oso Creek and Petronila Creek drainages in Nueces County that empty into Oso Bay and Alazan Bay, respectively. The extent and location of these improvements are shown on the Stormwater Master Plan profiles. This environmental section will also include impact assessments for the San Fernando, Jaboncillos and Arania Creek basins in Kleberg County.

For the following drainage basin discussions, hydrologic characteristics of the receiving streams and processes within the estuaries were defined from existing literature and from the hydrological engineering study. The end-results of these detailed descriptions are the environmental impact projections associated with the proposed drainage improvements in the study region.

AFFECTED DRAINAGE AREAS

Oso Creek

Oso Creek is an intermittent stream having a drainage area of about 600 km^2 (240 mi^2) located just to the south of Nueces and Corpus Christi Bays . Average discharge is 43,500 ac-ft, varying from about 17,000 ac-ft in dry years to 101,000 ac-ft in wet years (Hildebrand and King, 1978). Most of the area in the Oso Creek drainage is cropland, particularly in the southern part of the basin. However, urban areas, including Robstown in the upper watershed and southern Corpus Christi, appear to be expanding. Much of urban Corpus Christi is included in the watershed, but that 137 km^2 subbasin (53 mi^2) drains directly into Oso Bay and will not be affected by the proposed improvements. Hildebrand and King (1978) discuss the history of anthropomorphic changes in the basin, including drainage improvements, row cropping, urbanization, discharge of oil field brines, and the construction of sewage treatment facilities. Existing systems presently facilitate drainage over a substantial portion of the Oso Creek basin (Brown et al., 1976).

In addition to the extremely erratic runoff pattern in Oso Creek, the Texas Department of Water Resources (now the Texas Water Commission) presented data showing relatively high and quite variable levels of dissolved solids (TDWR, 1981). While total dissolved solids (TDS) averaged about 2350 mg/l, the range was from 500 to 5400 mg/l in runoff largely from cropland. Nutrient levels were also high with nitrate nitrogen and total phosphorus averaging about 3 and 2 mg/l, respectively, and exhibiting wide variations.

Baffin Bay Tributaries

The Petronila Creek system, including Agua Dulce, Pintas, Quinta, and Petronila Creeks, which empties into the extensive wind tidal flats of Cayo del Mazon and Cayo de Hinoso, at the head of Alazan Bay, drains an area of about 1768 km^2 (683 mi^2, HDR 1986; TDWR 1983 says 1320 km^2). This is an ungauged, intermittent drainage extending about 100 km to the northwest of Alazan Bay through western Nueces County into northern Jim Wells County. Using a water yield model, TDWR (1983) estimated that this basin contributed an average of about 36,000 ac-ft/yr to the Baffin Bay system during the 1941 through 1976 period of record. As is the case with Oso Creek and the tributaries of Baffin Bay, discharge in the Petronila Creek system is highly variable on both a monthly and an annual basis (TDWR, 1983).

Land use within the Petronila Creek basin is almost exclusively agricultural (both range and crop), except for oil and gas activities and some urban strip development in the vicinity of the highways U.S. 77 and State Hwy. 44 (Brown et al., 1976; 1977).

TDWR (1983) grouped the streams draining into the Upper Cayo del Grullo into the San Fernando Creek watershed. This 3313 km^2 (1610 mi^2) drainage is also intermittent and encompasses a lower, ungauged portion of 2,000 km^2 and a 1313 km^2 gauged area above Alice, Texas. Annual average inflow from this drainage was 60,991 ac-ft during the 1941-1976 period (TDWR, 1983). This drainage tends to provide a more constant inflow than do the other creek systems because of several upstream wastewater treatment facilities (Cornelius, 1984).

Land use in the San Fernando drainage basin is largely crop and range land with most of the cropland located between San Fernando Creek and

U.S. 77 (Brown et al., 1977). The cities of Kingsville and Alice are within the basin and undoubtedly influence downstream hydrology and water quality.

Arania, or Vattmann, Creek constitutes a small, intermittent drainage of 45 km^2 (16.5 mi^2) entering the Cayo del Grullo just south of Loyola Beach. The dominant basin land use is, again, crop and range. TDWR (1983) lumped this drainage with Los Olmos Creek.

The basin drained by Los Olmos and Salado Creeks extends through 103 km of ranchland to the west of its confluence with the Laguna Salada. The drainage includes a lower, ungauged 1080 km^2 area and a gauged 1240 km^2 basin northwest of Falfurrias (TDWR, 1983). Average annual inflow (1941-1976) to Baffin Bay was estimated to be 36,975 ac-ft/yr.

PROPOSED DRAINAGE IMPROVEMENTS

Oso Creek

The drainage improvements proposed for the Oso Creek basin are bridge replacements where FM 665 crosses West Oso Creek and at FM 763, State Hwy. 44, and the Texas-Mexican R.R. across Oso Creek, and the channelization of 10,947 ft of Oso Creek up and downstream of the FM 24 crossing. These actions are intended to relieve flooding along West Oso Creek and Oso Creek. Land use in both drainage basins above the proposed improvements is largely agricultural, greater than 75% (Brown et al., 1976). However, oil fields are present in both basins and urban areas have increased in importance, particularly north of Robstown in the Oso Creek drainage.

The proposed improvements will facilitate drainage of existing natural and artificial channels by increasing main channel capacity. A negligible net change in discharge and peak flow is expected to result from these improvements, while flow duration is expected to decrease somewhat. Total areas flooded by a given storm will decrease along the channelized reach, and drainage from surrounding areas will be more rapid due to the lowered water surface elevations in improved reaches.

Based on the projected maximum stream widths during a 100-year runoff event, improvements in Oso and West Oso Creeks will result in reducing overbank flooding by about 500 acres (see Section 5). For this same event, travel time from the upstream end of the Oso Creek channelized section to its confluence with West Oso Creek would be reduced about 12% from 12.44 hours to 10.9 hours. Considering both 25-year and 100-year events in West Oso Creek, travel time reduction after channel improvement is predicted to be from about 4 hours to 3 hours.

Baffin Bay Tributaries

Drainage improvements recommended for parts of the Petronila Creek system are limited to the channelization of single reaches on Pintas, Agua Dulce, and Petronila Creeks, and to replacement of the bridges at the FM 666 and 665 crossings. These streams are in many ways similar to Oso Creek, and the proposed improvements are predicted to have similar effects. No net change in discharge is expected to result, but peak flow travel times, presently on a scale of hours, would be reduced by 10 to 15% in the improved reaches of Petronila and Agua Dulce Creeks and up to about 40% through the Pintas Creek reach. Although substantial enhancements of average channel velocities are predicted to occur in the Pintas Creek reach (25-year event), the gentler slopes and greater channel widths in the other reaches will result in little or no velocity increase with the improvements. As in the case of Oso Creek, no substantial increase in sediment loading to estuarine areas is expected to result from the proposed drainage improvements, although the sediment load from Pintas Creek is expected to increase. As with the Oso Creek drainage, good design of the improvements will tend to minimize scour and erosion.

Data on nutrients and contaminents are not available for these streams, but since soil types, land use, and hydrology are similar to Oso Creek, it is very likely that they also exhibit relatively high and variable levels of nutrients and other dissolved materials.

Drainage improvements recommended for the intermittent streams draining into the Cayo del Grullo include both channelization and bridge replacements on Jaboncillos, Ebanito, San Fernando, and Arania Creeks and bridge replacements only on Escondido and Santa Gertrudis Creeks.

The nearly 62,000 ft channel improvement recommended on San Fernando Creek will result in substantially increased average channel velocities during peak flows through much of the improved reach (50-200% during a 25-year event). This, however, is the only major improvement recommended for this basin.

Relatively short reaches of Jaboncillos, Ebanito, and Arania Creeks would be channelized and numerous bridges replaced to relieve overbank flooding south of Kingsville.

AFFECTED ESTUARINE SYSTEMS

Descriptions and comparisons of the major physical, chemical and biological characteristics of Texas Coastal Systems can be found in a few works of broad scope with varied viewpoints (Collier and Hedgepeth, 1950; Odum, 1967; Hackney, 1978). A large number of more narrowly focused works exist which provide detailed information on physical or chemical conditions, numbers and distribution of species or some index of production over broad geographic areas (e.g., Odum and Hoskin, 1958; Simmons and Breuer, 1962; Sorenson and Conover, 1962; Conover, 1964; Gunter et al., 1964; Copeland and Hoese, 1966; Texas Landings Series; Texas Colonial Waterbird Society, 1982). These and many other works are summarized in the Environmental Geologic Atlas Series of the University of Texas Bureau of Economic Geology (Brown et al., 1976; 1977) and in the Texas Department of Water Resources Series "Influence of Freshwater Inflows" (TDWR, 1979; 1983). Other publications reporting physical, chemical or biological data from the geographic areas potentially affected by this project include: (1) for Nueces-Corpus Christi: Holland et al, 1975; EH&A, 1977; Hildebrand and King, 1974, 1975, 1976, 1977, 1978; (2) for Laguna Madre: Simmons, 1957; Copeland et al, 1966; Merkord, 1978; Pulich, 1980; (3) for Baffin Bay-Alazan Bay: Breuer, 1957; Jensen, 1974; Suhm, 1974; Fuls, 1974; Tinnin, 1974; Suhm, 1976; Martin, 1979; and Cornelius, 1984, 1984b.

Many of the documents listed above address salinity and freshwater inflow characteristics with respect to biological impacts. A very large body of literature exists on the salinity tolerance of estuarine species (partially reviewed in TDWR, 1983) as well as works directly concerned with the effects of changes in freshwater inflow (Hoese, 1960; Copeland, 1966; Kinne, 1971; Holliday, 1971; TDWR, 1978, 1979, 1983). The extensive work on salinity relations of commercially important species is reviewed in Gunter et al., 1964, 1969, 1974.

Nueces-Corpus Christi Bay

Oso Bay in the Nueces-Corpus Christi Bay system will receive the runoff from proposed drainage improvements in the watershed of Oso Creek.

Although Oso Creek and Oso Bay connect with Corpus Christi Bay, this relatively small system has more in common with the creeks emptying into the Baffin Bay-Laguna Madre system than with the Nueces River and its estuary. The Nueces System is distinguished from the others primarily by the amount and relatively constant presence of freshwater input, and is regarded as transitional between the low salinity bay systems to the northeast and the hypersaline lagoons to the south that receive only intermittent freshwater inflows.

In common with other Texas Coastal Systems, the Nueces-Corpus Christi system experiences relatively small excursions due to astronomical tides, with seasonal and meteorological effects generally much more important in determining circulation and water exchange with other systems.

Oso Bay and the Cayo del Oso (the tidally influenced portion of the creek), which extends upstream from the bayhead nearly 15 km, tend to be an extreme environment subject to periodic freshwater flooding on the one hand, and high salinities and water temperatures on the other because of restricted communication with Corpus Christi Bay during low flow periods. The estuary of Oso Creek is characterized by substantial areas of wind tidal flats that are sparsely vegetated and have historically been only temporarily covered by shallow, turbid water.

The inundated area of Oso Bay varies from about 2200 to 5700 acres. During the substantial periods when Oso Creek is not flowing, water levels in the Cayo del Oso have historically been governed by meteorological conditions. Wind tidal flats may be alternately exposed and inundated for days at a time. The fine silt and clay substrate here is easily resuspended, either by high winds when exposed surfaces dessicate, or by wind driven currents when inundated, resulting in characteristically turbid water over a soft, muddy bottom. The presence of a discharge from Central Power and Light's Davis Plant cooling pond appears to have ameliorated the environment in Oso Bay to some extent by reducing salinity fluctuations and improving circulation. Hildebrand and King (1978) estimated that the discharge of saltwater from the Laguna Madre into Oso Bay from this pond averages approximately 280 million gallons per day, or 311,000 ac-ft/yr, which is three times the wet-year flow of Oso Creek. This, together with the 20 million gallon per day (22,214 ac-ft/yr) freshwater discharge of two City of Corpus Christi sewage treatment plants, presently dominates the hydrology and water quality of Oso Bay.

Baffin Bay System

Freshwater inflows to the Baffin Bay-Laguna Madre system are quite small, and oceanic exchange is restricted since communication with the Gulf of Mexico is through the upper Laguna Madre whose only permanent openings are the Gulf Intracoastal Water Way (GIWW) to the south and Corpus Christi Bay in the north. Baffin Bay and the Laguna Madre are quite similar in water quality except when inflows from the creek systems north and west of Baffin Bay result in a salinity gradient from the bayheads out to the Laguna Madre. No other organized drainage system conveys freshwater to the upper Laguna Madre.

Laguna Madre waters tend to be relatively clear and shallow and support large stands of seagrasses. These account for much of that system's primary production and provide refuge and/or feeding areas for juvenile fin and shellfish. Baffin Bay waters are also shallow (average depth 0.9 m.) but tend to be more turbid, presumably because of the widespread silty clay substrates.

Numerous publications (e.g., Collier and Hedgepeth, 1950; TDWR, 1983; Cornelius, 1984, 1984b) discuss the large and essentially unpredictable changes in salinity and other water quality parameters characteristic of this system. Although the Baffin Bay-Laguna Madre complex is classified as a hypersaline lagoonal system, the frequency and severity of episodes of elevated salinity appear to have diminished since construction of the GIWW improved communication with Corpus Christi Bay and created a permanent opening through the land bridge to the Lower Laguna Madre.

A unique feature of Baffin Bay is the presence of calcareous reef structures built up of serpulid worm tubes. These reefs were thought to be extinct as recently as the early 1970's, but are now known to contain live worm populations. Likewise, seagrasses were also reported to be absent from the Baffin Bay system, but stands of shoalgrass (Halodule wrightii) and Widgeongrass (Ruppia maritima) are now present in appropriate habitat throughout the system. Although it is tempting to equate these apparent changes with the amelioration of hypersalinity mentioned above, the relationship is speculative.

The lower reaches of the drainages entering the Baffin Bay systems are dominated by extensive wind tidal flats which, in southern Texas, replace the bay head and creek mouth marshes common on the upper coast. The wind tidal flats are barren, featureless expanses of silts and clays that are irregularly flooded by meteorologically driven tides or (even more irregularly) by freshwater runoff. Wind tidal flat environments dominate the creek channels for many kilometers above the bay heads, being particularly well developed in the Cayo de Hinosa and Cayo del Mazon, and in the lower reaches of the San Fernando Creek drainage. The more frequently flooded portions of the flats support algal mat communities composed primarily of filimentous blue green algae and diatoms. These mat communities can be highly productive and appear to contribute considerable primary production to the bay system.

Permanently inundated areas may also occur on these flats, either as very shallow channels or as isolated pools. The channels may be associated with freshwater inflow or with saltwater drainage off the flats. In either case, these areas do not usually harbor algal mats because of the turbidity in waters over about 25 cm depth and because environmental conditions allow the development of herbivore populations capable of disrupting the mat community.

During periods of no freshwater inflow, creek channels may exhibit inverted salinity gradients, with salinities increasing upstream. This occurs when bay waters are isolated in stream channels by falling water levels. Salts become concentrated by evaporation and by solution of salts deposited in the substrata during previous cycles of inundation and evaporation. Numerous oilfield brine discharges also occur in these drainages, further contributing to hypersaline conditions in isolated pools. Large amounts of organic matter may accumulate in the hypersaline pools as the salt content, exotic ion ratios, and high water temperatures depress (or eliminate) grazer and decomposer populations.

Open water areas are dominated by benthic communities of polychaetes, molluscs, and small crustaceans. Large, mobile species important in the system include penaeid shrimp, black drum (Pogonais cromis), redfish (Sciaenops ocellata), mullet (Mugil cephalus) and others, all of which migrate into and out of these systems in response to changing environmental conditions.

IMPORTANT SPECIES AND HABITATS

Important species are defined as those which are (1) endangered or threatened, (2) commercially or recreationally important, or (3) essential to the maintenance of the ecosystem structure or function. Marine species and birds commonly associated with estuarine areas in category 1 regarded by the Texas Parks and Wildlife Department as actually or probably occurring in Nueces and Kleberg Counties are listed in Table 7-1.

Species listed by the U. S. Department of the Interior (USFWS, 1983, 1984) as endangered or threatened are protected under the provisions of the Endangered Species Act (1973, USC 1531 et seq.) amended in 1982 (PL 97-304), which enjoins the federal government from authorizing, participating in, or financing activities adversely affecting members of that species or its designated critical habitat (if any). State protected non-game species may not be taken, possessed, transported, exported, sold, or offered for sale, either directly or as part of a product (Rules 127.70.12.001-008 TPWD). This implies that all actions directly (provably) resulting in the death of members of protected non-game species would be a violation of these rules, absent the exceptions in 127.70.12.005-006, punishable as a misdemeanor. In addition, some of these protected non-game species correspond to federally listed threatened species (e.g., Atlantic Loggerhead, Atlantic Green Turtle) and are therefore also protected under federal regulations.

Of the federally listed species, there are four whales and three turtles which are marine forms, and the West Indian Manatee (Trichechus manatus) whose habitat includes large fresh and saltwater bodies that

Table 7-1

Endangered or Threatened Marine Species
Known, or Likely, to Occur in the Project Area

Species		Status[1]	Occurrence[2]
Mammals			
Dolphin, bridled	Stenella frontalis	P	Possible
Dolphin, rough-toothed	Stena bredanensis	P	Possible
Dolphin, spotted	Stenella plagiodon	P	Possible
Blue Whale	Balaenoptera musculus	P	Possible
Finback Whale	B. physalis	E	Possible
Right Whale	Eubalana spp.	E	Possible
Sperm Whale	Physeter catadon	E	Possible
Dwarf Sperm Whale	Kogia simus	P	Possible
False Killer Whale	Pseudorca crassidens	P	Possible
Goose-beaked Whale	Ziphius cavirostris	P	Possible
Killer Whale	Orcinus orca	P	Possible
Short-finned Pilot Whale	Globicephala macrorhynca	P	Possible
Pygmy Killer Whale	Feresa attenuata	P	Possible
Pygmy Sperm Whale	Kogia breviceps	P	Possible
Gulf Stream Beaked Whale	Mesoplodon europaeus	P	Possible
West Indian Manatee	Trichecus manatus	E	Possible
Birds			
Brown Pelican	Pelecanus occidentalis	E	Confirmed

Bald Eagle	Haliaeetus leuco-cephalus	E	Confirmed
Arctic Peregrine Falcon	Falco peregrinus tundrius	E	Confirmed
Whooping Crane	Grus americana	E	Possible
Interior Least Tern	Sterna albifrons athalassos	SE	Probable
Least Tern	S. albifrons anti-llarum	P	Confirmed
Reddish Egret	Egreta rufescens	P	Confirmed
White-Faced Ibis	Plegadis chihi	P	Confirmed
Osprey	Pandion haliaetus carolinensis	P	Confirmed
Reptiles			
Green Sea Turtle	Chelonia mydas	T	Confirmed
Hawksbill Turtle	Eretmochelys imbra-cata	E	Probable
Kemp's Ridley Turtle	Lepidochlys kempii	E	Probable
Leatherback Turtle	Dermochelys coriacea	E	Probable
Loggerhead Turtle	Caretta caretta	T	Confirmed

1(Status) E - Endangered, listed by U.S. Fish and Wildlife Service (1983)
T - Threatened, listed by U.S. Fish and Wildlife Service (1983)
SE- Listed by State of Texas as Endangered (31T.A.C. 57.131-.136, 1984)
P - Listed by State of Texas as Protected Non-game species (127.70.12.001-.008)

2(Occurrence) Based on Texas Parks and Wildlife Information for Nueces and Kleburg Counties.

support substantial aquatic vegetation (Davis, 1974; Collins, 1981).

Among the endangered bird species listed in Table 7-1, the Brown Pelican and Bald Eagle are noted to have been actually observed ("confirmed") in Nueces and Kleberg Counties, while the Arctic Peregrine Falcon is "probable." The Brown Pelican (Pelicanus occidentalus) is strictly coastal, resting, feeding, and nesting in tropical and subtropical bay and estuary habitats on Atlantic and Gulf Coasts (Oberholzer, 1974).

Bald Eagles (Haliaeetus leucocephalus) are essentially non-migratory and along the Gulf Coast breed from late October through early May (Oberholzer, 1974). Bald Eagles typically inhabit margins of seacoasts, estuaries, and large freshwater bodies where suitable nest and lookout locations (tall trees or cliff ledges) are present. The Arctic Peregrine Falcon (Falco peregrinus tundrius), which is a winter migrant along the Texas Coast, likewise prefers isolated, elevated nesting areas, but non-nesting individuals may utilize a wide range of habitats (Oberholzer, 1974). Although suitable habitat is essentially non-existent around Oso Bay and contiguous areas of Corpus Christi Bay, the relatively isolated and undisturbed area of the King Ranch adjacent to Baffin Bay and the Laguna Madre contains appropriate habitat.

The Interior Least Tern (Sterna albifrons athalassos), a geographic race of the Least Tern (Sterna albifrons antillarum), characteristically inhabits broad sandy bottomlands commonly associated with large rivers. No substantial habitat for this species is expected to occur in the estuarine receiving bodies (Oberholzer, 1974). The lower reaches of the creeks draining into Oso Bay, Alazan Bay, and the Cayo del Grullo, where extensive sand flats occur, are brackish to hypersaline. These areas would appear to be more attractive to the Least Tern than to the Interior Least Tern.

Commercially and recreationally important species comprise the second category of critical species inhabiting these bay systems, and they are discussed by a large number of authors with varying viewpoints. The requirements of these species, including the blue crab (*Callinectes sapidus*), white shrimp (*Penaeus setiferus*), croaker (*Micropogon undulatus*), black drum (*Pogonais cromis*), redfish (*Sciaenops ocellata*), and spotted seatrout (*Cynoscion nebulosus*), which are the most important species in the Baffin Bay-Upper Laguna Madre Fishery, are well known and can be considered in evaluating potential project impacts.

The third important species category, consisting of those essential to the ecosystem, is less well defined than the others, but in the context of the low diversity communities of the project area, this category includes the most abundant species present. Conditions resulting in the reduction or elimination of these populations would result in greatly altered communities. Examples include the mat-forming species of bluegreen algae discussed above and the sheepshead minnow (*Cyprinodon varigatus*), the only fish capable of inhabiting the shallow, hypersaline habitats in the area.

Habitats to be considered in project evaluation include those habitats critical to the well-being of important species. This is particularly important where the habitat may be particularly sensitive to the types of change associated with the project, or where the habitat is wholly or largely encompassed by the area of maximum impact. Freshwater marsh and swamp areas (largely confined to the Nueces River Valley) are considered of the highest value in the coastal bend region because of their importance to waterfowl and their limited extent. Seagrass beds and salty to brackish water marshes are also considered important, primarily because of their utility as nursery grounds for commercially and recreationally important species, but also because of the organic matter they contribute to bay food webs. Unique habitats, such as the serpulid reefs of Central Baffin Bay, are also considered to be important in impact evaluations.

POTENTIAL IMPACTS

Potential effects on estuarine systems from the drainage improvements discussed above could result from changes in (1) the amount of freshwater input, (2) the timing of inflows, and (3) the amount and nature of dissolved and suspended material carried by the streamflow. Whether any effect could actually be detected in the estuary and whether that effect would be adverse depend on the magnitude of change in streamflow characteristics and on the nature of the receiving body.

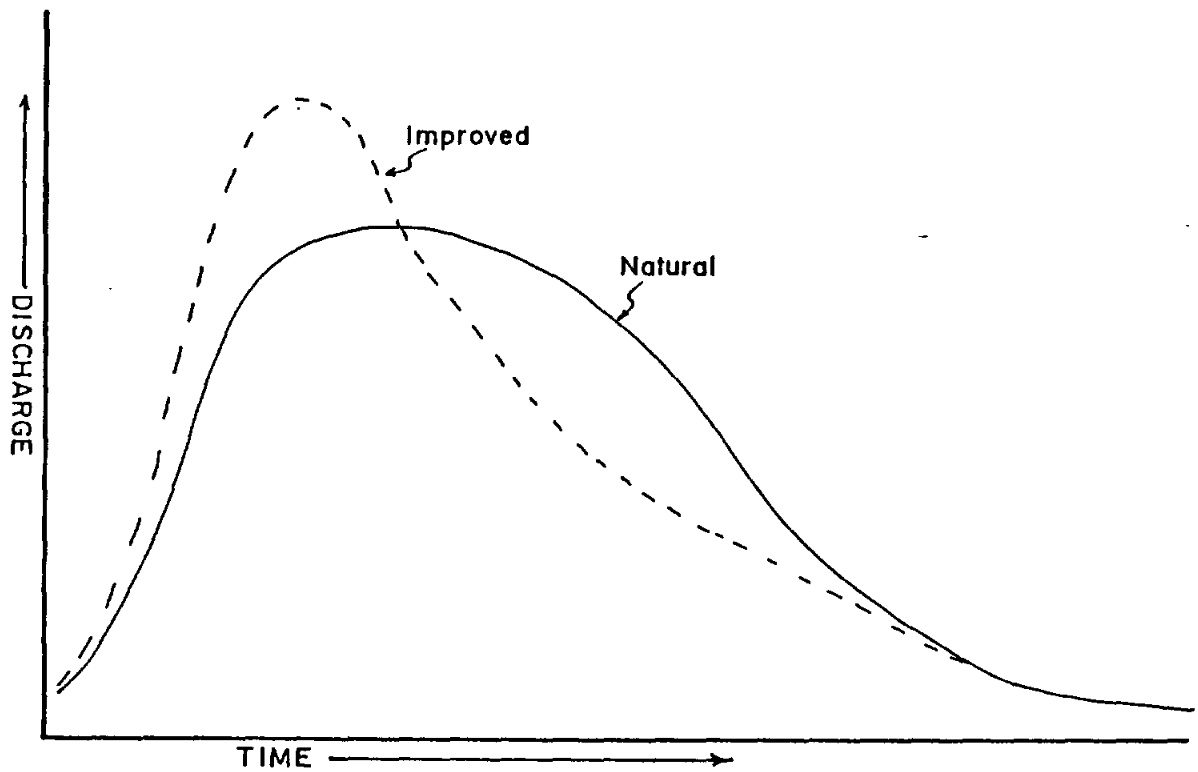
As already mentioned, the proposed bridge replacements and channelizations are not expected to result in any significant change in total discharge in any of the affected stream systems. However, some decrease in peak travel time during a storm event, together with higher current velocities, will occur in the improved sections. This will have the effect of reducing the amount of time after the flood peak during which large volume flows continue. The difference appears to amount only to hours or a few days since only main channel capacity will be increased and overbank flooding prevented. Drainage of ponded areas filled by upland runoff will be only incidentally affected and base flow from groundwater seepage will not be affected at all. Therefore, the longer term low flows that occur following sufficient rainfall should continue relatively unaltered after implementation of the recommended improvements.

Although more rapid drainage should result in shorter contact times for dissolution of nutrient or contaminant materials in flooded soils, the higher rates of flow will enhance transport of suspended materials. Water quality studies, primarily in urbanized areas (Austin, 1983, 1984a, 1984b), have shown that substantial proportions (e.g., 30-60%) of the nutrients, organic carbon, metals, and pesticides in runoff water can be associated with suspended solids. However, even in the extreme case of a 100-year runoff event in the Oso Creek channelized reach, water surface elevations were predicted to decrease by only about 1.5 to 2.5 feet from the natural to the improved condition. With the relatively flat topography typical of the region, no substantial increase in transport of upland soil material into the channels would occur. Although it is unlikely that there would be any substantial increase in sediment eroded from upland areas, some increase in competence and channel scour may occur as a result of increased velocities in and adjacent to improved reaches, as a result of higher current velocities. These velocities, however, will not reach a point that causes excessive scour or erosion. Properly designed channels and bridges will minimize this erosion potential. Channel velocities in the improved reaches are generally below 6 feet per second due to the flat slopes.

The short-term hydrologic changes (decrease in peak travel time, more rapid transport of water otherwise trapped in extensive overbank areas by channel constrictions) will tend to be attenuated during flow through the lower reaches of the streams. Increased current velocities are not expected to persist below the improved channel sections. This is indicated by the lack of significant changes in computed travel times and channel velocities in reaches below improved reaches.

Unfortunately, the type of modeling performed to evaluate the drainage improvements does not result in quantitative descriptions of the "before" and "after" hydrologic regimes. Figure 7-1 is a conceptual hydrograph (a plot of stream discharge over time at a given point) showing the type of change expected to result from removing channel restrictions. After improvement, peak discharge is somewhat greater, and discharge is initially reduced more rapidly since water is no longer retained in overbank storage by inadequate channel capacity. The area under the curve (total discharge) and the long-term tail-off to zero flow are unaffected by the proposed improvements.

FIGURE 7-1



TYPICAL HYDROGRAPH, SHOWING RUNOFF CHARACTERISTICS
OF A CHANNEL REACH BEFORE AND AFTER IMPROVEMENT.

Oso Bay appears very unlikely to be affected by changes in the hydrologic regime of Oso Creek as a result of the drainage improvements discussed above. While the proposed improvements are limited in scope and located high in the basin, the primary reason for this conclusion is the present domination of Oso Bay hydrology and water quality by Central Power and Light's cooling pond discharge, which amounts to about three times the total wet year discharge of Oso Creek.

Alazan Bay and the Cayo del Grullo do not contain habitats that are dependent on a regular regime of freshwater input to maintain them. While the nutrients and other materials supplied by freshwater inflow are certainly important, maintenance of a particular salinity regime or relatively constant mixing zone, exemplified by the river delta and creek mouth brackish marshes characteristic of the upper coast, is not. Freshwater input and, in consequence, salinity can vary rapidly and unpredictably; Cornelius (1984), for example, reported Alazan Bay salinities ranging from below 10 to 50 ppt (parts per thousand).

The bayhead areas are not only devoid of macrophytes, but are largely flat, featureless expanses of silt and clay that do not provide sheltered nursery areas or food sources for important marine species. The important environmental factors in the biology of these areas are the relatively long periods of shallow inundation and dessication by meteorological tides, and the hypersaline conditions that result from successive episodes of inundation and evaporation (and oil field brine discharges). Salinities over 100 ppt are not uncommon in the Cayos surrounding Baffin Bay, including the large ones forming the mouths of Petronila and San Fernando Creeks.

The organisms characteristic of these areas -- blue-green algae mats, a few insect and crustacean species, sheepshead minnows, and the mullet -- are opportunistic, adapted to the rapid exploitation of disturbed and stressful habitats. These species are typically generalists, tolerant of a wider range of environmental conditions than are most species. As a consequence they are often widely distributed, but may show their largest population sizes in stressed areas where environmental conditions are unsuitable for competing species or predators.

Sessile species will typically be tolerant of wide ranges of salinity and dissolved oxygen concentrations, ionic ratios, temperature, and other unpredictably fluctuating factors. Mobile species often exhibit migratory behavior that is not simply programmed by season, but is strongly modified by changes in environmental conditions. Most of these species will exhibit high rates of growth and reproduction when conditions are favorable, will not be heavily dependent on the reproduction of a single year class, and will have several mechanisms for the dispersal of juveniles. The latter is a critical adaptation to recolonizing a disturbed habitat.

Events such as large inputs of freshwater, hypersaline episodes or dessication, and storm disturbance of sediments may produce tremendous local mortality, even among tolerant species. Exploitation of such areas following the return of more favorable conditions is an important component of estuarine production. It seems unlikely that the rather subtle changes in hydrology that appear to result from the proposed drainage improvements would have any substantial effect on such habitats and communities.

Arania Creek, unlike the other drainages, flows directly into the central Cayo del Grullo, and its discharge is therefore in much closer proximity to open water bay habitats. These include seagrass beds in some shallower areas and extensive benthic communities dominated by polychaete worms and molluscs (primarily Mulinia lateralis) in deeper bay waters. It is these areas that are important to the penaeid shrimp, black drum, and other economically important populations of the Baffin Bay system. However, these species also must be tolerant of the wide and unpredictable changes in environmental conditions that are characteristic of this system. Since the expected changes in freshwater inflow as a result of the recommended drainage improvements will amount to small differences in the pattern of input, it is not probable that effects of any biological consequences could be demonstrated, either on the wind tidal flats or in the bay community.

Because of increased current velocities in at least the improved reaches, an increased rate of sedimentation is a potential effect of drainage improvements. No quantitative data are available on scour and sediment transport increase. However, it can be expected that increased sediment loading from an improved reach would occur when channel velocities are increased over the present condition for a given runoff event. Based on 25-year events, average channel velocity changes are predicted over a range from -33% to over 200%. These increases are only at peak flows, which do not persist for long, and are not predicted to extend substantially below the improved reaches. Smaller events, with return intervals less than 25 years, will have lower current velocities and probably less difference between the improved and unimproved conditions and, consequently, should result in proportionately smaller sediment transport increase.

Since the estuarine receiving systems are characterized by extensive marginal flats, and bay bottoms of fine-grained, unconsolidated material are presently quite turbid and do not support large seagrass meadows except in the Laguna Madre, only a very large increase in sediment loading could result in evident effects. Siltation on seagrass beds and extant benthic communities would have to increase appreciably beyond the present level of disturbance due to flooding or to scour and burial by storm events. Considering the known resiliency of the estuarine community to disturbance of this type and the probable small increments in sediment loading, it does not seem likely that any impact would be noticeable in the estuary.

Among the endangered, threatened, and protected species potentially present in the project area, all the mammals, except for the West Indian Manatee, are primarily restricted to marine habitats outside the potential range of influence of the proposed drainage improvements. The Manatee typically inhabits tropical, heavily vegetated waters. While suitable habitat may be present in the Laguna Madre, it is not in either Oso or Baffin Bays, and the proposed drainage improvements are not considered of sufficient magnitude to affect aquatic macrophyte stands anywhere in the system.

The various sea turtle species listed in Table 7-1 are known to utilize inshore waters to varying extents, and might therefore be found in Baffin Bay waters. Among the birds, a small Least Tern nesting colony is known to have persisted on shell spits in Oso Bay at least through 1977, while the Reddish Egret and White Faced Ibis have been observed to nest on the GIWW spoil island located in the Laguna Madre at the mouth of Baffin Bay. The other listed birds would be much more likely to be found around Baffin Bay than Oso Bay.

No mechanism whereby the proposed drainage improvements could adversely impact any of these species is evident. Small changes in short-term flow patterns and sediment loading are likely to be detectable, if at all, only in the uppermost estuarine reaches of these systems. Certainly they will not result in any change in physical habitat or potential in estuarine areas. Changes in water quality parameters, particularly contaminants such as pesticides, are expected to be small. Contaminant loadings might be expected to increase in association with sediment loads, but both factors are probably much more sensitive to land use and agricultural practices within the basins than to channelization of stream courses and bridge replacements.

Increases in endangered bird populations, notably Bald Eagles, Ospreys, and Brown Pelicans, have been widely attributed to the elimination of the widespread use of chlorinated hydrocarbons. While some of this insecticide material (particularly the degradation products of DDT) persists in the soils and sediments of the project area, the proposed drainage improvements do not appear capable of substantially increasing the availability of this material in the downstream estuarine areas.

SECTION 8 - CAPITAL IMPROVEMENT PROGRAM

Priority Ranking

Drainage improvement rating criteria provide a means to develop a priority list for construction of the recommended alternatives. In this procedure several items, or criteria, are used to evaluate the alternatives and compare them. The criteria used should represent the important County concerns in the decision-making process. All the criteria are not equally important, so weighting factors are applied to them, which will tend to make the alternatives that best meet the objectives of the County the higher priority items. Some of the criteria used to evaluate the alternatives are judgement values (such as socio-economic benefits) and some are more easily quantified (such as costs). For this study, seven criteria were used in evaluating the alternatives:

1. Severity of existing problem, which includes the flooding of homes, businesses, roads and utilities
2. Development potential
3. Environmental impacts, primarily on the bays and estuaries
4. Capital costs
5. Required maintenance
6. Ease of implementation
7. Socio-economic benefits, which include access during flooding, duration of flooding, public concern, etc.

The weighting factors used for the evaluation criteria are listed in Table 8-1.

TABLE 8-1

WEIGHTING FACTORS FOR EVALUATION CRITERIA

	Evaluation Criteria	Weighting Factor
1.	Severity of Existing Problem	5
2.	Development Potential	4
3.	Environmental Impacts	3
4.	Capital Costs	5
5.	Required Maintenance	2
6.	Ease of Implementation	1
7.	Socio-Economic Benefits	3

Each of the alternatives was evaluated as having a range of impacts from desirable to undesirable effects. High impacts, assigned a value of 3, were given to alternatives that produced desirable effects, and low impacts, assigned a value of 1, were given to alternatives that produced undesirable, or negative, effects. Medium impacts were assigned a value of 2. Table 8-2 evaluates the alternatives according to weighting factors and impact values. Table 8-3 lists the improvements by rank.

TABLE 8-2

ALTERNATIVES RANKING TABLE

Basin	Alternative	Evaluation Criteria[1]							Total Points
		1 WF=5	2 WF=4	3 WF=3	4 WF=5	5 WF=2	6 WF=1	7 WF=3	
Oso	BR[2] @ FM 763	H-15	H-12	H-9	H-15	H-6	H-3	H-9	69
	BR @ SH 24	H-15	H-12	H-9	H-15	H-6	H-3	H-9	69
	BR @ Tex-Mex RR	H-15	H-12	H-9	M-10	H-6	L-1	H-9	62
	CI[3] @ SH 24	H-15	H-12	L-3	M-10	L-2	M-2	M-6	50
	BR @ FM 665	M-10	H-12	H-9	H-15	H-6	H-3	H-9	64
Petronila	BR @ FM 2826	L-5	M-8	H-9	M-10	H-6	H-3	H-6	47
	DD[4] @ Driscoll	H-15	H-12	M-6	M-10	M-4	M-2	M-6	55
	CI	H-15	M-8	L-3	L-5	M-4	M-2	H-9	46
Pintas	CI	M-10	L-4	L-3	L-5	L-2	L-1	L-3	28
Agua Dulce	BR @ FM 666	M-10	M-8	H-9	M-10	H-6	M-2	M-6	51
	CI	H-15	L-4	L-3	L-5	L-2	L-1	L-3	33
Quinta	BR @ FM 1833	M-10	H-12	H-9	H-15	H-6	H-3	H-9	64
San Fernando	CI	H-15	M-8	L-3	L-5	L-2	L-1	L-3	37
	BR @ FM 1355	M-10	L-4	H-9	M-10	H-6	M-2	M-6	47

For example, H-15 in column 1 means the alternative is assigned a high impact at a point value of 3 (see page 8-2) and in Column 1 the weighting factor equals 5; hence, the point evaluation is 3 x 5, or 15. M (or medium) rates 2 points, and L (or low) rates 1 point.

1. Evaluation Criteria Numbers are shown in Table 8-1.
2. BR = Bridge Replacement
3. CI = Channel Improvement
4. DD = Construct Drainage Ditch

TABLE 8-3

PRIORITY RANKING

Rank	Basin	Alternative	Points
1	Oso	Bridge at FM 763	69
2	Oso	Bridge at SH 24	69
3	Oso	Bridge at FM 665	64
4	Oso	Bridge at Tex-Mex RR	62
5	Quinta	Bridge at FM 1833	64
6	Petronila	Drainage Ditch at Driscoll	55
7	Agua Dulce	Bridge at FM 666	51
8	Oso	Channel Improvement	50
9	Petronila	Bridge at FM 2826	47
10	San Fernando	Bridge at FM 1355	47
11	Petronila	Channel Improvement	46
12	San Fernando	Channel Improvement	37
13	Agua Dulce	Channel Improvement	33
14	Pintas	Channel Improvements	28

SECTION 9 - LEGAL REQUIREMENTS

Texas counties are authorized to regulate development in flood areas by two statutes, both of which were passed to provide eligibility for flood insurance under the National Flood Insurance Act of 1968.

Art. 1581e-1 was enacted in 1969. It authorizes any county bordering on the Gulf of Mexico or the tidewater limits thereof to determine and describe the boundaries of flood, or rising water prone, areas.

This statute defines "flood, or rising water prone, area" to mean "an area that is subject to or exposed to flooding by the Gulf of Mexico or its tidal waters, including lakes, bays, inlets, and lagoons, which results in damage to land or property."

The commissioners court of any such county is authorized "to enact and enforce regulations which regulate, restrict, or control the management and use of land, structures, and other development in flood, or rising water prone, areas in such a manner as to reduce the danger or damage caused by flood losses. This power and authority may include, but not be limited to, requirements for flood-proofing of structures which are permitted to remain in, or be constructed in, flood, or rising water prone, areas; regulations concerning minimum elevation of any structure permitted to be erected in, or improved in, such areas; specifications for drainage; and any other action which is feasible to minimize flooding and rising water damage."

The Texas Flood Control and Insurance Act was first enacted in 1969, and was later amended in 1977. It appears in Section 16.311 et seq. of the Texas Water Code.

This Act authorizes counties (and all political subdivisions, including the South Texas Water Authority) to take all necessary and reasonable actions to comply with the requirements and criteria of the National Flood Insurance Program, including but not limited to:

"(1) making appropriate land use adjustments to constrict the development of land which is exposed to flood damage and minimize damage caused by flood losses;

(2) guiding the development of proposed future construction, where practicable, away from a location which is threatened by flood hazards;

(3) assisting in minimizing damage caused by floods;

(4) authorizing and engaging in continuing studies of flood hazards in order to facilitate a constant reappraisal of the flood insurance program and its effect on land use requirements;

(5) engaging in floodplain management and adopting enforcing permanent land use and control measures consistent with the criteria established under the National Flood Insurance Act;

(6) declaring property, when such is the case, to be in violation of local laws, regulations, or ordinances which are intended to discourage or otherwise restrict land development or occupancy in flood-prone areas and notifying the secretary, or whomever he designates, of such property;

(7) consulting with, giving information to, and entering into agreements with the Department of Housing and Urban Development for the purpose of:

(A) identifying and publishing information with respect to all flood areas, including coastal areas; and

(B) establishing flood-risk zones in all such areas and making estimates with respect to the rates of probable flood-caused loss for the various flood-risk zones for each of these areas;

(8) cooperating with the secretary's studies and investigations with respect to the adequacy of local measures in flood-prone areas as to land management and use, flood control, flood zoning, and flood damage prevention;

(9) taking steps to improve the long-range management and use of flood-prone areas;

(10) purchasing, leasing, and receiving property from the secretary when such property is owned by the federal government and lies within the boundaries of the political subdivision pursuant to agreements with the Department of Housing and Urban Development or other appropriate legal representative of the United States Government;

(11) requesting aid pursuant to the entire authorization from the commission;

(12) satisfying criteria adopted and promulgated by the commission pursuant to the National Flood Insurance Program; and

(13) adopting permanent land use and control measures with enforcement provisions which are consistent with the criteria for land management and use adopted by the secretary."

The jurisdiction of counties pursuant to these statutes has been defined by several Attorney General opinions.

Attorney General opinion No. H-978, dated April 12, 1977, concluded that counties can adopt only land use regulations that are required for compliance with the National Flood Insurance Program, and that these regulations can apply only in the areas designated by the Flood Insurance Administrator.

Attorney General opinion No. H-1024, dated July 18, 1977, concluded that Art. 1581e-1 limits the power of the commissioners court to enacting regulations applicable to areas subject to flooding by the Gulf of Mexico or its tidal waters, including lakes, bays, inlets, and lagoons.

However, the Attorney General pointed to Section 2 of Art. 1581e-1 which authorizes counties to determine and describe the boundaries of flood or rising water prone areas, and further providing that this determination "shall be conclusively established" when the commissioners court shall make a finding in a resolution passed by it that an area or areas located within the boundaries of such county or flood or rising water prone area.

The Attorney General concluded that the commissioners court may conclusively determine the geographical scope of its powers under Art. 1581e-1, and that such determination shall be final.

Nueces County borders on the Gulf of Mexico and is therefore authorized by Art. 1581e-1 to enact land use regulations applicable only to areas subject to flooding by the Gulf of Mexico or its tidal waters, including lakes, bays, inlets, and lagoons. The commissioners court may conclusively establish the limits of these areas by making findings in a resolution.

Attorney General opinion MW-171, dated April 15, 1980, concluded that Sec. 16.311 et seq. of the Texas Water Code authorized Harris County to require building permits only in the areas designated by the Federal Flood Insurance Administrator. However, the opinion concluded that Art. 1581e-1 gives the Harris County Commissioners Court authority to require building permits in incorporated areas for structures constructed or placed in defined flood, or rising water prone, areas after these areas have been established by resolution of the commissioners court.

Attorney General opinion JM-123, dated December 30, 1983, concluded that Cameron County has no power to require utilities to deny service to individuals or entities not in compliance with the county flood control regulations.

Attorney General opinion JM-328, dated June 21, 1985, concluded that regulations enacted under Art. 1581e-1 and Sec 16.311 et seq. of the Texas Water Code do not constitute on their face a "taking" in violation of the federal or state constitutions.

In addition to the counties, the jurisdiction of political subdivisions pursuant to these statutes has been defined by several Attorney General opinions.

Attorney General opinion No. H-978, dated April 22, 1977, concluded that political subdivisions can adopt only land use regulations that are required for compliance with the National Flood Insurance Program, and that these regulations can only apply in the areas designated by the Flood

Insurance Administrator.

Attorney general opinion JM-123, dated December 30, 1983, concluded that Cameron County has no power to require utilities to deny service to individuals or entities not in compliance with the county flood control regulations. However, the Attorney General noted a rule of the Public Utility Commission permitting a utility to decline service to an applicant who has not complied with the utility's approved rules and regulations filed with the Commission or an applicant whose equipment is hazardous or of such character that satisfactory service cannot be given. The Attorney General concluded that a utility can voluntarily deny service to an applicant for the reasons set out in the Commission rules. The Attorney General also noted that a utility can seek an amendment to its regulations to deny service to buildings which lack permits required by law. Finally, he noted that if the county's regulations guard against the same conditions expressed in the utility's approved regulations on file with the Commission or if they prohibit utility hookups to applicants with equipment hazardous or unsatisfactory because of the danger of being located in a flood-prone area, the utility may voluntarily comply with them.

CONCLUSION

The Commissioners Court of Nueces County has the following authority:

1. To adopt land use regulations having as their purpose and effect compliance with the requirements and criteria promulgated pursuant to the National Flood Insurance Program. These regulations apply only to areas designated by the Flood Insurance Administrator.

2. To define areas subject to flooding by the Gulf of Mexico or its tidal waters, including lakes, bays, inlets, and lagoons, and to adopt land use regulations for flood problems within these areas.

The provisions of the statute, and the Attorney General opinions, lead to the following conclusions concerning the authority of the South Texas

Water Authority to regulate development in flood hazard areas.

(1) South Texas Water Authority can adopt land use regulations which have as their purpose and effect compliance with requirements and criteria promulgated pursuant to the National Flood Insurance Program, provided these regulations apply only in areas designated by the Federal Flood Insurance Administrator as having special flood hazards.

(2) Utilities supplied with wholesale water by South Texas Water Authority can voluntarily agree with the Authority that they will deny service to structures in special flood hazard areas provided that the areas are identified by the utility as being ". . . of such character that satisfactory service cannot be given," or, that the utility places this provision in its regulations and has this provision approved by the Texas Water Commission.

In addition to the authority to regulate development in flood hazard areas, the Commissioners Court of Nueces County is authorized to regulate subdivisions by Art. 6702-1, Sec. 2.401. This statute requires the owner of any tract that is outside the corporate limits of any city who shall divide it into two or more parts for the purpose of laying out a subdivision to cause a plat to be filed in accordance with the requirements therein set forth.

At the request of the Commissioners Court the county attorney may file an action to enjoin a violation of any requirement established under the Commissioners Court subdivision order, and to recover damages to compensate the county in undertaking any construction or other activity necessary to bring about compliance with the subdivision order.

A person commits an offense if the person knowingly or intentionally violates a requirement of the subdivision order adopted by the Commissioners Court under this statute. The offense is a Class B misdemeanor.

Sec. 2.401 of Art. 6702-1 is the successor of the former Art. 6626a, which has been repealed.

Nueces County has adopted a subdivision order under the authority of

Article 6626a. This subdivision order requires, in Section 19, that "roadway & drainage plans shall be prepared by a Registered Professional Engineer (Texas Registration)." This section may be amended to require that all drainage plans shall be in accordance with the Nueces County "Drainage Criteria and Design Manual" adopted by the Commissioner's Court of Nueces County, on _________, 198__, recorded in Volume _______, Page ___, as the Drainage Manual may be amended from time to time by order of the Commissioners Court.

The existing subdivision ordinance needs to be amended to reflect that it is adopted under the authority of Sec. 2.401 of Art. 6702-1, rather than the repealed 6626a.

It is therefore recommended that the following procedure be taken:

1. Adoption of the "Drainage Criteria and Design Manual" by the Commissioners Court.

2. Adoption of a new subdivision order containing the above-described addition to the existing order, and reflecting that it is adopted under the authority of Sec. 2.401 of Art. 6702-1.

Nueces County also has authority to require development or building permits for construction in unincorporated areas that are floodplain areas designated by the Federal Insurance Administrator, and in areas designated by the Commissioners Court as being flood, or rising water prone, areas.

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