Table 5-4 Data on Recharge Enhancement Structures

Site	Recharge Pool Capacity (acft)	Recharge Pool Surface Area (acres)	Acreage Impacted by Construction	Area to be Filled that Falls Under USACE Jurisdiction Pursuant to Section 404, Clean Water Act (acres)
Frio	17,500	1,099	461	1.16
Sabinal	8,750	454	43	1.36
Hondo	2,800	232	12	0.44
Verde	3,600	334	76	0.39

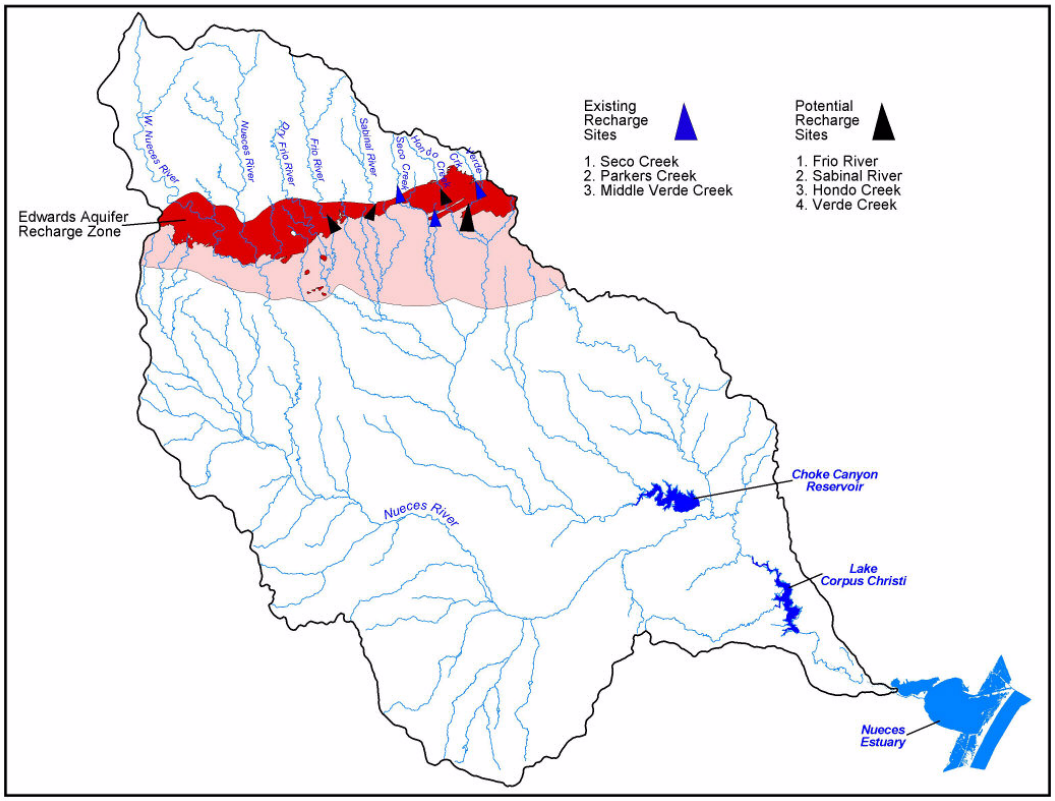

Figure 5-13 Map of Proposed Recharge Enhancement Projects

Aquifer recharge can be accomplished by constructing small to medium size reservoirs near the lower end of the recharge zone and by impounding flood water and allowing it to percolate into the aquifer instead of letting it flow downstream to be lost primarily to channel losses and evapotranspiration, see Figure 5-14. The streams downstream of the recharge locations are predominantly intermittent and do not support significant aquatic ecosystems as explained earlier. Figure 5-15 demonstrates how the recharge zone affects local streams. The

first photo shows a flowing stream upstream of the recharge zone, the second picture is the same stream on the same day a few miles downstream over the recharge zone. These photos are indicative of the rapid recharge rates that are associated with the Edwards formation. Figure 5-16 shows an existing recharge project and the way the environment has adapted to the structure. The photograph was taken from on top of the dam looking upstream into the catchments basin to show how the habitat adapts with the construction of the reservoir.

Previous studies have indicated that about 15 percent of the streamflow that currently flows past the potential recharge sites eventually makes it to Choke Canyon Reservoir, with the other 85 percent being lost to channel losses, aquifer recharge and evapotranspiration. Studies have shown that the combined impact of the four proposed recharge structures on the yield of the CCR/LCC System would be a reduction of about 5,500 acft/yr (5,500 acft/yr represents about 3% of the year 2010 yield of the CCR/LCC system) and would require mitigation.

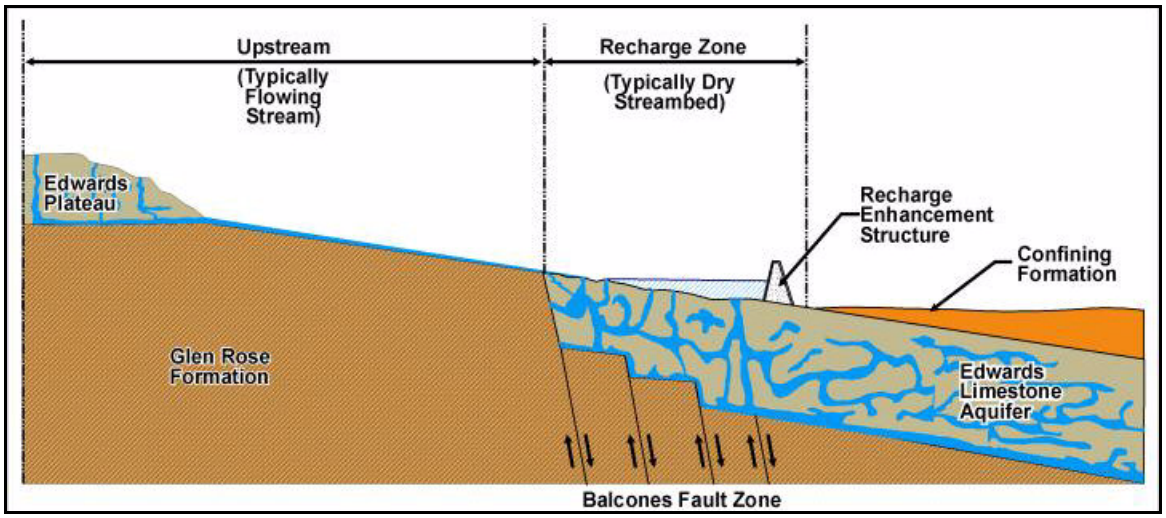

Figure 5-14. Schematic of a Typical Recharge Enhancement Structure

Figure 5-15. Typical Stream Above Recharge Zone, Same Stream Over Recharge Zone

Figure 5-16. Existing Recharge Site Upstream of Dam

Benefits: Recharge enhancement structures will significantly contribute to the restoration of the fragile ecosystems of significant spring systems. Additionally, flows in the Leona, San Antonio, Comal, Guadalupe and San Marcos Rivers will be increased. An increase in springflows and their reliability serves to enhance the habitat of several endangered species such as the Texas Blind Salamander, Fountain Darter and Texas Wild Rice. The additional available springflows not only contributes to the flow of the Leona, San Antonio, Comal, San Marcos and Guadalupe Rivers but will also increase flows to the bays and estuaries downstream at the Gulf of Mexico. Water supply will be increased by the enhanced recharge in the form of Edwards Aquifer Authority recharge recovery permits. Based on historical simulation of the 1934 – 1989 period of record, the long-term average annual recharge enhancement from these projects will be approximately 48,000 acft/yr with a long-term average increase in the springflows of 27,000 acft/yr and water supply benefits of up to 21,000 acft/yr. These potential projects will have a relatively low impact in the Nueces River Basin, due to their location on predominately dry streams and large channel losses downstream of the projects. Stream segments below the recharge zones are intermittent at best and only intermittently support deep pool habitat, because of the combination of recharge, shallow slopes, and high channel losses. The downstream segments are typically dry streambeds that would see both a reduction in peak flood flows and an increase in base flows after flood events, as shown by the hydrographs in Figure 5-17.

One impact from these recharge opportunities would require some form of mitigation. There would an estimated 5,500 acft/yr reduction in the overall system yield of Choke Canyon Reservoir/Lake Corpus Christi System from the reduction of inflows. Even though the streams downstream of the recharge projects are intermittent, normally dry reaches, the reduction in flood flows would reduce the inflow into Choke Canyon Reservoir. Several other options listed in this report could serve as mitigation for this impact.

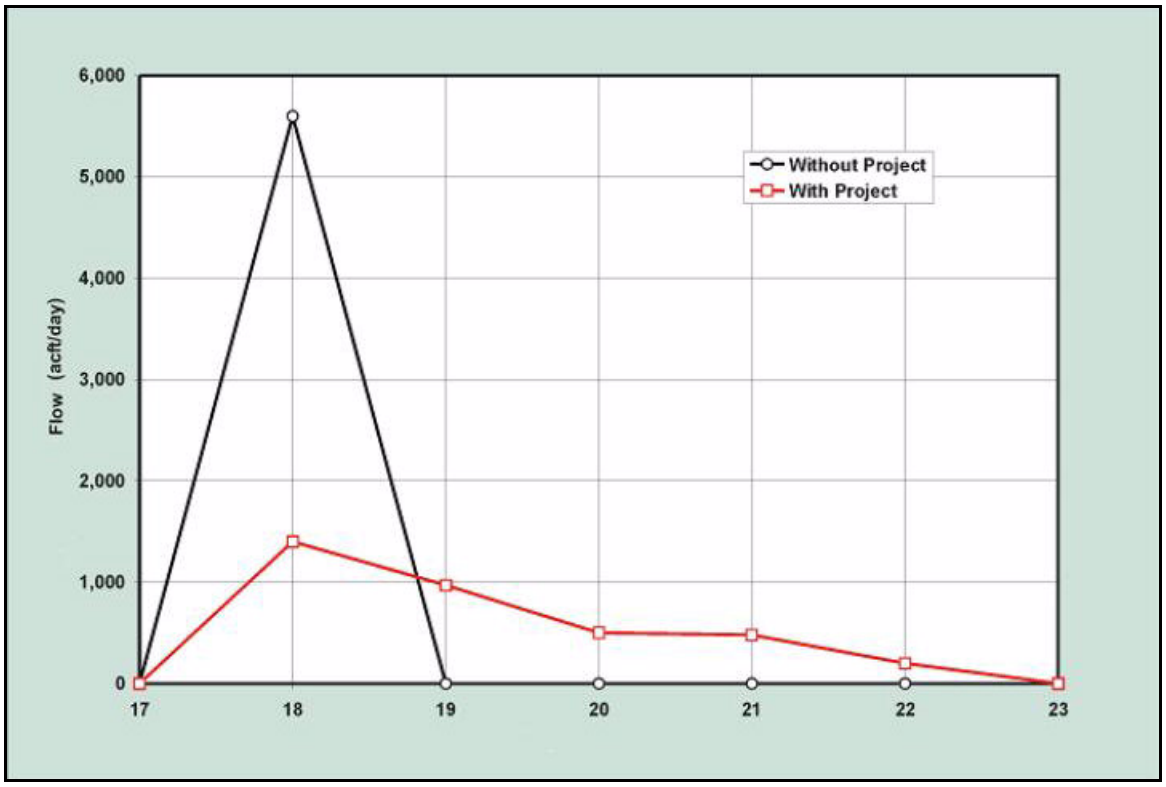

Figure 5-17. Sample Hydrograph at Recharge Structures Showing Flow Differences

One minor impact the Edwards Aquifer recharge structures will have, which could be challenging to mitigate, is a reduction in recharge to the Carrizo-Wilcox Aquifer. Recharge to the aquifer will be reduced due to the reduction in flood hydrograph volumes that will be captured by the recharge structures. However, analysis of future water levels in the Carrizo-Wilcox Aquifer in Frio County were performed during the preparation of the South Central Texas Regional Water Plan (Region L) both with and without the Edwards Aquifer recharge structures. As shown in Figure 5-18 projected water levels by the year 2050 are estimated to be only about 4 feet lower with the recharge structures than without the structures. The analysis performed by the Region L Plan actually over predicts the effects of the four-recharge structures discussed in this report as the impacts in the Region L Plan also included additional Edwards Aquifer recharge structures and additional regional pumpage on the Carrizo-Wilcox Aquifer. Brush management could be a prime candidate as a project that could mitigate the minor impacts to the Carrizo-Wilcox Aquifer recharge associated with the Edwards Aquifer recharge enhancement structures.

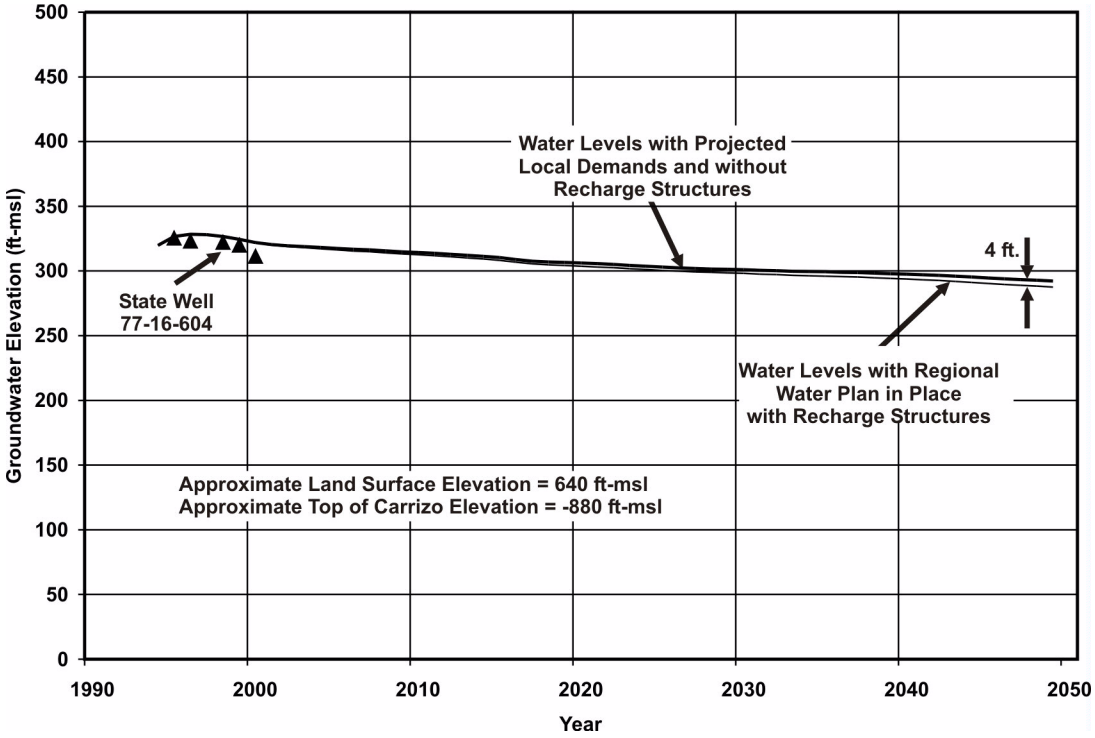

Figure 5-18 Central Frio County Hydrograph for Carrizo-Wilcox Aquifer

Figure 5-19 shows a comparison of the predicted harvest of the commercial species from the Nueces Estuary both with and without the recharge enhancement structures. This figure demonstrates the impact on the commercial species of the estuary from the recharge enhancement structures. Most of the changes between the two scenarios are minor (+/- 2 Klbs) and in the case of brown shrimp, there is a sharp increase in the predicted harvest. This graph was developed using the TPWD and TWDB harvest equations.

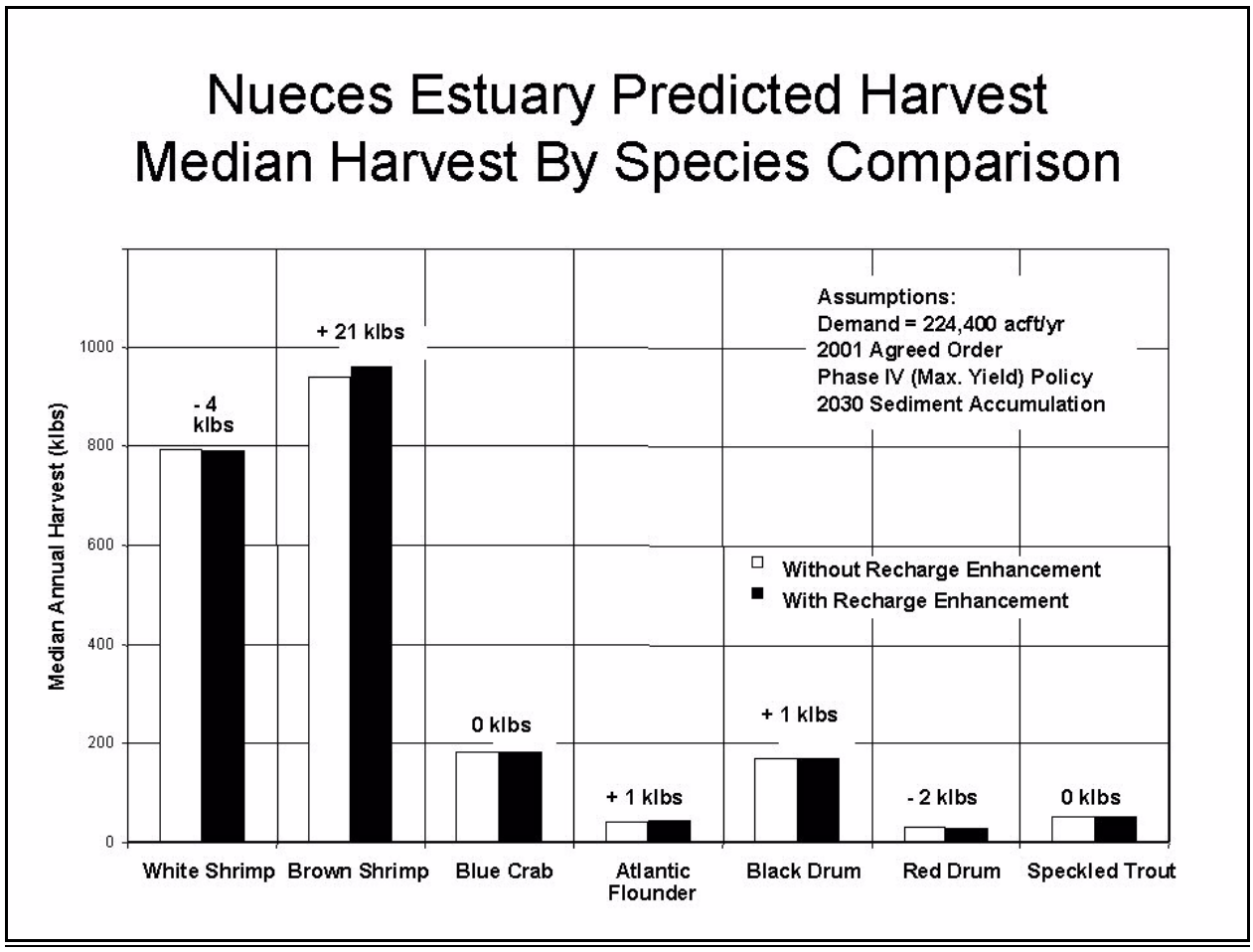

Figure 5-19 Estimated Commercial Fishing Harvest with and without Recharge Enhancement Structures

Costs: The overall cost of the four-recharge projects is estimated at $65 million in 1999 dollars based on the findings of the Regional Water Plan for South Central Texas.

Sponsors: There are several potential sponsors all showing high levels of interest in pursuing recharge enhancement structures. Among these are SAWS, SARA, and GBRA. Potentially, the City of Corpus Christi and the Nueces River Authority could also support aquifer recharge opportunities if satisfactory mitigation for impacts to their water supplies are incorporated into the project plan.

5.6.3.4 Cotulla Diversion Project to Support CCR/LCC System Storage

Description: There is a high level of sponsor support for further study regarding the potential Cotulla Reservoir site. This project could serve as an ecosystem and water quality

enhancement project, water supply (possibly as mitigation of the effects of recharge dams), recreation and flood damage reduction reservoir. The Corps of Engineers studied Cotulla Reservoir site in the 1960's at a storage capacity of 527,500 acft and an inundated surface area of 31,410 acres. The revisited version of this project would likely be a downsized version of the original study to minimize the impacts associated with reservoir construction. Figure 5-20 shows the location of the proposed reservoir on the Nueces River. Also included in the feasibility study would be a pipeline to divert water directly into Choke Canyon Reservoir to bypass the high channel losses associated with the 81-mile "braided reach" of the Nueces River that is located just downstream of the proposed reservoir site and to increase Choke Canyon storage and help improve the water quality in Choke Canyon Reservoir for fish, wildlife and for municipal water supply.

Benefits: Construction of a reservoir at the Cotulla site could provide both ecosystem and water supply benefits for fish and wildlife located in this part of the coastal bend region, as well as the citizens served by the CCR/LCC System. The reservoir could also serve as a source of recreation for boaters, fishermen and swimmers alike. The estimated yield available for water supply from the originally studied reservoir is 57,000 acft/yr. The flood damage reduction aspect would require additional study to determine potential benefits. It is hypothesized that since the majority of upstream floods travel down the Nueces River, and since Lake Corpus Christi has no flood storage pool, that a reservoir upstream of LCC may be able to capture and mitigate these flood events before reaching the Lake Corpus Christi area. For example in the recent flooding the peak daily flow at the Cotulla site was about 17,000 cfs which was about one third of the peak flow at Lake Corpus Christi of 50,000 cfs. Additionally benefits from this project are likely if combined with the two-way pipeline project. Because the two-way pipeline will eliminate channel losses on water releases from Choke Canyon Reservoir, it would also eliminate channel losses on any water from the Cotulla site stored in Choke Canyon Reservoir and subsequently released to Lake Corpus Christi.

Cost: The cost of the originally studied project is $176 million in 1999 dollars with an estimated yield of 57,000 acft/yr. The costs for the downsized version of the reservoir and associated pipeline to CCR have yet to be determined.

Sponsors: The City of Corpus Christi and the Nueces River Authority are all interested sponsors of this project. Potentially, the San Antonio Water System may also be interested in sponsorship if this project were structured to provide mitigation for the recharge projects.

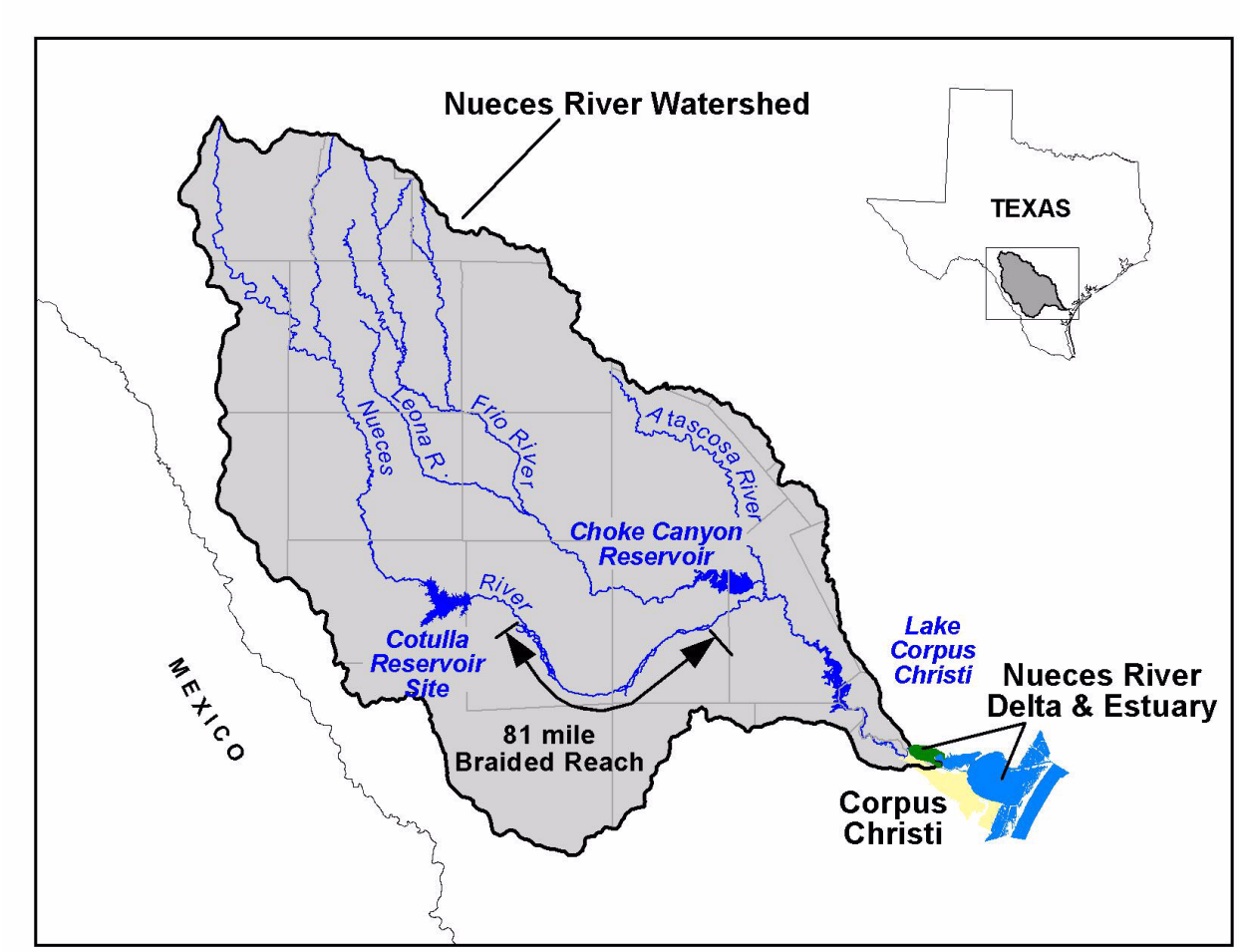

Figure 5-20 Cotulla Reservoir Proposed Site

5.7 Summary from the Preliminary Screening

Table 5-5 lists projects that have the greatest potential for Federal interest and non-Federal Sponsor support. Many of these projects compliment each other and could be implemented together for a greater overall benefit to the basin. This creates opportunities for an environmentally sustainable holistic watershed management approach to combine and enhance the benefits of individual projects into a greater multi-objective benefit.

Table 5-5 Projects with Greatest Potential for Implementation

Project	*Project Type*	*Sponsor Support*
Flooding Downstream of Lake Corpus Christi & throughout the Nueces Basin	Flood Damage Reduction	City of Corpus Christi and potentially NRA
Recharge Enhancement Projects	Multipurpose	SAWS, GBRA, SARA and possibly NRA and the City of Corpus Christi with mitigation
Cotulla Diversion Project to Enhance Storage in LCC/CCR System	Multipurpose	City of Corpus Christi, NRA, and possibly SAWS for mitigation purposes
Two-Way Pipe Project to Increase Reservoir System Storage	Multipurpose	City of Corpus Christi, NRA, and possibly SAWS for mitigation purposes
Desalination	Multipurpose	City of Corpus Christi, NRA, Governor's office of the State of Texas
Treated Effluent Placement in Nueces Delta	Ecosystem Restoration	City of Corpus Christi, TPWD, NRA and possibly SAWS for mitigation purposes
Water Quality in Choke Canyon Reservoir	Ecosystem Restoration	City of Corpus Christi, TPWD, NRA and possibly SAWS for mitigation purposes
Stream Restoration in the Upper Nueces Basin	Ecosystem Restoration	NRA and TPWD
Brush Management	Ecosystem Restoration	NRA, TPWD and others
Exotic Aquatic Plant Removal	Ecosystem Restoration	NRA, TPWD and others

5.8 Establishment of a Plan Formulation Rationale

The conclusions from the preliminary screening form the basis for the next iteration of the planning steps that will be conducted in the feasibility phase.

6. Federal Interest

Examination of the water resources related problems present in the Nueces River Basin indicate that there are significant opportunities for Federal participation in the study area. The broad spectrum of problems and opportunities to enhance the environments and associated Federally-listed endangered species, the willingness of numerous local sponsors, and the complexity of the strategies involved demonstrate the need for further study.

Alternatives identified by this preliminary screening process specifically address issues of flood damage reduction, ecosystem restoration, water quality, recreation, and water supply (in conjunction with other benefits as a multipurpose context). The preliminary assessment from this screening process indicates that there are water resource opportunities in the Nueces River Basin that are environmentally beneficial, economically justified, supported by local sponsors, and consistent with the Army Corps of Engineers' policies, thus creating a Federal interest.

If funded and authorized, follow-on feasibility studies will utilize existing reports where applicable to expedite reporting of study findings for problems and areas that are deemed to be separate and individual in location, scope, and solution. The first phase of a feasibility study would evaluate how projects that have previously been looked at on an individual basis be combined to maximize their cumulative benefits, minimize their environmental impact and minimize project costs. If additional problems and or opportunities are identified during the first phase, then the scope and nature of the second phase of the Feasibility Study can be adjusted, additional sponsors sought, and additional studies performed.

7. Preliminary Financial Analysis

Certain local sponsors have stated a willingness to consider and potentially pursue a feasibility study and participate in a Federal Cost Sharing Agreement. These sponsors are aware that they will be required to provide 50 percent of the cost of the feasibility phase, of which 100 percent of the non-Federal sponsors cost can be in-kind services. A letter of support from one of the local sponsors indicating a willingness to share in the feasibility costs is included in this report and can be found in Appendix B.

8. Summary of Feasibility Assumptions

The following assumptions will provide a basis and guidance for the feasibility study:

- Without Project Condition Assumptions, and
- Non-Federal sponsor support and in-kind services of known and projected conditions.

9. Feasibility Milestones

An estimated timeline for the feasibility study is as follows.

Table 9-1 Feasibility Schedule / Milestones

Milestones	*Description*	*Duration (months)*	*Cumulative (months)*
Milestone F1	Initiate Study	0	0
Milestone F2	Public Workshop/Scoping	2	2
Milestone F3	Feasibility Analysis & Meetings	11	13
Milestone F4	Identify/Analyze Favorable Alternatives	9	22
Milestone F5	Selection and Analysis of Recommended Plan	5	27
Milestone F6	Alternative Formulation Briefing	3	30
Milestone F7	Draft Feasibility Report	3	33
Milestone F8	Final Public Meeting	1	34
Milestone F9	Feasibility Review Conference	1	35
Milestone F10	Final Report to SWD	3	38
Milestone F11	DE's Public Notice	1	39
-	Chief's Report	4	43

It is recommended the project be performed in a minimum of two phases. Phase one would include work through milestone F3 and would include analysis to evaluate both individual projects and preliminary combinations of projects to determine cumulative benefits, preliminary costs, and environmental effects. Phase 2 would include milestones F4 through F11 and include detailed analysis on the best combination of projects and define both individual and cumulative benefits, costs and impacts in more detail.

10. Feasibility Costs

The following table lists the preliminary cost estimate for the Feasibility Study. This table shows the overall cost of evaluating the projects identified in this 905(b). The detailed estimate found in Appendix C shows the approximate breakdown of cost and schedule in terms of individual projects. Appendix C estimates the cost to study each project individually where the table below shows a cumulative study cost for all proposed projects with some cost savings realized due to the overlap of studying similar elements for differt projects.

Table 10-1 Feasibility Cost Estimate

WBS#	Description	Cost ($1,000)
JAA00	Feas – Surveys and Mapping except Real Estate	360
JAB00	Feas – Hydrology and Hydraulics Studies and Report	970
JAC00	Feas – Geotechnical Studies and Report	190
JAE00	Feas – Engineering Design and Analysis Report	200
JB000	Feas – Socioeconomic Studies and Report	170
JC000	Feas – Real Estate Analysis and Survey	140
JD000	Feas – Environmental Studies and Report (Except USF&WL)	215
JE000	Feas – Fish and Wildlife Coordination Act Report	230
JF000	Feas – HTRW Studies and Report	130
JG000	Feas – Cultural Resources Studies and Report	120
JH000	Feas – Cost Estimates	200
JI000	Feas – Public Involvement Documents	125
JJ000	Feas – Plan Formulation and Evaluation	100
JL000	Feas – Final Report Documentation	60
JLD00	Feas – Technical Review Documents	40
JM000	Feas – Washington Level Report Approval (Review Support)	50
JPA00	Project management and Budget Documents	140
JPB00	Supervision and Administration	50
JPC00	Contingencies	180
L0000	Project Management Plan (PMP)	20
Q0000	PED Cost Sharing Agreement	30
	Feasibility Phase Study Total Costs	3,720

11. Views of Other Agencies

No preliminary coordination was initiated with other Federal Agencies. It is expected that the U.S. Fish and Wildlife Service will express interest in the ecosystem restoration possibilities identified especially for the Nueces Delta and Estuary and critical habitat of species dependent on flows from Comal and San Marcos Springs. It is expected that the USBR will express an interest in any projects that involve Choke Canyon Reservoir. The Nueces Estuary Advisory Council is anticipated to have a high level of interest in any ecosystem restoration project associated with the Nueces Delta or Estuary.

12. Potential Issues Affecting Feasibility Phase

Continuation of this study into the cost-shared feasibility phase is contingent upon an executed Feasibility Cost Sharing Agreement (FCSA), with one or more interested local

sponsors. Failure to achieve an executed FCSA within 18 months from the approval date of the 905(b) Analysis will result in the termination of the study.

13. Project Map

A detailed map of the study area is included in Appendix A.

14. Recommendations

It is recommended that more detailed feasibility studies be performed for the purpose of flood damage reduction, ecosystem restoration and other multipurpose projects in the Nueces River Basin and the Nueces Estuary system. This proposal is consistent with Army and budgetary policies and it is likely that projects meeting the criteria for Federal participation will proceed to implementation.

Date

Gordon M. Wells
Colonel, Corps of Engineers
District Engineer