



Flood gates at Lake Corpus Christi, May 2019

Chapter 6 – Impacts of Regional Flood Plan and Contributions to Water Supply Development and State Water Plan

31 TAC § 361.40 and 361.41

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6 Impacts of Regional Flood Plan and Contributions to Water Supply Development and State Water Plan

The objective of this chapter is to summarize the impacts and contributions of implementing the regional flood plan (RFP) would have on reducing flood risks and provide a region-wide summary and description of the contribution that the RFP would have on water supply development. In previous chapters, existing and future flood risks were determined based on 1% and 0.2% annual chance flood events within the Nueces Flood Planning Region (NFPR). In addition, an inventory and assessment of existing infrastructure, including major constructed infrastructure and natural features were compiled for use as a baseline. Flood mitigation needs were identified leading to recommendations of flood management evaluations and strategies, and flood mitigation projects. This chapter summarizes the positive benefits and negative effects of implementing the RFP and identifies impacts the RFP could have on water supply development and the State Water Plan.

6.1 Impacts of Regional Flood Plan

Impacts are determined before-and-after RFP implementation of recommended flood management evaluations (FME), flood management strategies (FMS), and flood mitigation projects (FMPs) relative to existing and future flood risk. These two comparisons may, for example, also indicate a percent change in flood risk, including flood exposure to vulnerable communities and critical infrastructure. The comparison before-and-after RFP implementation estimates both how much the region's existing flood risk will be reduced through implementation of the plan as well as how much additional, future flood risk (that might otherwise arise if no changes were made to floodplain policies etc.) will be avoided through flood management or mitigation activities. This in turn, will help guide the NFPR towards measuring the impacts of floodplain management goals described in Chapter 3 and additional changes/improvements to the region's floodplain management policies that might be necessary in the future.

This effort included:

- a region-wide summary of the relative reduction in flood risk that implementation of the RFP would achieve within the region including with regard to life, injuries, and property.

- a general description of the types of potential positive and negative socioeconomic or recreational impacts of the recommended FMSs and FMPs within the NFPR.
- a general description of the overall impacts of the recommended FMPs and FMSs in the Regional Flood Plan on the environment, agriculture, recreational resources, water quality, erosion, sedimentation, and navigation.

6.1.1 FMP Impacts

A total of four FMPs were identified in the NFPR. After evaluating these FMPs, these identified FMPs were determined to be ineligible because they already had funding, insufficient detail was available to determine level of service of project benefits, or information was lacking to confirm that the project when implemented would not negatively affect neighboring areas within or outside of the NFPR. The flood exposure for existing conditions is shown in Table 6-1. Since the NFPR has no recommended FMPs, flood exposure after FMP implementation and exposure reduction could not be quantified.

Table 6-1. Impacts Prior to and After FMP Implementation

Flood Exposure	Existing Conditions		After FMP Implementation		Exposure Reduction from FMPs	
	1% Annual Chance Event (ACE)	0.2% ACE	1% ACE	0.2% ACE	1% ACE	0.2% ACE
Exposed Structures	60,967	+37,197	N/A	N/A	N/A	N/A
Exposed Population	144,053	+100,356	N/A	N/A	N/A	N/A
Exposed Area (Square Miles)	4,578	+1,287	N/A	N/A	N/A	N/A
Exposed low water crossings (LWC) ¹	503	+23	N/A	N/A	N/A	N/A
Exposed Critical Facilities	445	461	N/A	N/A	N/A	N/A

N/A= Not applicable.

¹Out of a total of 576 LWCs in the NFPR obtained from Texas Natural Resources Information System (TNRIS) and local government entities.

6.1.2 FMS Impacts

A total of 60 FMSs were identified in the NFPR. After evaluating these FMSs based on the Texas Water Development Board (TWDB) guidance, 40 were recommended. FMSs are defined by the Texas Administrative Code (TAC) as “a proposed plan to reduce flood risk or mitigate flood hazards to life or property.” The types of FMSs recommended by the Nueces Regional Flood Planning Group (NRFPG) include updating flood ordinances, adding flood gages for monitoring, property buy-outs, implementing flood early warning systems, and other programs for which benefits are difficult to quantify with certainty.

For this evaluation, the impacts of implementing recommended FMSs were estimated in the form of flood protection for areas within the watershed that might benefit through implementation of the FMS. However, due to the nature of the FMSs, this may or may not correlate to a direct reduction in loss of life, injuries, and property according to the values indicated. To study the impact of the FMSs on the Region, the number of exposed structures, population square miles, LWCs and critical facilities that overlap the FMS polygons were summed and shown in Table 6-2. Presumably, the structures, population, LWC and critical facilities within the FMS polygons will benefit from the FMS, however it’s impossible to know exactly what will benefit from an FMS unless a detailed impact analysis is performed. For example, an FMS to improve low water crossing signage may not improve the exposed structures within its boundaries. Therefore, the analysis in this section was meant to give a very rough and best-case estimate of the impact of the FMSs.

By implementing FMSs, up to 66% of structures may benefit and as many as 64% fewer people may be exposed to flood inundation. However, this may not necessarily correlate to removal from 0.2% annual chance flood inundation area since many of the FMSs are related to education campaigns or low water crossing signage. The NFPR exposed to flood risk may increase by as much as 26%. Exposed low water crossings could be reduced by up to 10%, and exposed critical facilities could be reduced by as much as 61% from 0.2% annual chance flood inundation after FMS implementation.

Table 6-2. Impacts Prior to and After FMS Implementation

Flood Exposure	Existing Conditions		Future Conditions (no RFP)		Future Conditions Unlikely to Benefit through FMSs		Benefitting from RFP FMSs	
	1% ACE	0.2% ACE	1% ACE	0.2% ACE	1% ACE	0.2% ACE	1% ACE	0.2% ACE
Exposed Structures	60,967	37,197	77,878	34,611	29,465	8,367	48,413	26,244
Exposed Population	144,053	100,356	198,915	94,363	79,021	25,809	119,894	68,554
Exposed Area (Square Miles)	4,578	1,287	4,629	1,283	3,426	966	1,203	317
Exposed LWC	503	23	509	526	414	522	95	4
Exposed Critical Facilities	445	384	642	493	334	109	308	384

6.1.3 FME Impacts

A total of 179 FMEs were identified in the NFPR. After evaluating these FMEs based on TWDB guidance, 163 were recommended. While compiling data during the baseline development of the RFP, the NRFPG identified many data gaps within the NFPR pertaining to areas of high flood risks that lacked floodplain management practices, flood management enforcement, detailed hydrologic and hydraulic models, and inundation mapping as described in Chapter 4. The lack of data leads people and structures to being potentially exposed to unnecessary flood hazards. FMEs were developed to address that exposure. In general, the FMEs include flood hazard modeling and mapping to identify flood risk, flood mitigation alternatives analysis and feasibility studies, and preliminary engineering studies among others.

To study the impact of the FMSs on the Region, the number of exposed structures, population square miles, LWCs and critical facilities that overlap the FME polygons were summed and shown in Table 6-3, similar to the analysis in The FMS impacts section 6.1.2. Presumably, the structures, population, LWC and critical facilities within



the FME polygons will benefit from the FME, however it’s impossible to know exactly what will benefit from an FME unless a detailed impact analysis is performed.

By reducing the number of square miles affected by flooding by implementing FMEs, the population living within those areas ultimately benefits with reductions in flood risk. Since the high flood risk areas could potentially be reduced by implementing recommended FMEs, the subsequent population that receives this benefit is estimated to be 61,029 (or 25% of the population that are inside the future 0.2% annual chance flood inundation area). The socioeconomic benefit to the population varies based upon location. Descriptions of those benefits are discussed below in Section 6.1.5. The estimated population in the 1% annual chance exceedance floodplain that could benefit with recommended FMEs is shown in Table 6-3. While the number of injuries and deaths prevented by implementing the plan is not quantifiable, the benefits are expected to be significant in terms of reducing flood risk for areas that are currently shown to be flood-prone. The benefits are achieved by improving the accuracy of inundation mapping and extent of flood hazard to reduce flood risk to structures, roads, and property (structural flood mitigation projects) and changing the way people interact with flood risk (non-structural flood mitigation projects and strategies) through regulatory improvements, education campaigns, and identifying areas of concern to address with structural or non-structural drainage and flood mitigation improvements.

Removing structures from short-term and long-term flood risk benefits communities who rely on those structures for residences, work, industry, and critical facilities. Critical facilities identified generally as municipal utilities and buildings, hospitals and care facilities, and schools are of special importance. Table 6-3 shows the estimated reduction in the number of structures and critical facilities by implementing the RFP.

Table 6-3. Exposures Benefitting from FMEs

Exposures	Number Benefitting from FMEs (1% ACE)
Structures	61,029
Population	142,133
Ag Land (Acres)	14,660
Critical Facilities	507
Road Length (miles)	665
Low water Crossings (LWCs)	183

6.1.4 Low water Crossings and Impacted Roadways

Implementing FMSs and FMPs across the FPR will reduce the impact of existing low water crossings (LWCs). As projects are implemented over time, the number of LWCs

will be reduced saving life and property. The total number of LWCs benefiting by implementing recommended FMSs in the NFPR is shown above in Table 6-2.

Flooded roadways also benefit from the NRFP being implemented. Roadways that are often closed due to flooding pose risks to life, property, and transportation in general.

6.1.5 Socioeconomic and Recreational Impacts

6.1.5.1 Socioeconomic

Socioeconomic impacts were taken into consideration while developing the NRFP to verify that flood reduction benefits were evenly distributed among all groups and balanced across the region. The NFPR has a diverse population with wide ranging economic levels. Disadvantaged socioeconomic populations have limited access to resources hindering response and recovery from flood events. As discussed in Chapter 1, the NFPR was divided into four subregions based on differences in socioeconomic, land characteristics, and types of flooding. Most of the population, over 82%, is in the lower half of the NFPR. Three of the basins are similar regarding median household income, households below the poverty line, and diversity, as shown in Table 6-4. The upper mid basin is the outlier with lower diversity, lower household income and a higher percentage of households below the poverty line. Zavala County, located in the upper mid basin, is also identified as the seventh poorest county in the country based on median household income.

Table 6-4. NFPR Socioeconomic Information

Basin	Population	Median Household Income	Households below Poverty Line	Diversity Index	Households
Upper	72,672	\$50,821	15%	48%	24,807
Upper Mid	52,882	\$36,235	27%	23%	16,407
Lower Mid	136,020	\$48,122	20%	43%	46,382
Lower	535,465	\$53,435	18%	51%	192,680

In developing the appropriate FMSs, FMPs, and FMEs, the NRFPG included goals to reduce impacts due to flood events and improve the lives of all socioeconomic groups, ensuring the most disadvantaged were well represented. Flood exposure and vulnerability analyses completed for the NFPR and described in Chapter 2 used socioeconomic indicators to identify vulnerabilities of communities and critical facilities that are most susceptible to high flood risk.

6.1.5.2 Recreation Impacts

Many parks located along water fronts are designed to be flooded periodically with minimal impact to infrastructure. Floodplains and wetlands can support recreation and tourism. Flood control basins often include reservoirs, which are recreational and wildlife attractions. Choke Canyon Reservoir is a good example of this. Although not specifically identified in the NRFP, as FMSs and FMPs are implemented and structures in floodplains are removed, new opportunities become available for local sponsors to re-develop these lands for public benefit. These areas can be used for county parks and hiking and biking trails. The NRFPG encourages local flood administrative agencies to seek secondary benefits such as recreational opportunities in flood-prone areas and to support public education campaigns and clear signage indicating flood potential. While the NRFPG supports such repurposing of floodplain areas for recreation, no negative impacts to existing recreation activities in the Nueces Basin should be caused by these activities.

6.1.5.3 Floodplain Management Practices Impacts

By implementing the RFP, the existing floodplain management standards identified in Chapter 3 will be leveraged and have basis to bolster and expand local regulations to protect future life and structures from high flood risk events. Currently, there are sparse moderate to strong regulations and the additional future flood risks identified in Chapter 2 necessitate stronger floodplain management practices to reduce impacts to life, injury, or properties. The NRFPG has identified a minimum floodplain management standard throughout the region, as discussed in Chapter 3, and implementation of the RFP will provide more accurate flood inundation mapping to support communities as they align future floodplain management standards and ordinances to mitigate future risk exposure.

6.1.6 Overall Impacts of Recommended FMSs and FMPs on Environment, Agriculture, Water Quality, Erosion, Sedimentation, and Navigation

Flood risk management concepts to consider when evaluating FMSs and FMPs include the following²:

- Flood is a natural process that has many benefits to human and natural systems.
- Promoting some flooding as desirable and making room for water promotes native species, maintains vital ecosystem services, and reduces the chance of flooding elsewhere.

² From Texas Parks and Wildlife, October 26, 2022.

- Natural landscapes and watersheds provide flood mitigation functions that should be promoted, protected, enhanced, and restored.
- Prioritize risk reduction over flood control by focusing first on reducing loss of life and injury.
- Utilize limited resources fairly.
- Address flood risk using a portfolio approach to first implement non-structural (policy, land management, emergency management) followed by structural (grey and natural and nature-based) strategies.
- Criteria for assessing projects strategies should include a comprehensive suite of measures spanning economical, operational, societal, and environmental advantages and disadvantages. Assessments focusing on economics alone (number of buildings, acres) should be avoided.

Implementing the RFP provides numerous benefits associated to the primary purposes of FMSs, FMPs, and FMEs. The FMS benefits although not readily quantifiable, will protect the health and safety of the region by reducing flood risk through advanced flood warning systems, removing roads and structures from flooding, and providing officials the tools to properly manage flood prone areas.

The recommended FMSs in the NRFP are anticipated to have a beneficial impact on environment, agriculture, water quality, and erosion by providing additional data and understanding of flood events that will lead to implementation of flood mitigation projects that divert or address flood flows to reduce their impact. Several recommended FMSs are specifically identified to reduce erosion and sedimentation impacts. Flood projects should consider stream crossing designs that allow for sediment transport and passage of aquatic organisms and do not impound water.

The FMSs recommended in the NRFP are not anticipated to impact navigation.

No long-term impairment to designated water quality in the State Water Quality Management Plan is anticipated as a result of recommended FMS or FMPs.

The plan, when implemented, will not negatively affect neighboring areas located within or outside the flood planning region.

Several FMSs were identified to have a positive impact on water supply. They are described in the following section on water supply.

6.2 Contributions to and Impacts on Water Supply Development and the State Water Plan

According to TWDB guidance, RFPs must include a regionwide summary of the contribution that the RFP would have to water supply. As part of this analysis, FMSs



and FMPs were reviewed to determine whether impacts to water supply/availability exists. Impacts include contributions as well as reductions in water supply and availability. These impacts as determined are sorted according to the following categories:

1. Involves directly impacting water supply volume available during drought of record which requires both availability and directly connecting supply to specific water user group(s)
2. Directly benefits water availability
3. Indirectly benefits water availability
4. Or has no anticipated impact on water supply

A coordinated effort with representatives from multiple regional water planning groups occurred to identify water management strategies that could be impacted. Those regional water planning groups include, Region N (Coastal Bend), Region L (South Central Texas), and Region M (Rio Grande). There are four FMS that were identified by the NRFPG on June 27, 2022, that have benefits related to water supply development. These strategies, with exception of a direct Nueces River diversion to Choke Canyon Reservoir (CCR) have been evaluated and included in Coastal Bend (Region N) Regional Water Plans. In order for the Nueces River diversion to CCR project to be included as a recommended FMS in the RFP, it must have an estimated annual water supply. This project, therefore, was not eligible for recommendation. The three FMS with water supply benefits that were recommended by the NRFPG are shown in Table 6-5. A map showing the location of these recommended FMSs in relation to the 1% annual chance flood inundation area is shown in Figure 6-1.

Table 6-5. FMS/FMP Contributions to Water Supply

Name	FMS/ FMP	Volume (AF/YR)	Impacts Water Supply Volume	Directly Benefits Water Availability	Indirectly Benefits Water Availability	No Impacts on Water Supply
Two-way pipeline (LCC-CCR)	FMS	Approx. 22,000 – 40,000	X			
Nueces Off Channel Reservoir	FMS	Approx. 30,000 – 48,000	X			

LCC Sediment Removal	FMS	Approx. 9,000	X			
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AF-YR=acre-feet per year

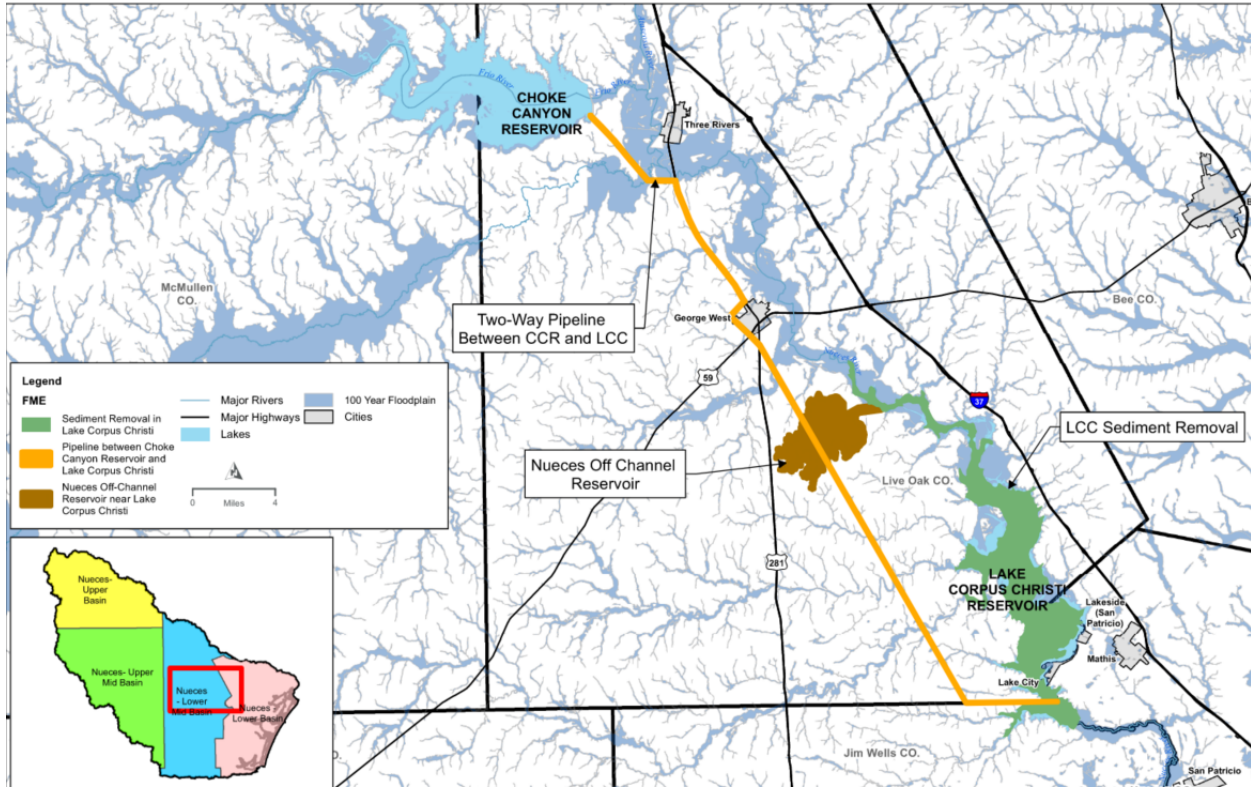


Figure 6-1 FMS related to Water Supply

Two-way pipeline between Choke Canyon Reservoir (CCR) and Lake Corpus Christi (LCC) - The two-way pipeline has been recommended as a water management strategy in previous Coastal Bend (Region N) Regional Water Plans and State Water Plans. The groundwater – surface water interactions in the alluvial soils of the Gulf Coast aquifer between CCR to LCC are complex. The channel losses along this stretch of the river are considerable with amounts varying based on seasonal conditions. Losses are more pronounced during prolonged drought events. A two-way pipeline between CCR and LCC would mitigate the losses in the natural stream between the two reservoirs. The two-way pipeline provides operators the ability to balance water volumes in the two lakes to better make use of the extra capacity to store water in CCR while freeing up capacity in LCC to capture additional flood flows from the Atascosa and Nueces Rivers that converge at the City of Three Rivers. In extended drought periods, water can be moved from CCR to LCC minimizing losses while maximizing water supply for contracted users. Simulations for the historical period 1934-2003 concluded that this pipeline operation could provide a firm yield of approximately 22,000 – 40,000 acre-feet per year. This strategy was not recommended in the 2022 State Water Plan.

Nueces off-channel reservoir - The Nueces off-channel reservoir (OCR) has been recommended as a water management strategy in previous Coastal Bend (Region N) Regional Water Plans and State Water Plans. The OCR can serve to enhance the system yield of CCR and LCC while capturing water that would otherwise spill into LCC. The OCR would be operated in conjunction with water levels at LCC to maximize the total volume of water stored. The capture of additional flood flow provides added protection against prolonged droughts ensuring water supply availability for contracted users. In addition to water supply, the OCR can simultaneously maintain the instream flows to the Nueces Bay and Estuary (B&E). Past studies show that, for a 280,000 acre-foot reservoir, the firm yield ranges from approximately 30,000 – 48,000 acre-feet per year. This strategy was not recommended in the 2022 State Water Plan.

Although it has not been studied previously, there may be additional benefits achieved through operation of the Nueces off-channel reservoir in conjunction with Aquifer Storage and Recovery (ASR). Such an ASR concept might include treating water from the Nueces off-channel reservoir and recharging aquifers in favorable hydrogeologic areas near treatment facilities for later recovery and use by local or regional water providers during drought or high seasonal water demand periods. In 2019, the Corpus Christi Aquifer Storage and Recovery Conservation District and the City of Corpus Christi conducted an ASR exploratory program in Nueces County using reclaimed water for industrial purposes and the results appear favorable up to yields of 18 MGD. Although this specific project would not be a candidate to use in conjunction with the Nueces off-channel reservoir, it was a recommended water management strategy in the 2021 Coastal Bend Regional Water Plan and 2022 State Water Plan. Additional studies would be needed to evaluate aquifers in proximity to the Nueces OCR and local water treatment plants, to further evaluate conjunctive use opportunities with the OCR and ASR.

Sedimentation Removal at LCC - Sediment accumulation in LCC has been discussed for decades. To address this issue, dredging of LCC was considered. This project was evaluated in the 2001 Coastal Bend (Region N) Regional Water Plan, but has not been re-evaluated or considered as a water management strategy in the most recent four planning cycles. In the 2001 Coastal Bend Regional Water Plan, it was estimated that approximately 163 million cubic yards (in situ volume) of sediment needs to be dredged to restore the storage capacity of LCC to 1959 conditions. The removal of sedimentation would free up capacity to store additional water and/or allow for more flood water capture. For water supply, the dredging program could provide a long-term yield (30-year) of approximately 9,000 acre-feet per year. This strategy was costly and presented disposal challenges.