Drought Management through Water Supply Diversification

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Abstract

As Texas experiences some of the worst droughts in its history, cities that have been proactive in securing water for their future are more prepared for what lies ahead. Corpus Christi is one such city that has worked to diversify their water supply over the years and has put themselves in a good defensive position against extreme drought conditions. This diversification is necessary as the Nueces River basin is prone to severe and unpredictable periods of both drought and water excess. In the late 1980’s, the City began searching for an additional water source to add to and diversify its supply. The two original water sources for the City were Lake Corpus Christi and the Choke Canyon Reservoir. In 1993, the City contracted with Lavaca Navidad River Authority to purchase the third water supply. This supply comes from 41,840 acre-feet of water per year from Lake Texana. The Lake Texana water supply was a key acquisition for the City as it supplies approximately 50 to 70 percent of the drinking water to Corpus Christi citizens.

Upon acquisition of the Lake Texana water supply, the City recognized that additional diversification sources would be required to supply the City beyond the year 2020. Therefore, when designing the pipeline to deliver the Lake Texana water supply, additional capacity was provided in the pipeline. This pipeline, known as the Mary Rhodes Pipeline, was constructed in 1998.

The City’s three present water sources meet the needs of over 500,000 customers in Corpus Christi and the Coastal Bend. The City continued with its diversification plan and, in the early 1990’s, identified a fourth water source. This source came in the form of the CRGWR. The City secured the option to buy 35,000 acre-ft per year of water from the Garwood Irrigation Company in 1993. Between 1993 and 1998, the Texas Natural Resource Conservation Commission approved the use of the City’s portion of the CRGWR for municipal and industrial use.

In 2003, the City contracted FNI to perform a screening study of various options for delivering water from the CRGWR to the Mary Rhodes Pipeline. FNI identified and studied preliminary delivery options including the following: transmission of water through a proposed pipeline, transmission of water through existing waterways and partnering with Lower Colorado River
Authority (LCRA) and San Antonio Water System (SAWS) on the LCRA-SAWS Water Supply Project. By 2006, FNI and the City narrowed the delivery options down and completed a more detailed study on three preferred options.

FNI recommended and the City ultimately chose to move forward with transmission of the CRGWR through a proposed pipeline from the Colorado River to the Mary Rhodes Pipeline. The routing development and permit acquisition are currently underway and the preliminary design for the pipeline and pump station are scheduled to kickoff in March of 2010. By 2011, the City plans to have their fourth major water source designed and shovel-ready so they can manage any and all severe drought conditions that come their way.
Section 1: The History of Corpus Christi Water

As Texas experiences some of the worst droughts in its history, cities that have been proactive in securing water for their future are more prepared for what lies ahead. Corpus Christi is one such city that has worked to diversify their water supply over the years and has put themselves in a good defensive position against extreme drought conditions. This diversification is necessary as the Nueces River basin is prone to severe and unpredictable periods of both drought and water excess.

The history of Corpus Christi water begins in the early 1890’s with the construction of the salt water barrier dam, also known as the Calallen Dam on the Nueces River. In 1929, the La Fruita Dam was constructed on the Nueces River to form Lake Lovenskiold. This dam washed out shortly after it was constructed and was rebuilt in 1935. The reservoir created by the new dam was renamed Lake Corpus Christi. This new dam was replaced by the Wesley Seale Dam in the 1950’s. A shortage of funds on Corpus Christi’s part necessitated the funding of a third party. For this purpose, the Legislature created the Lower Nueces Water Supply District. The Lower Nueces Water Supply District built and owned the reservoir until the bonds were paid off in 1986. At this time, Corpus Christi assumed ownership. Wesley Seal Dam/Lake Corpus Christi has a present storage capacity of 242,241 acre-feet.

In the early 1970’s, Corpus Christi began looking for a second water source to increase and diversify its water supply. The Bureau of Reclamation financed, designed and built the Choke Canyon Reservoir. The reservoir was dedicated in 1982. Corpus Christi currently finances, operates and maintains the facility. Choke Canyon Reservoir stores 695,271 acre-feet of water.

Corpus Christi’s most recent water source is Lake Texana. They made an agreement in the 1990’s with the Lavaca Navidad River Authority (LNRA) for the withdrawal of up to 41,840 acre-feet per year from Lake Texana. This includes 10,400 acre-feet per year that may be taken back by LNRA if required for use in Jackson County. In addition to the 41,840 acre-feet, Corpus Christi has contracted for 12,000 acre-feet per year of interruptible water supply if available in Lake Texana. Upon making the agreement with LNRA, Corpus Christi designed and built the Mary Rhodes pipeline to transport the Lake Texana water to the O.N. Stevens Water Treatment Plant where it is treated for their customers. This pipeline was completed in 1998. Approximately 50% of the water delivered to homes in Corpus Christi comes from Lake Texana.

Corpus Christi designed the Mary Rhodes Pipeline with an additional water source in mind. The pipeline was designed with possible upgrades to carry 35,000 additional acre-feet per year. This 35,000 acre-feet of additional water will come in the form of the Mary Rhodes Pipeline
Phase 2 project. This water supply project utilizes water taken from the Colorado River under the Garwood Water Right.
Section 2: Utilization of the Garwood Water Right - Phase 1

The Garwood Water Right is the most senior water right on the Lower Colorado River, with a priority date of November 1, 1900. This water right authorizes the diversion of 168,000 acre-feet per year from the Colorado River at a maximum diversion rate of 750 cubic feet per second (cfs).

In September of 1992, Corpus Christi entered into an option agreement for the purchase of up to 35,000 acre-feet per year from the Garwood Irrigation Company. On March 18, 1993, the Texas Water Commission (TWC), now the Texas Commission on Environmental Quality (TCEQ), authorized an amendment to Garwood’s water right that allows for the use of 35,000 acre-feet of its annual right for municipal and industrial purposes. With this amendment granted, Corpus Christi and Garwood Irrigation Company were able to proceed with the sale of the desired portion of the Garwood water right.

On October 13, 1998, the Texas Natural Resource Conservation Commission (TNRCC, now TCEQ) approved Corpus Christi’s purchase of the 35,000 acre-feet per year designated for municipal use from Garwood. The amendment of the certificate of adjudication authorizes Corpus Christi to divert 35,000 acre-feet per year from the Colorado River for irrigation, municipal and industrial purposes at a maximum rate of 150 cfs. The certificate also subordinates the 35,000 acre-feet per year to the remaining portion of the original Garwood water right by giving it a priority date of November 2, 1900. This remaining water right is owned by LCRA and used largely for irrigation of land that is located in the Lavaca-Navidad River Basin.

In 2002, Corpus Christi contracted Freese and Nichols (FNI) to evaluate options for transporting the Garwood water to the existing Mary Rhodes Pipeline. As previously stated the Mary Rhodes pipeline and associated pump stations were designed to allow upgrades for greater flow capacity.

Phase 1 in FNI’s evaluation of possible options was a screening study of delivery options. The objective of this phase was to identify up to eight delivery options and then choose two or three options for more detailed study. This phase included brief studies of the following:

- Alternate intake pump station locations along the Colorado River or existing irrigation canals.
- Alternate delivery methods of operations. Methods of operations may include peak pumping from the Colorado River, the use of off-channel storage, or constant pumping from the river.
• Alternate partnership schemes, such as a system wholly owned by Corpus Christi or a system where Corpus Christi and other water providers form a partnership.

The eight delivery options were developed in a collaborative effort between Corpus Christi and FNI. These options are as follows:

• Option 1: Combined Facilities with LCRA and San Antonio Water System (SAWS) – In 2004, at the time of this study phase, LCRA and SAWS were working on a project to transport water from the Lower Colorado River to San Antonio. The state legislature mandated that a seven-year period be utilized to study the impact that the transfer may have on the Colorado River Basin. At this time, it was possible that the diversion point for the LCRA/SAWS water project would be located near Bay City in which case facilities between Bay City and Lake Texana could be shared with Corpus Christi. Corpus Christi and LCRA/SAWS could have a combined pipeline, pumping station, and possibly off-channel storage. This delivery alternative is attractive because the joint use of off-channel reservoirs, pipelines and pump stations would likely result in capital cost savings, operations cost savings and possible improvements to the permit process.

• Option 2: Bay City to Mary Rhodes Pipeline with Peak Pumping – A transmission pipeline between Bay City and the Lake Texana Intake Pump Station is a strong option for the Mary Rhodes Pipeline Phase 2 project because of its relatively short pipeline length. It is also attractive because of the existing channel dam near Bay City. This option includes construction of a new intake pump station located within the pool created by the existing channel dam near Bay City used by the Gulf Coast Irrigation District and a 37.5-mile pipeline to the existing Lake Texana Intake Pump Station. The pipeline would parallel existing roadways and utility corridors in order to minimize impact on private property. A continuous diversion rate of 31 MGD (48 CFS) is needed to divert the full water right of 35,000 acre-feet per year. The diversion rate for this option was determined by applying a 2.0 peaking factor, resulting in a design flow rate of 62 MGD (96 CFS).
• Option 3: Bay City to Mary Rhodes Pipeline with Off-Channel Storage – Option 3 also utilized the pool created by the existing channel dam near Bay City. Additionally, it includes an 8,750 acre-foot off-channel storage reservoir sized to provide a 3-month water supply and a 6-mile pipeline to deliver water from the Colorado River to the off-channel storage. At the off-channel storage reservoir, a booster pump station pumps water through a 40-mile pipeline to the Lake Texana Intake Pump Station. In order to maximize the use of the off-channel reservoir, the diversion rate from the Colorado River to the off-channel storage was set at 97 MGD (150 CFS), the maximum diversion rate allowed by the water right. The flow between the off-channel reservoir and the Lake Texana Intake Pump Station was set at 46 MGD (72 CFS). This flowrate applies a peaking factor of 1.5 to the constant rate of 31 MGD. This option would require more extensive environmental permitting for an off-channel storage reservoir as well as a possible amendment to the Garwood water right, as the off-channel reservoir can be interpreted as a non-closed pipeline conveyance.

• Option 4: Bay City to Mary Rhodes Pipeline with Base Pumping – Option 4 is identical to Option 2 except for the diversion rate from the river. Option 4 assumes that pumping from the Colorado River can be at a more constant rate with peak demand flows being supplied from Lake Texana and/or Lake Corpus Christi and Choke Canyon Reservoir. By operating in this manner, Lake Texana, Lake Corpus
Christi and Choke Canyon Reservoir would function as storage for the Garwood water, even though the Garwood water does not go through the lakes. As stated in Option 2, the continuous diversion rate to obtain the full 35,000 acre-foot water right is 31 MGD (48 CFS). A peaking factor of 1.5 is applied resulting in a design flowrate of 46 MGD (72 CFS). Like Option 2, Option 4 includes a pump station near Bay City and a 37.5-mile transmission pipeline.

- Option 5: Garwood Town Canal to West Mustang Creek – FNI and Corpus Christi evaluated the use of Garwood Irrigation District canals and adjacent creeks to transport water from the Colorado River near Garwood to Lake Texana. They discussed various locations of canal and creek intersections with the Irrigation District and determined that if the diversion point could be on one of the main Garwood canals, the canal capacity would be enough to accommodate Corpus Christi’s required flow. West Mustang Creek intersects the main irrigation canals at two points near the main canal. The southern intersection point at “Town Canal” was selected. Option 5 proposes diversion of water from the Colorado River into Town Canal where it would be diverted to West Mustang Creek and then carried south to Lake Texana. This would require coordination with LCRA to deliver Corpus Christi’s Garwood water to the canal. Furthermore, as stated previously, Corpus Christi’s Garwood water right requires conveyance through a closed pipeline. As a result, Option 5 would require a revision to the water right to allow transfer of water through the creek to Lake Texana. Another concern for this option is the possible losses in the creek due to infiltration, diversions by adjacent landowners, and evaporation.
• Option 6: Gulf Coast Furbor Canal to Mary Rhodes Pipeline – Option 6 requires coordination with LCRA to deliver Corpus Christi’s Garwood water to one of the northwest canals, the Furbor Canal, within the Gulf Coast Irrigation District near Bay City. This option includes diversion from the Colorado River to the Furbor Canal, a new pump station located on the Furbor Canal, and a 29-mile pipeline to the existing Lake Texana Intake Pump Station. The 29-mile pipeline follows an alignment similar to the alignment for Options 2, 3 and 4. This option would use a peaking factor of 2.0 resulting in a design flow rate of 62 MGD (96 CFS). Like Option 5, Option 6 would require an amendment to the Garwood water right to account for conveyance through the Furbor Canal.
• Option 7: Pierce Ranch to West Mustang Creek – This option includes the construction of a new intake pump station located within the pool created by the existing channel dam near Wharton used by the Pierce Ranch Irrigation District. It also includes a 14-mile pipeline to West Mustang Creek. Corpus Christi’s Garwood water would then flow down West Mustang Creek to Lake Texana. A 2.0 peaking factor would be applied to the constant flowrate resulting in a design flowrate of 62 MGD (96 CFS) for the 14-mile pipeline. This option has the same concerns as Option 5 including amendment to the water right and potential water losses in West Mustang Creek.

• Option 8: Garwood Channel Dam/Pump Station to West Mustang Creek – Option 8 is similar to Option 5 because it proposed the use of West Mustang Creek and a diversion near the existing Garwood Irrigation District facilities. It includes construction of a new intake pump station located within the pool created by the existing channel dam near Garwood used by the Garwood Irrigation District and a 6-mile pipeline to West Mustang Creek at Town Canal. Corpus Christi’s Garwood water would then flow down West Mustang Creek to Lake Texana. This option utilizes a peaking factor of 2.0 resulting in a design flowrate of 62 MGD (96 CFS). This option had the same concerns as Option 5 and Option 7 including amendment to the water right and potential water losses in West Mustang Creek.
FNI and Corpus Christi worked together to develop the appropriate criteria for evaluating the options described above. The following criteria were used:

- **Requirements for facilities:** Includes an evaluation of the facilities required for each option in comparison to the other options. For example, one option may require two pump stations versus just one pump station, or one option may require a significantly longer pipeline than another option. More facilities will require higher operation and maintenance costs.

- **Construction cost:** Includes an estimate of the construction cost for each option.

- **Land Cost:** Includes an estimate of the cost to obtain easements for each option. A study of the area was performed to determine the approximate land values that can be expected for the project.

- **Environmental Conflicts:** Includes an evaluation of the environmental conflicts that are possible with each option and examines the significance of the conflict in relation to other options. For example, an option that involves the construction of an off-channel storage reservoir may have more complex environmental concerns than an option that only proposes a pipeline and pump station.

- **Difficulty of Permitting:** Includes an evaluation of the expected permitting process of one option compared to other options. For example, options that require a
revision to the water right are significantly more difficult than options that don’t require a revision to the water right.

- **Flexibility for Additional Partners:** Involves an evaluation of each option in relation to the ability to form partnerships for the diversion of water from the Colorado River. Because it may be beneficial to Corpus Christi to share the cost of facilities with another entity, it may be important that an option be compatible with another user.

- **Water Availability:** Involves an evaluation of each option as it relates to the availability of water in the Colorado River. Options that require continuous pumping at a low diversion rate may not obtain the full water right in dry years.

At the conclusion of the screening study, FNI and Corpus Christi chose to move forward with Option 1, Combined Facilities with LCRA and SAWS, Option 5, Garwood Town Canal to West Mustang Creek and Option 6, Gulf Coast Furbor Canal to Mary Rhodes Pipeline. The decision matrix used for this analysis is shown in Table 1.
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<td>Combined Facilities with LCRA/SAWS</td>
<td>Bay City to Mary Rhodes Pipeline with Peak Pumping</td>
<td>Bay City to Mary Rhodes Pipeline with Off-Channel Storage</td>
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<td>Garwood Town Canal to West Mustang Creek</td>
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<td>Intake PS; 6 mile 60&quot; Pipeline to Off-Channel Reservoir; Booster PS; 40 mile 48-inch Pipeline to Mary Rhodes Pipeline</td>
<td>Intake PS; 37.5 mile 48-inch Pipeline to Mary Rhodes Pipeline</td>
<td>Existing Garwood Irrigation District Intake PS to Town Canal; tap into Town Canal and convey water in West Mustang Creek to Lake Texana</td>
<td>Existing Gulf Coast Irrigation District Intake PS to Furbor Canal; Booster PS; 29 mile 54-inch Pipeline to Mary Rhodes Pipeline</td>
<td>Intake PS; 14 mile 54-inch Pipeline to West Mustang Creek; convey water in West Mustang Creek to Lake Texana</td>
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Section 3: Utilization of the Garwood Water Right – Phase 2

According to the 2006 regional water plan for the Coastal Bend Region, Corpus Christi’s current water supplies will meet demands through the year 2030. With no new water supply development, around 2030 Corpus Christi and its customers will experience a shortage of 570 acre-feet per year, increasing to 39,505 by 2060. Figure 1 shows the supply and demand summary included in the 2006 Coastal Bend Regional Water Plan.

![Figure 1: Coastal Bend Region Water Supply and Demand Summary](image)

In 2006, Corpus Christi looked ahead to domestic water demands for several surrounding, growing communities as well as a growing industrial and manufacturing base. They were in a strong position to effectively supply water to meet future growth due to multiple diverse sources. It was important for Corpus Christi to move forward with delivery of the Garwood water at this time in order to secure the use of the water right and avoid the potential that this right may be restricted by future environmental regulatory changes. Additionally, it was prudent for Corpus Christi to have a functional alternative to provide water in the event of an unforeseen problem with other supplies. At this time, the Garwood water was needed to offset impacts of drought on the operation of the Lake Corpus Christi/Choke Canyon System which, in recent years, had seen heavy fluctuations between drought conditions to water excess conditions and back to drought. The Garwood water could be used to help moderate the impacts from these water availability fluctuations and provide for more efficient system operations.
With this information in mind, FNI and Corpus Christi moved forward with the more detailed study of the delivery options highlighted in Phase 1. Option 1, Combined Facilities with LCRA and SAWS was rejected in this phase of the project because of time constraints and possible permitting issues. FNI and Corpus Christi focused the majority of their energy in this phase on studying Option 5, Garwood Town Canal to West Mustang Creek because of its low capital investment and the fact that there were no inherent barriers to proceeding in this direction. In evaluating Option 5, the following negative factors were identified:

- **Aquatic Habitat – Impact on aquatic habitat in West Mustang Creek would have to be minimized.** Possible issues identified are potential increase in exogenous species and effect of variable flows on habitat.
- **Transportation Losses – The potential for transportation losses of the Garwood water during the flow down West Mustang Creek is identified as a concern.**
- **Loss of Water to Other Diverters – Diversion of water from West Mustang Creek and Lake Texana is a concern.**
- **Bed and Banks Permit – A Bed and Banks Permit may be needed from TCEQ in order to divert Corpus Christi’s Garwood water through West Mustang Creek and into Lake Texana. Several interest groups could challenge the permit application in order to seek additional environmental protection mechanisms for the diversion.**
- **Delivery through Lake Texana – Possible issues in delivery through Lake Texana are potential loss of water to other diverters, potential effect on noxious plant populations, operational protocol, bay and estuary releases, accounting of water in the lake and water quality impacts.**
- **Risk Associated with Opening the Water Right – Water right permit applications are ruled by the state statutes and rules at the time of submittal to the state. Future applications may be impacted by changes in the law regarding water rights. There are potential risks with opening the water right to make an amendment.**

With these factors in mind, FNI and Corpus Christi chose to move forward with a variation of Option 6, Gulf Coast Furbor Canal to Mary Rhodes Pipeline. This variation includes a pipeline from the Colorado River near Bay City to the Lake Texana Intake Pump Station and does not utilize the Furbor Canal. It is similar to Options 2, 3 and 4 analyzed in the first phase of the project. This option avoids the need for an amendment to the water right. It also does not include partnerships with outside entities that may cause schedule delays. Lastly it does not include off-channel storage which will complicate and lengthen the permitting process. This option does, however, include the highest capital costs of all of the original options. Corpus Christi will minimize this problem by seeking federal funding to postpone payment and lower
the interest rate for the design and construction of the project. Corpus Christi and FNI determined that the pipeline option is a more permanent transmission option than the use of West Mustang Creek.

Following this decision, FNI completed the preliminary routing study for the pipeline in July of 2009. This routing report identified three location alternatives for the Colorado River Intake Pump Station and three alternatives for the transmission pipeline route. Pump Station locations 1 and 2 are both upstream of the existing channel dam near Bay City in wide, straight stretches of the Colorado River. Option 3 utilizes the existing LCRA Pump Station. The pipeline options all parallel existing roadways or utility easements to minimize impacts to property owners in the project area. Two options are approximately 37 miles in length while the third option is approximately 41 miles in length.
Section 4: The Future of Corpus Christi Water

The planning phase of the Mary Rhodes Pipeline Phase 2 project is on schedule to begin in February of 2010. The planning and final design phases will be completed in the last quarter of 2011. At this time, Corpus Christi will evaluate the immediate need for the Garwood water in order to determine a starting date for the bid and construction phases.

According to the 2006 regional water plan for the Coastal Bend Region, Mary Rhodes Pipeline Phase 2, combined with their existing water sources, will meet Corpus Christi’s water needs through (approximately) 2058. As previously discussed, this water will also provide for more efficient overall system operations for Corpus Christi’s water sources. With an efficient and diverse water supply system in place, Corpus Christi now has the time to find the best additional future water source for its customers. This may be the purchase of an additional inland water source or, with future technology, the jump to desalination of sea water. Whatever the future holds, Corpus Christi is in a good position to provide water to their customers for years to come.

References
