November 2016

City of Corpus Christi
Wastewater Management Plan

Prepared for: City of Corpus Christi

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Sign-off Sheet

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Abbreviations

ADF	Average Dry Weather Flow
AS	Activated Sludge
BOD5	5-day Biochemical Oxygen Demand
CBOD5	5-day Carbonaceous Biochemical Oxygen Demand
CHP	Combined heat and power
CIP	Capital Improvement Plan
CMAR	Construction Manager at Risk
DAF	Dissolved Air Floatation
DB	Design-Build
DBM	Design-Build-Maintain
DBO	Design-Build-Operate
DMR	Discharge Monitoring Report
DP	Design Professional
FAF	Facility Assessment Form
FTE	Full time equivalents
GIS	Geographical Information System
GMP	Guaranteed Maximum Price
GPCD	Gallons per capita day
MGD	Million gallons per day
MLSS	Mixed liquor suspended solids
NACWA	National Association of Clean Water Agencies
NPDES	National Pollution Discharge Elimination System
O&M	Operations and Maintenance
OPC	Opinion of Probable Cost
PDB	Progressive Design Build
P3	Public-Private-Partnership
QBS	Qualifications Based Selection
RAS	Return Activated Sludge
SRT	Solids Retention Time
SSO	Sanitary Sewer Overflow
TCEQ	Texas Commission on Environmental Quality
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
TWDB	Texas Water Development Board
TSWQS	Texas Surface Water Quality Standards
USEPA	United States Environmental Protection Agency
UV	Ultraviolet Disinfection
WAS	Waste Activated Sludge
WRP	Water Reclamation Plant
WWTP	Wastewater Treatment Plant

Executive Summary

Executive Summary

Recommendation

Based on the analysis outlined within this report, it is recommended that the City of Corpus Christi (City) adopt Option 4D for their Wastewater Management Plan. The configuration of this preferred option is presented in **Figure ES-1** and the primary elements summarized in **Table ES-1**.

Figure ES-1 General Configuration of Preferred Alternative

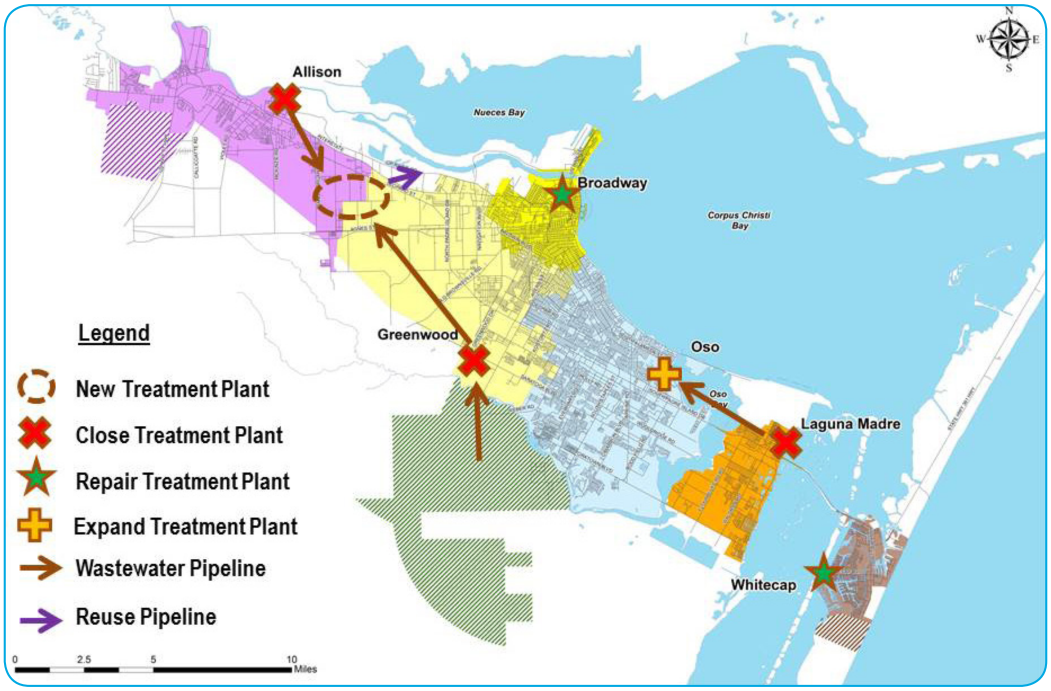

Table ES-1 Key Infrastructure Requirements for recommended Option 4D

Plant	Infrastructure Requirements
Collection System	• Repair system in accordance with requirements to reduce overflows • Redirect some flow from Greenwood to Broadway sewer shed in the interim
Allison	• Repair over next 10 years • Decommission the plant after 10-years and build new pumping station to direct flows to the new North treatment plant.
North Treatment Plant	• Construct a new 12 MGD facility at the North treatment plant site in the next 5 years. • Provide effluent reuse facilities for industry in next 10 years
Greenwood	• Repair during 0 to 5 year period • Demolish the plant and decommission the existing site after the 5 year time period. • Build a new pumping station at the Greenwood site to transfer wastewater from Greenwood to the new North treatment plant site.
Broadway	• Repair over next 20 years
Oso	• Repair plant over next 20 years • Upgrade plant to BNR and expand to 20 MGD over next 5 years.
Laguna Madre	• Repair the existing plant over the next 5 years • Demolish the plant and decommission the existing site after the 5 year time period. • Build a new pumping station at the Laguna Madre plant to transfer wastewater from Laguna Madre to the Oso treatment plant.
Whitecap	• Repair over next 20 years

Project Approach

The overall objective of this project is to determine the optimal long-range wastewater treatment plant, consolidation and trunk sewer pumping scenario. The optimal strategy will support treatment plant environmental compliance while remaining sensitive to the impact to rate payers from recommended improvements. After determining the optimal strategy, the City wishes to develop an improvements implementation plan elaborating logical project limits for procurement, project sequencing, and overall program schedule and budgets for each element.

The project plan was developed under three phases as follows:

- Phase 1 – Develop an optimal wastewater treatment configuration
- Phase 2 – Develop an implementation phasing plan
- Phase 3 – Develop an implementation programming schedule

Develop Optimal Wastewater Treatment Configuration

The City of Corpus Christi presently owns and operates six (6) wastewater treatment facilities. Four of the plants (Allison WWTP, New Broadway WWTP, Oso WRP, and Greenwood WWTP) are located in the main part of the city, one (Laguna Madre WWTP) is located on and services the Flour Bluff area, and one (Whitecap WWTP) is located on Padre Island.

One of the primary reasons for conducting this study was to confirm the potential benefits of consolidating flows from the six existing wastewater treatment facilities into a lesser number of newer larger treatment plants. The unit operating costs for larger wastewater treatment plants tend to be lower than for smaller facilities. This is primarily due to reduced staffing levels, measured as full-time equivalents (FTEs) per million gallon (MG) treated, and lower unit power costs measured as kilowatt hours (kW-hr) per million gallon treated that decline with increasing plant capacity. Ten consolidation options were evaluated for this study, as summarized in **Table ES-2**.

Table ES-2 Wastewater Servicing Options

Category	Description	Options
1 – Maintain all Existing Plant sites	• Keep six sites. Replace Greenwood on same site. Continue with current operations and planned maintenance.	• 1 - Maintain Existing Sites
2 – Consolidate at Existing Plant sites	• Keep Broadway & Whitecap. • Consolidate remainder at two of the existing plant sites.	• 2A - Allison + Laguna Madre • 2B - Allison + Oso
3 – Consolidate at New Plant site	• Keep Broadway & Whitecap. • Consolidate remainder at one new plant site.	• 3A - North site • 3B - Southwest site • 3C - Southeast site
4 – Combination of New and Existing sites	• Keep Broadway & Whitecap. • Consolidate remainder at two sites with at least one new site plus an existing site.	• 4A - North + Laguna Madre • 4B - Southwest + Laguna Madre • 4C - North + Southeast • 4D - North + Oso

The city is facing an estimated sustaining capital spend at the six existing wastewater treatment facilities of approximately $220 M. The majority of the capital requirements are for the Greenwood (approximately $61 M) and Oso (approximately $81 M) facilities. The contributing sewer shed for these two plants is also where the majority of anticipated demand growth is expected to occur.

The 2016 capital improvement plan is for an estimated capital spend to 2035 of approximately $524 M and results in utility rates that are considered unaffordable based upon EPA affordability criteria. User rate increases are driven in large part by increases in capital spend. The increase in capital spending can be partly offset by reductions in annual operation and maintenance (O&M) spend. Options requiring a large upfront capital spend over the next 5 to 10 years will have a significant further negative impact upon wastewater user rates if not offset by O&M cost efficiencies.

The implementation of any of the options presented in this report needs to strike the appropriate balance between minimizing the sustaining capital spend on existing facilities destined to be taken out of service and consolidating existing facilities as soon as practical in order to realize annual O&M savings associated with economies of scale, while staging planned capital spending for new facilities in order to minimize the impact upon user rates.

The best way to assess the options under consideration was to construct a detailed cash flow model for each. The consulting team constructed detailed capital and O&M cost models for each of the ten options considered for this study. All of the options were compared against Option 1 – Maintain existing six plant sites, which was treated as the benchmark. The team then conducted sensitivity analyses on each of the options considered to determine how changing conditions might impact costs as well as the recommended servicing option.

The financial analysis suggests Option 1 – Maintain the six existing plant sites has the lowest overall capital cost associated with treatment and pumping infrastructure given that it takes maximum advantage of existing infrastructure. However, Option 1 has the highest O&M costs of the options considered. Option 1 also has the highest capital cost for industrial reuse water given reuse water would likely have to be provided from two treatment plants as opposed to one under other options, which renders no significant user rate savings.

The cost analyses suggest Options 2B and 4D are competitive with Option 1 from an overall cost perspective considering capital costs for treatment and reuse as well as cumulative O&M costs. The relative impact on user rates for options 1, 2B, and 4D is essentially equal. Option 3A, which has the highest cumulative capital cost of the options considered, would have a statistically significant impact on user rates relative to the Option 1 benchmark.

Sensitivity analysis demonstrates that the difference in O&M cost savings is most sensitive to labor costs and labor cost inflation. The consolidation options each result in significant staff reductions relative to the bench mark Option 1 even after optimizing existing plant operations. Higher future labor costs and increased labor inflation will favor the consolidation options, particularly options 2B and 4D, relative to the benchmark (Option 1).

Prior to evaluating the Options, the City staff and their consultant team engaged with the citizens and other stakeholders to hear what issues and concerns needed to be considered in selecting the optimum future wastewater configuration. As can be expected, there was a wide range of opinions expressed by the general public, neighborhood associations, agencies, business professionals and other interested parties. These issues of concern were then grouped into preliminary evaluation criteria to cover the Economic, Social, Natural and Technical environments. The preliminary criteria were presented to City staff at an evaluation workshop where the team could confirm that these fully covered the range of relevant issues and also establish the relative priorities. Three priority levels and associated weightings were proposed: normal items were unweighted (level 1), important items were given a double weighting (level 2) and the most critical items were given a triple weighting (level 3).

Having established the evaluation criteria, each of the 10 Options was evaluated using a qualitative five-point scale that ranged from strongly negative to strongly positive with a neutral midpoint level. It should be emphasized that the evaluation is subjective in nature and seeks to determine the relative performance or predicted impact under each criteria of an option as compared to the performance or impact of the other servicing options. To reinforce that the evaluation is qualitative in nature, symbols rather than numbers were used to represent the "score" under each criterion. The evaluation of the ten options are presented here in **Figure ES-2**.

Based on this evaluation, the highest ranked wastewater servicing configuration (identified as 4D) is to consolidate future wastewater treatment around two main facilities – a new North plant and the existing Oso plant. It should be noted that this evaluation was based on assumptions of future water quality effluent standards which will still need to be verified.

Project Risks and Evaluation of Delivery Methods

The key project elements associated with implementation of the preferred configuration (Option 4D) along with the key implementation risks are summarized here in **Table ES-3**. Rehabilitation and small upgrade projects identified in the physical condition survey would likely be delivered under traditional Design Bid Build (DBB) delivery or some form of job order contracting (JOC) arrangement.

Table ES-3 Key Project Elements and Associated Critical Implementation Risks

Project	Time Frame	Estimated Cost ($M)	Key Risk Elements
Oso WRP BNR upgrade and Expansion	0-5 year	$72 M	• Constructability associated with existing plant • Impact of construction on existing plant operations. • Inability to secure discharge permit. • Higher cost due to unforeseen circumstances. • Estimated operations cost savings not achieved.
Greenwood PS and Force main	0-5 year	$73 M	• Ability to secure required easements for force main. • Delay in PS and force main construction delays flow transfer to North plant and increases Greenwood WWTP sustaining capital spend. • Traffic impacts during construction. • Flooding of construction site.
Laguna Madre PS and Force main	6-10 year	$18 M	• Ability to get permit for Oso Bay pipeline crossing. • Securing required easements for force main. • Traffic impacts during construction.
New North WWTP	0-5 year	$103 M	• Ability to secure suitable project site. • Delay in getting effluent discharge permit for new plant. • New plant construction not completed on time resulting in additional sustaining capital spend at Greenwood. • Greenwood PS and force main not ready in time to commission new plant. • Operations cost savings not attained post construction.
Allison PS and Force main	11-15 years	$22 M	• Securing required easements for force main. • Traffic impacts during construction.

A multi criteria analysis (MCA) was conducted to confirm the best delivery method for each project. Based on this analysis, recommended delivery methods are as follows:

- Laguna Madre PS and Force Main – Design-Bid-Build (DBB)
- Alison PS and Force Main – Design-Bid-Build (DBB)
- Greenwood PS and Force Main – Design-Build (DB)
- New North WWTP – Design-Build-Operate (DBO)
- Oso WRP BNR Upgrade and Expansion – Construction Manager at Risk (CMAR)
- Industrial Reuse – Public Private Partnership (P3)

Figure ES-2 Options Evaluation Matrix

Category	Sub-Topic	1	2A	2B	3A	3B	3C	4A	4B	4C	4D
											
Cost	Total Capital Cost	Strongly positive – capital cost less than $800M	Neutral - mid level capital cost of $900M to $1,000M	Positive - capital cost less than $900M	Negative - capital cost more than $1,000M	Negative - capital cost more than $1,000M	Negative - capital cost more than $1,000M	Neutral - mid level capital cost of $900M to $1,000M	Neutral - mid level capital cost of $900M to $1,000M	Neutral - mid level capital cost of $900M to $1,000M	Positive - capital cost less than $900M
Cost	Total O&M Cost	Negative - high level O&M cost more than $550M	Neutral - mid level O&M cost of $525M to $550M	Strongly positive - low O&M cost less than $500M	Neutral - mid level O&M cost of $525M to $550M	Neutral - mid level O&M cost of $525M to $550M	Neutral - mid level O&M cost of $525M to $550M	Positive - lower O&M cost of $500M to $525M	Neutral - mid level O&M cost of $525M to $550M	Neutral - mid level O&M cost of $525M to $550M	Strongly positive - low O&M cost less than $500M
Cost	Cash Flow	Strongly positive - max annual spend of approx $100M	Neutral - max annual spend of approx $200M	Neutral - max annual spend of approx $200M	Negative - max annual spend of approx $250M	Negative - max annual spend of approx $250M	Negative - max annual spend of approx $250M	Negative - max annual spend of approx $250M	Strongly negative - max annual spend of approx $300M	Strongly negative - max annual spend of approx $300M	Neutral - max annual spend of approx $200M
Receiving Streams	Maintaining base flow	Neutral - keeps all flows at status quo	Negative - reduce flows to Oso Bay	Neutral - keeps critical flows at status quo	Negative - reduce flows to Oso Bay	Strongly negative - reduce flow to Oso Bay, increase to Oso Creek	Negative - reduce flows to Oso Bay	Negative - reduce flows to Oso Bay	Strongly negative - reduce flows to Oso Bay, increase to Oso Creek	Negative - reduce flows to Oso Bay	Neutral - keeps critical flows at status quo
Receiving Streams	Effluent requirements	Negative - continues challenges in Oso Bay and Nueces River	Neutral - continues challenges in Nueces River	Negative - continues challenges in Oso Bay and Nueces River	Positive - allows lower treatment requirements	Neutral - continues challenges in Oso Creek	Neutral - continues challenges in Oso Creek	Positive - allows lower treatment requirements	Neutral - continues challenges in Oso Creek	Positive - allows lower treatment requirements	Neutral - lower treatment in north, challenges in Oso Bay
Receiving Streams	Local eco systems	Neutral - keeps status quo	Negative - potential impact at Blind Oso from loss of flow	Neutral - keeps status quo	Negative - potential impact at Blind Oso from loss of flow	Negative - potential impact at Blind Oso from loss of flow	Negative - potential impact at Blind Oso from loss of flow	Negative - potential impact at Blind Oso from loss of flow	Negative - potential impact at Blind Oso from loss of flow	Negative - potential impact at Blind Oso from loss of flow	Neutral - keeps status quo
Schedule	Phasing potential	Positive - can proceed with multiple projects at one time	Neutral - can proceed at two sites and with pipelines	Neutral - can proceed at two sites and with pipelines	Negative - requires all projects to be completed at same time	Negative - requires all projects to be completed at same time	Negative - requires all projects to be completed at same time	Neutral - can proceed at two sites and with pipelines	Neutral - can proceed at two sites and with pipelines	Neutral - can proceed at two sites and with pipelines	Neutral - can proceed at two sites and with pipelines
Schedule	Immediate start to work	Neutral - challenges at Oso, remainder available	Positive - can work adjacent to both existing plants	Neutral - challenges at Oso, remainder available	Negative - requires acquisition of land	Negative - requires acquisition of land	Positive - can work independently on new plant	Negative - requires acquisition of land	Negative - requires acquisition of land	Negative - requires acquisition of land	Negative - requires acquisition of land and working at Oso

Legend

Strongly Negative | Negative | Neutral | Positive | Strongly Positive

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Category	Sub-Topic	1	2A	2B	3A	3B	3C	4A	4B	4C	4D
											
Plant Sites	Neighboring land use	Neutral - continues residential conflicts at Oso and Greenwood	Positive - uses sites with good buffers	Neutral - continues residential conflicts at Oso	Strongly positive - new plant in industrial area	Negative - new plant in generally residential area	Negative - new plant in generally residential area	Positive - uses sites with good buffers	Negative - new plant in generally residential area	Neutral - Continues residential conflicts at Oso and Greenwood	Neutral - Continues residential conflicts at Oso
Plant Sites	Land ownership	Positive - no new land required for 20 years	Strongly positive - no new land required for >30 years	Strongly positive - no new land required for >30 years	Negative - land required for new plant	Strongly negative - new land required in residential area	Strongly positive - no new land required for >30 years	Negative - land required for new plant	Negative - land required for new plant	Negative - land required for new plant	Negative - land required for new plant
Plant Sites	Existing impacts	Neutral - continues status quo	Positive - removes impacts at Greenwood and Oso	Neutral - Continues impacts at Oso	Positive - removes impacts at Greenwood and Oso	Neutral - continues impacts at Oso Creek	Neutral - continues impacts at Oso Creek	Positive removes impacts at Oso Creek	Neutral - continues impacts at Oso Creek	Neutral - continues impacts at Oso Creek	Neutral - continues impacts at Oso Creek
Plant Sites	Flooding potential	Negative - requires new flood wall at Greenwood	Positive - removes impact from flooding at Oso Creek	Positive - removes impact from flooding at Oso Creek	Positive - removes impact from flooding at Oso Creek	Neutral - requires additional flood protection along Oso Creek	Neutral - requires additional flood protection along Oso Creek	Positive - removes impact from flooding at Oso Creek	Neutral - requires additional flood protection along Oso Creek	Neutral - requires additional flood protection along Oso Creek	Positive - removes impact from flooding at Oso Creek
Construction Impacts	Restoration requirements	Strongly positive - minimal new pipelines required	Negative - new pipelines required	Negative - new pipelines required	Strongly negative - requires extensive pipeline construction	Strongly negative - requires extensive pipeline construction	Strongly negative - requires extensive pipeline construction	Negative - new pipelines required	Negative - new pipelines required	Negative - new pipelines required	Negative - new pipelines required
Construction Impacts	Traffic disruption	Strongly positive - minimal new pipelines required	Neutral - new pipelines in generally open areas	Neutral - new pipelines in generally open areas	Negative - pipelines cross built up areas	Negative - pipelines cross built up areas	Negative - pipelines cross built up areas	Neutral - new pipelines in generally open areas	Neutral - new pipelines in generally open areas	Negative - pipelines cross built up areas	Neutral - new pipelines in generally open areas
Operational Flexibility	Potential for Reuse	Negative - Long distance to servicing industry	Positive - Allison plant close to industry	Positive - Allison plant close to industry	Strongly positive - North plant close to industry	Negative - Long distance to servicing industry	Strongly negative - Longest distance to servicing industry	Positive - North plant close to industry	Negative - Long distance to servicing industry	Positive - North plant close to industry	Positive - North plant close to industry
Operational Flexibility	Servicing new Development	Negative - needs a new plant to service new growth	Neutral - requires expansion of pumping and plant	Neutral - requires expansion of pumping and plant	Neutral - requires expansion of pumping and plant	Strongly positive - close to new growth	Strongly positive - close to new growth	Positive - can readily provide capacity for new growth	Strongly positive - close to new growth	Strongly positive - close to new growth	Positive - can readily provide capacity for new growth
Operational Flexibility	Efficiency of O&M	Strongly negative - continues operations at 6 sites	Neutral - consolidate to two main plants, one new	Neutral - consolidate to two main plants, one new	Strongly positive - consolidate to one main new plant	Strongly positive - consolidate to one main new plant	Strongly positive - consolidate to one main plant	Positive - consolidate to two main plants, both new	Positive - consolidate to two main plants, both new	Positive - consolidate to two main plants, both new	Neutral - consolidate to two main plants, one new
Operational Flexibility	Flexibility for future consolidation	Negative - does not facilitate future consolidation	Neutral - can consolidate Whitecap but not Broadway	Neutral - can consolidate Whitecap but not Broadway	Neutral - can consolidate Broadway but not Whitecap	Negative - does not facilitate future consolidation	Neutral - can consolidate Whitecap but not Broadway	Positive - can consolidate both Whitecap and Broadway	Neutral - can consolidate Whitecap but not Broadway	Positive - can consolidate both Whitecap and Broadway	Positive - can consolidate both Whitecap and Broadway
Overall Rating		**102**	**101**	**104**	**95**	**78**	**86**	**100**	**84**	**92**	**106**

The estimated cash flow requirements for the recommended servicing plan are summarized here in **Table ES-4**. All capital costs are presented here in 2016 constant dollars. The capital spend by project and year is included with the cash flow models presented in **Appendix K**.

Table ES-4 Summary of Fund Requirements

Program Element	Implementation Time Frame			
	0-5 yr.	6-10 yr.	11-15 yr.	16-20 yr.
Collection System Upgrades Associated with Reducing Overflows	$127 M	$127 M	$127 M	
Allison WWTP Repair and Rehab	$13 M	$4 M		
Allison PS and Force main			$22 M	
Broadway WWTP Repair and Rehab	$11 M	$3 M		$1 M
Oso WRP Repair and Rehab	$54 M	$3 M	$6 M	$18 M
Oso WRP BNR Upgrade & Expansion	$72 M			
Greenwood Repair and Rehab	$14 M			
Greenwood PS and Force main	$73 M			
Laguna Madre Repair and Rehab	$7 M			
Laguna Madre PS and Force main		$18 M		
New North WWTP	$103M			
Whitecap WWTP Repair and Rehab	$19 M		$2 M	$2 M
TOTALS	**$493 M**	**$155 M**	**$157 M**	**$21 M**

The total estimated capital spend for Option 4D is approximately $826 M with O&M savings over the next 30-years of approximately $60 M relative to the benchmark option of maintaining the six existing wastewater treatment plants.

Optimal Wastewater Treatment Configuration

1.0 Optimal Wastewater Treatment Configuration

The overall objective of this project is to determine the optimal long-range wastewater treatment plant, consolidation and trunk sewer pumping scenario. The optimal strategy will support treatment plant environmental compliance while remaining sensitive to the impact to rate payers from recommended improvements. After determining the optimal strategy, the City wishes to develop an improvements implementation plan elaborating logical project limits for procurement, project sequencing, and overall program schedule and budgets for each element.

The project plan was developed under three phases as follows:

- Phase 1 – Develop an optimal wastewater configuration scenario
- Phase 2 – Develop an implementation phasing plan
- Phase 3 – Develop an implementation programming schedule

Our general approach to the wastewater management plan development included:

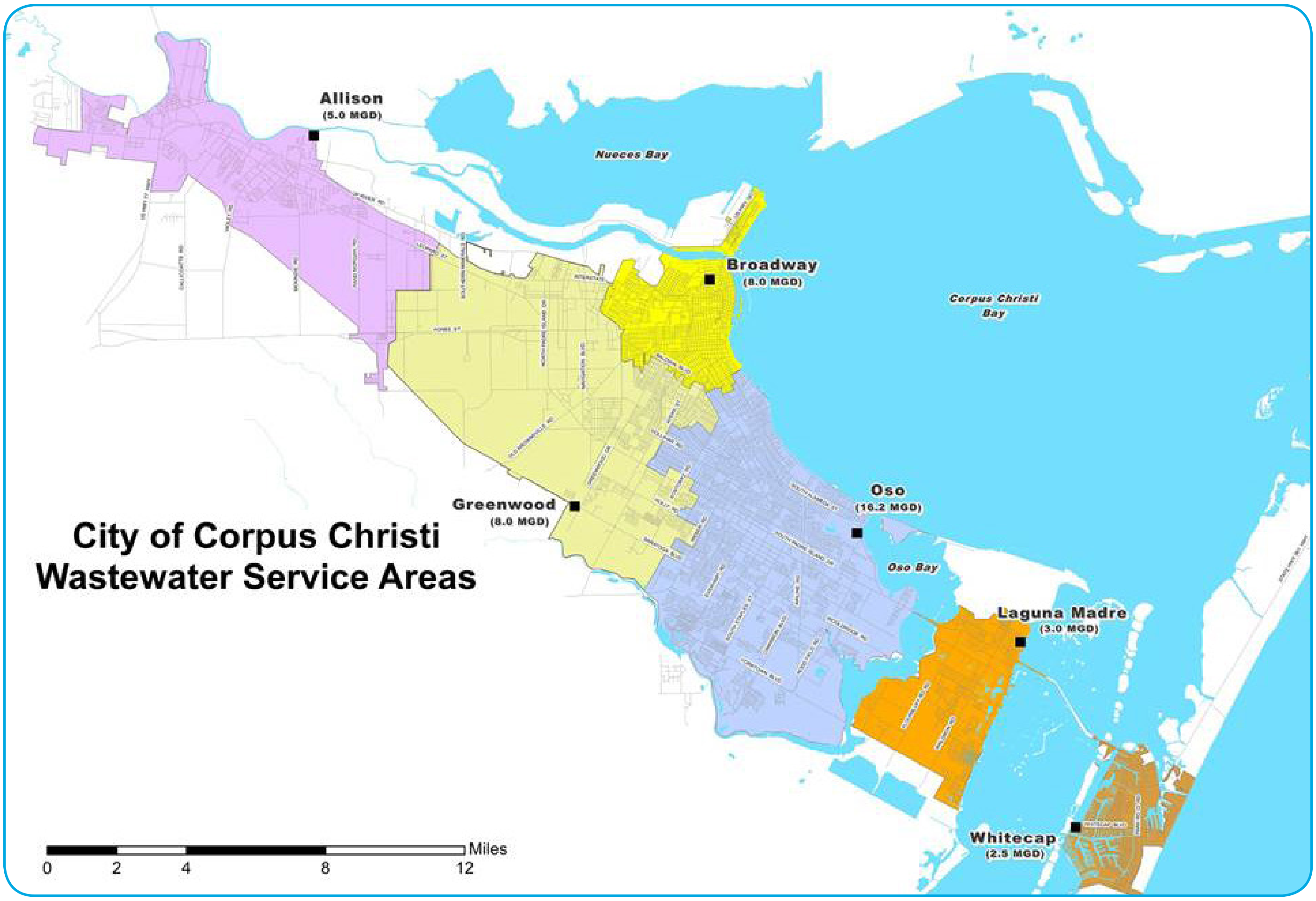
- Confirm what drives capital and operating and maintenance costs – Sustaining capital requirements needs were identified for each of the six (6) existing wastewater treatment plants (WWTPs). Those factors that will drive future capital expenditure were also identified. Current operating and maintenance (O&M) costs were benchmarked against other comparable facilities and opportunities to optimize existing costs were identified.
- Confirm anticipated costs and associated user rates for the status quo alternative – All of the options considered for this study were compared against the alternative of continuation of the existing six-plant system. The project team confirmed the city's current upgrading and expansion plans for the six existing plants. Operational improvements were also identified so that each option considered could be compared against the upgraded, expanded, and optimized six-plant system.
- Determine the best recapitalization and consolidation plan that balances cost and technical requirements – An extensive stakeholder engagement plan was conducted to assist in identifying non-financial factors important to the overall plan development. A pre-screening analysis that considered financial, social, environmental and technical factors was used to short-list the best options.
- Develop a plan that allows for adjustments to the overall implementation – It is critically important to develop a plan that is flexible enough to account for potential market, regulatory, and technology changes. The pre-screening analysis favored long term servicing options that support flexible implementation.
- Develop a CIP and list of contracting packages – Contracting packages that support a cost-effective solution and provide the best value to the City and rate payers were identified.
- Identify risk factors associated with implementation – Every project involves some degree of risk. The key project risks, probability of their occurrence, and consequences of a specific risk being realized were identified. A risk management plan was then developed to address identified risks.
- Identify the best project delivery approach and plan for each contracting package – The party best able to manage potential project risks was identified in consultation with the City, and the best project delivery approach for each contracting package was determined.
- Develop a cash flow plan and schedule – The results of the study were summarized into a cash flow plan and associated schedule.

1.1. Current Wastewater System Configurations and Operations

1.1.1 Existing System Configuration and Operations

The City of Corpus Christi presently owns and operates six (6) wastewater treatment facilities. Four of the plants (Allison WWTP, New Broadway WWTP, Oso WRP, and Greenwood WWTP) are located in the main part of the city, one (Laguna Madre WWTP) is located on and services the Flour Bluff area, and one (Whitecap WWTP) is located on Padre Island. The service area for each of the existing six plants is presented here in **Figure 1-1**.

Figure 1-1 Service Area Boundary of Six Existing Wastewater Treatment Plants



The plants vary in age from the original construction in the 1940s and 1950s to the recently constructed New Broadway WWTP.

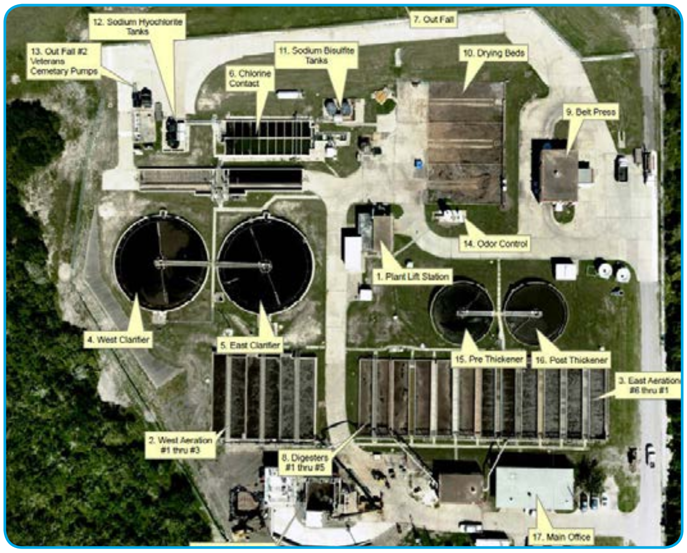
The wastewater collection system is extensive and consists of 1,243 miles of sanitary sewer, 100 pumping stations, and 100 miles of force main.

A brief description of each of the six wastewater treatment plants is provide in the text that follows.

1.1.1.1 Allison WWTP

The Allison WWTP is a 5 million gallon per day (MGD) activated sludge facility that is currently being operated in "contact stabilization" mode. Originally constructed in 1966 as a 2 MGD facility, the Allison WWTP was expanded in 1984 to its current capacity and modified to allow for wastewater treatment to be accomplished in either the "contact stabilization" or "complete mix" mode. An annotated aerial photograph of the existing Allison WWTP is shown in **Figure 1-2**.

Figure 1-2 Aerial Photo of Existing Allison WWTP



The liquid treatment unit processes of the Allison WWTP include screening, grit removal, complete mix activated sludge process, secondary clarification, filtration, disinfection, sludge stabilization and sludge dewatering.

Raw wastewater enters the plant through a gravity collection system and the force main from the Sharpsburg Lift Station and is then pumped by the Plant Lift Station to the new Mechanical Bar Screen Facility where debris is screened from the flow. The wastewater continues by gravity to the adjacent Grit Removal Unit where grit is separated from the flow before it is split between the East and West Aeration Basins.

The activated sludge treatment process consists of nine aeration basins. The aeration basins are separated into the east and west plants. The east plant is from the original 1966 construction and consists of six aeration basins and the west plant was constructed in 1984 and consists of three aeration basins. There are four centrifugal blowers located in the Blower Building that are used to supply air to the east and west aeration basins, east aeration airlift, west aeration airlift, pre-thickener airlift pumps, and aerobic digesters 1 thru 4.

Mixed liquor from the Aeration Basins flow to the two Final Clarifiers where solids are allowed to settle out and the clear water (effluent) flows over the weirs to the Automatic Backwash Filter. Return Activated Sludge (RAS) pumps recirculate the solids to the head of the Aeration Basins to mix with the incoming raw wastewater.

The Automatic Backwash Filters provide additional solids removal from the effluent before it is dosed with liquid Sodium Hypochlorite for disinfection in the Chlorine Contact Chamber. At the end of this chamber the effluent is dosed with Sodium Bisulfite to remove the chlorine in the water.

Solids are removed from the system, concentrated in the thickeners and stabilized in the Aerobic Digesters prior to dewatering on the two belt presses in the Sludge Dewatering Building. The existing Sludge Drying Beds provide a location for dewatering other material collected at the plant. Dried solids are transported to the City's landfill for disposal.

Treated effluent from the Allison WWTP is permitted by the TCEQ to be discharged from two separate outfalls. Outfall 001 is the original discharge method through two parallel 24-inch diameter pipes leading from the plant site, north to the Nueces River. Treated effluent can also be pumped to Outfall 002, known as the Effluent Diversion Demonstration Project, located across the Nueces River from the plant. Discharge from Outfall 002 is into South Lake in the west end of Nueces Bay.

The existing effluent discharge permit for the Allison WWTP was issued January 12, 2015 and expires on May 1, 2018. The current permit limits are summarized here in **Table 1-1**.

Table 1-1 Permit Limits for Existing Allison WWTP

Effluent Characteristic	Daily Average
Outfall No. 001 – Nueces River Tidal	
Flow	5 MGD (peak 2-hour flow = 15 MGD)
BOD_5	20 mg/L (weekly – 30 mg/L, max – 45 mg/L)
Total Suspended Solids (TSS)	20 mg/L (weekly – 30 mg/L, max. – 45 mg/L)
Ammonia – Nitrogen	12 mg/L (weekly-18 mg/L, max. – 24 mg/L)
Enterococci	35 MPN/100 mL (max. – 104 MPN/100 mL)
Outfall No. 002 – Nueces to South Lake	
Flow	2 MGD (peak 2-hour flow = 4 MGD)
BOD_5	20 mg/L (weekly – 30 mg/L, max – 45 mg/L)
Total Suspended Solids (TSS)	20 mg/L (weekly – 30 mg/L, max. – 45 mg/L)
Ammonia – Nitrogen	4 mg/L (weekly- 6 mg/L, max. – 10 mg/L)
Enterococci	35 MPN/100 mL (max. – 104 MPN/100 mL)

1.1.1.2 Broadway WWTP

The Broadway WWTP is an 8 MGD activated sludge facility that was constructed between 2010 and 2013 to replace the original Broadway WWTP constructed in 1938 and subsequently upgraded in 1940, 1950, 1954, and 1980. An aerial photo of the existing Broadway WWTP is shown in **Figure 1-3**..

Figure 1-3 Aerial Photo of Existing Broadway WWTP

The new Broadway WWTP consists of influent pumping, screening, grit removal, three aeration basins, two secondary clarifiers, and UV disinfection. The new Broadway WWTP is the only existing facility that accepts hauled waste. The plant discharges treated effluent to the Corpus Christi inner harbor.

The existing effluent discharge permit for the new Broadway WWTP was issued December 10, 2013 and expired on June 1, 2016. The City is currently negotiating a permit renewal with TCEQ. The current permit limits are summarized here in **Table 1-2**. Note that the peak 2-hour capacity has been planned and permitted for 40 MGD but to date has only been built at 20 MGD.

Table 1-2 Permit Limits for New Broadway WWTP

Effluent Characteristic	Daily Average
Discharge – Corpus Christi Inner Harbor	
Flow	8 MGD (peak 2-hour flow = 40 MGD)
BOD_5	20 mg/L (weekly – 30 mg/L, max – 45 mg/L)
Total Suspended Solids (TSS)	20 mg/L (weekly – 30 mg/L, max. – 45 mg/L)
Total Copper	0.0241 mg/L (max. – 0.051 mg/L)
Enterococci	35 MPN/100 mL (max. – 104 MPN/100 mL)

1.1.1.3 Greenwood WWTP

The Greenwood WWTP is an 8 MGD activated sludge facility that currently operates in the "complete mix" mode. Constructed in 1957, the Greenwood WWTP, was originally known as the Westside WWTP and operated as a trickling filter plant with anaerobic digestion. Since then the Greenwood WWTP underwent two major expansions. The first in 1990 increased the plant's capacity to 6 MGD and converted the contact stabilization. The second expansion occurred in 1998, which further increased the plant's capacity to 8 MGD and converted the wastewater treatment process from the "contact stabilization" mode to the "complete mix" mode. An annotated aerial photo of the existing Greenwood WWTP is shown in **Figure 1-4**.

Figure 1-4 Aerial Photo of Existing Greenwood WWTP

The liquid treatment unit processes of the Greenwood WWTP include screening, grit removal, complete mix activated sludge process, secondary clarification, disinfection, sludge stabilization and sludge dewatering.

All raw wastewater flow enters the plant through the gravity collection system and is then pumped by the Plant Lift Station to the Influent Structure where debris is removed by the mechanical bar screens and grit is separated in the grit chambers. A Parshall flume and flow meter measure and record the influent flow stream. Splitter Box No. 1 on the end of this structure divides the flow to the four Primary Clarifiers.

A portion of the solids settle out in the primary clarifiers and they are pumped to the thickener. The remaining raw wastewater overflows the clarifier weirs and continues on to Splitter Box No. 2.

Splitter Box No. 2 is used to mix the raw wastewater from the Primary Clarifiers with the Return Activated Sludge (RAS) from the Final Clarifiers and then divides it to each end of the Aeration Basins. The activated sludge treatment process consists of five aeration basins. There are four centrifugal blowers located in the Blower Building that are used to supply air to the Aeration Basins and various airlift pumps and aerated structures.

Mixed liquor from the Aeration Basins flow to the two Final Clarifiers where solids are allowed to settle out and the clear water (effluent) flows over the weirs to the Effluent Screening Facility. RAS pumps recirculate the solids to Splitter Box No. 2 to mix with the raw wastewater. A portion of the settled solids is removed as Waste Activated Sludge (WAS) and is pumped to the thickener.

The Effluent Screening Facility removes any remaining larger solids from the effluent before it travels through the Ultraviolet (UV) Disinfection Unit. The effluent is dosed with ultraviolet light in the UV Disinfection Unit to kill pathogens and provide disinfection of the effluent prior to discharge.

A Parshall flume and flow meter measure and record the effluent prior to discharge at the Effluent Structure. This structure also contains the non-potable water pumps that pump the treated effluent into the plant non-potable water distribution system for use around the plant site.

An Effluent Pump Station is located adjacent to the Effluent Structure and pumps water for off-site effluent reuse.

Primary solids from the four primary clarifiers, as well as Waste Activated Sludge (WAS) from the secondary clarifiers are pumped to the Dissolved Air Floatation (DAF) Thickener for additional thickening. The supernatant from the DAF is either transported back to the lift station at the headworks of the plant or is re-circulated through the DAF following air-injection. From the DAF, the sludge goes through the Digester Pump Building and is pumped into one of two primary anaerobic digesters: Primary Digester No. 2 and Primary Digester No. 3, which are filled alternately. The sludge in the primary digesters is recirculated through the sludge heaters in the Digester Pump Building. These heaters are operated as necessary (mostly in the winter months when the ambient temperatures are low) to maintain optimal temperatures for anaerobic digestion.

The sludge is then pumped through the Digester No. 1 Pump House into Primary Digester No. 1 where further anaerobic digestion occurs. Under designed operating conditions Primary Digester No. 1 is filled from the bottom and the sludge is mixed periodically through recirculation. The sludge then gravity feeds into the Secondary Digester for final digestion. In the Secondary Digester the sludge is also periodically recirculated while decanting supernatant from the sludge. This supernatant is transported back to the Influent Lift Station through a 10-inch drain line.

From the Secondary Digester, the sludge is pumped into the Sludge Dewatering Building and fed into one of the two belt filter presses. The filtrate from the belt filter presses is transported back to the Influent Lift Station through the same 10-inch drain line conveying the supernatant from the secondary digester. Even though the plant has the ability to utilize two belt filter presses, only one is used at a time because the 10-inch drain line tends to overflow. The dewatered solids from the belt filter presses are transferred to containers and transported off-site for disposal. The plant has sludge drying beds, but these are not routinely in use for dewatering sludge. The beds are occasionally used if the belt filter presses are down or if a greater volume of solids needs to be wasted from the plant.

Biogas is collected from all four digesters. The biogas from Primary Digester No. 2 and No. 3 is collected and is either re-injected into the respective digesters, transported to the Digester Pump Building to be combusted in the heaters, or is sent to the facility Waste Gas Burner (Flare). The heaters utilize the biogas and supplemental natural gas to heat the undigested sludge to improve the efficiency of the anaerobic digestion process. The biogas produced from Primary Digester No. 1 and the Secondary Digester is collected and flows to the Digester Pump Building to also be used by the sludge heaters. Excess biogas not utilized by the sludge heaters is combusted through the Waste Gas Burner (Flare).

The existing effluent discharge permit for the Greenwood WWTP was issued March 24, 2014 and expires on June 1, 2017. The current permit limits are summarized here in **Table 1-3**.

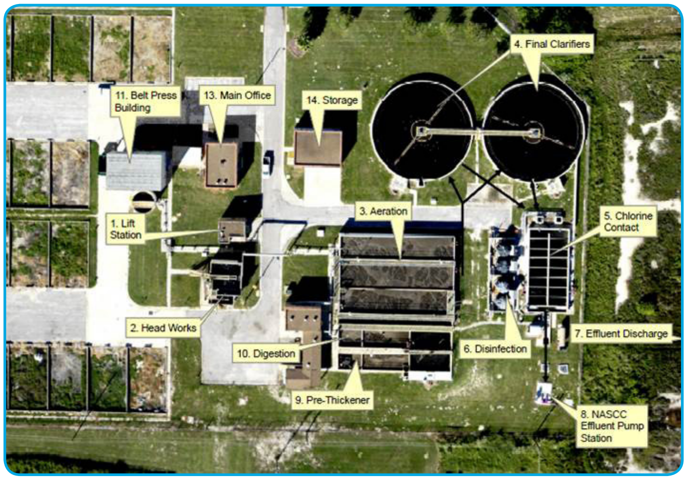
Table 1-3 Permit Limits for Greenwood WWTP

Effluent Characteristic	Daily Average
Discharge – La Volla Creek (thence to Oso Creek and thence to Oso Bay in Segment No. 2485)	
Flow	8 MGD (peak 2-hour flow = 24 MGD)
BOD_5	10 mg/L (weekly – 15 mg/L, max – 25 mg/L)
Total Suspended Solids (TSS)	15 mg/L (weekly – 25 mg/L, max. – 45 mg/L)
Total Copper	0.013 mg/L (max. – 0.027 mg/L)
Ammonia-Nitrogen	3 mg/L (weekly- 6 mg/L, max. – 10 mg/L)
Enterococci	35 MPN/100 mL (max. – 104 MPN/100 mL)
Dissolved Oxygen	4 mg/L minimum

1.1.1.4 Laguna Madre WWTP

The Laguna Madre Wastewater Treatment Plant is a 3.0 MGD activated sludge facility that is currently operated in the extended aeration mode. The plant was originally constructed in 1971 to serve the Flour Bluff area of Corpus Christi, and was expanded in 1986 to meet projected population demand. The Laguna Madre Plant has the ability to be operated in either extended aeration or contact stabilization mode. An annotated aerial photo of the existing Laguna Madre WWTP is presented here as **Figure 1-5**.

Figure 1-5 Aerial Photo of Existing Laguna Madre WWTP



The existing plant process consists of an influent lift station, headworks (including manual bar screen and grit removal facility), aeration basins, secondary clarifiers, return activated sludge (RAS) pumps, chlorine contact chamber, chlorination and dechlorination equipment, effluent pump station, sludge pre-thickener, aerobic sludge digestion, sludge holding tank, and belt filter press. The plant has sludge drying beds which are not used at the present time, but are used when the belt press is taken offline for maintenance.

Raw sewage flows into the influent lift station where the sewage is pumped to the headworks. Flow from the influent lift station is combined with raw sewage flows from the Jester Street lift station and the Laguna Shores lift station which enter the plant directly at the headworks. The combined flows pass through a manual bar screen into a grit chamber where grit and debris settle and are removed by air lift pump and grit screw conveyor. The wastewater then flows into the aeration basin where it is mixed with the RAS from both clarifiers. The mixed liquor then flows through a series of three aeration basins, where air is added to the mixed liquor using fine bubble diffusers. The aerated mixed liquor then flows over a straight weir, into a splitter box that splits the flow between the two clarifiers via two sluice gates. In the clarifiers, the mixed liquor is stilled to allow solids to settle. Solids are collected in the center cone and flows by gravity to the RAS station, where it is either sent back to the aeration chambers as RAS or it is wasted as sludge. The clarified effluent is collected through a system of overflow weirs and then flows, by gravity, to the chemical injection boxes where it is disinfected with a solution of sodium hypochlorite (hypochlorite). The effluent then flows by gravity into the chlorine contact chamber over an aeration weir and then through a v-notch weir where the chlorinated effluent is dechlorinated using a solution of sodium bisulfite. The flow rate of the dechlorinated effluent is measured by a Parshall flume. After passing through the Parshall flume, the effluent moves into a diversion box where the effluent can either be discharged by gravity to the primary outfall, (the Laguna Madre) or diverted to the effluent lift station where it is pumped off site for reuse.

The plant is set up in such a way that sludge may be wasted from the center aeration basin, the clarifiers, or both. Sludge and scum from the center aeration basin are gravity fed to the pre-thickener and then pumped into the aerobic digesters where air is added to the sludge using coarse bubble diffusers and then flows to the concentrator (sludge thickener). The RAS pumps transfer the sludge from the clarifiers to either the aeration basin (as return) or digesters (as waste). The wasted sludge from the concentrator is pumped to a small sludge holding tank, and then pumped to a larger sludge holding tank and finally dewatered using a belt filter press. While the plant has drying beds, they are currently not being used. If the sludge drying beds are needed the sludge would be pumped from the small sludge holding tank to the drying beds.

If the plant is operated in contact stabilization mode, wastewater from the headworks would be directed into the last aeration chamber and the return sludge from the clarifiers would be directed to the first aeration chamber. The return sludge would be aerated and stabilized before combining with the untreated wastewater in the last chamber. Once the mixed liquor passes over the straight weir into the splitter box, flow moves through the plant as described above.

Compressed air is supplied to the processes through a series of five (5) blowers. The three (3) newer blowers provide air to the grit chamber, the sludge holding tank near the belt filter press, and the aeration basin. The two (2) older blowers provide air to the sludge digesters.

The hypochlorite and the bisulfite are stored in above-ground tanks inside of a containment area. The plant is designed to use chemical feed pumps paced off the effluent flow meter to inject these solutions into the process.

The existing effluent discharge permit for the Laguna Madre WWTP was issued August 6, 2015 and expires on April 1, 2020. The current permit limits are summarized here in **Table 1-4**.

Table 1-4 Permit Limits for Laguna Madre WWTP

Effluent Characteristic	Daily Average
Discharge – Laguna Madre	
Flow	3 MGD (peak 2-hour flow = 9 MGD)
BOD_5	20 mg/L (weekly – 30 mg/L, max – 45 mg/L)
Total Suspended Solids (TSS)	20 mg/L (weekly – 30 mg/L, max. – 45 mg/L)
Enterococci	35 MPN/100 mL (max. – 104 MPN/100 mL)

1.1.1.5 Oso WRP

The Oso Water Reclamation Plant (WRP) has a capacity of 16.2 MGD making it the largest of the six wastewater treatment plants in the City of Corpus Christi. The plant serves approximately 50% of the City's population located on the City's south side . The original Oso WRP was constructed in 1941 and has undergone several expansion projects with the most recent upgrade taking place in 1982. The existing treatment plant is operated as a conventional activated sludge facility with aerobic digestion and without primary clarification. An annotated aerial photo of the existing Oso WRP is presented here as **Figure 1-6**.

Figure 1-6 Aerial Photo of Existing Oso WRP

The Oso WRP is configured as two parallel trains; each rated at 8.1 MGD average daily flow. Although the original contact stabilization configuration was recently modified and improved with the addition of breakpoint chlorination and step feed pumps, the process was not originally intended, nor is it operationally efficient at removing ammonia.

Influent is delivered to the Oso WRP by two in-plant lift stations and a remote lift station (Williams Lift Station), all of which discharge at the plant's headworks facility. The existing headworks includes two coarse bar screens (1-inch spacing), and an aerated grit tank which has been out of service for many years. The screenings drop to a conveyor where they discharge into a screenings box for disposal.

Screened influent is introduced into the aeration basins (contact basins) where it is "contacted" with a high concentration of activated sludge. The microorganisms rapidly absorb BOD, as they have been without an external carbon source while passing through the re-aeration basins (stabilization basins).

Flow from the aeration basins is directed to the rectangular secondary clarifiers, where activated sludge settles, separating it from the effluent. Activated sludge is then returned to the re-aeration basins, and the effluent proceeds to the chlorine contact basins for disinfection. The effluent from the two trains is fed to a common junction box where it is then dechlorinated and proceeds to the permitted outfall in Oso Bay.

Return activated sludge (RAS) is delivered to the re-aeration basins where oxygen from additional aeration promotes metabolism of absorbed BOD. Waste activated sludge (WAS) is pumped to the end of the first pass of the re-aeration basins and is delivered to the aerobic digesters (four in series). Digested sludge is piped from Digester 1 to the recently constructed belt press building. The sludge is mixed with polymer, pressed in one of four filter presses, and then stored in a container until it is trucked to landfill for disposal.

The existing effluent discharge permit for the Oso WRP was issued April 29, 2011 and expired on June 1, 2014. The City submitted a permit renewal and amendment application to TCEQ, on December 3, 2013. The permit application has been declared administratively complete and is currently under review. The current and proposed permit limits are summarized here in **Table 1-5**.

Table 1-5 Permit Limits for Oso WRP

Effluent Characteristic	Daily Average
Discharge – Oso Bay	
Flow	16.2 MGD (peak 2-hour flow = 98 MGD)
$CBOD_5$	20 mg/L (weekly – 30 mg/L, max – 45 mg/L)
Total Suspended Solids (TSS)	20 mg/L (weekly – 30 mg/L, max. – 45 mg/L)
Ammonia-Nitrogen	4 mg/L (weekly- 6 mg/L, max. – 10 mg/L)
Chlorine Residual	0.1 mg/L (maximum)
Minimum Dissolved Oxygen	5 mg/L
Enterococci	35 MPN/100 mL (max. – 89 MPN/100 mL)

1.1.1.6 Whitecap WWTP

The Whitecap WWTP is a 2.5 MGD activated sludge treatment plant that was constructed in 1974 and serves the Padre Island portion of the City of Corpus Christi. An annotated aerial photo of the existing Whitecap WWTP is presented here as **Figure 1-7**.

Figure 1-7 Aerial Photo of Existing Whitecap WWTP

Raw influent enters the plant at the Bar Screen Building/ Headworks. This structure houses one climber screen with approximately 3/4-inch bar spacing. Large solids are removed by the screen and carried to a small roll-off container by a belt conveyor. The screened wastewater flows to the Influent Lift Station which is configured as a wet-pit/dry-pit pump station. Screened influent is pumped to the Aeration Basin Distribution Structure equipped with gates and weirs to control flows to the Aeration Basins.

The mixed liquor, a combination of raw sewage and RAS, is then split between two Aeration Basins with fine-bubble, membrane diffusers. After aeration, the Secondary Distribution Structure directs flow to one or both Secondary Clarifiers. Clear water from Clarifiers 1 and 2 flows over v-notch weirs and is disinfected in the Ultraviolet (UV) Disinfection Basin. Treated effluent is discharged into a saltwater channel connecting Corpus Christi Bay and Baffin Bay on the west side of Padre Island. The non-potable and reuse water systems draw treated effluent from a box just upstream of the Parshall Flume.

Solids from the Clarifiers are removed by the RAS/WAS pumps in the RAS/WAS Pump Station. Return Activated Sludge (RAS) is directed to the Aeration Basin Distribution Structure and the Waste Activated Sludge (WAS) is pumped to the Aerobic Digesters. After digestion, solids are pumped into an effluent chamber and piped to the Solids Handling Building. WAS is pumped to the belt filter press, mixed with polymer, and pressed to a cake. The cake is disposed of by truck and landfilled. The plant also has the ability to utilize sludge drying beds for solids handling, as a contingency.

The existing effluent discharge permit for the Whitecap WWTP expires on July 1, 2017. The current permit limits are summarized here in **Table 1-6**.

Table 1-6 Permit Limits for Whitecap WWTP

Effluent Characteristic	Daily Average
Discharge – Laguna Madre in Segment No. 2491 of the Bays & Estuaries	
Flow	2.5 MGD (peak 2-hour flow = 7.5 MGD)
BOD_5	20 mg/L (weekly – 30 mg/L, max – 45 mg/L)
Total Suspended Solids (TSS)	20 mg/L (weekly – 30 mg/L, max. – 45 mg/L)
Minimum Dissolved Oxygen	4 mg/L
Enterococci	35 MPN/100 mL (max. – 104 MPN/100 mL)

1.1.2 Physical Condition Survey of Existing Plants and Major Pumping Stations

1.1.2.1 Physical Condition Survey Overview

The consulting team conducted a physical condition survey of the City's six wastewater treatment facilities and two large wastewater lift stations. The primary objective of the assessment was to confirm the physical condition of the primary assets and estimate the required sustaining capital requirements for each facility.

The Team had access to previous Assessment Reports, compiled by others, and the City of Corpus Christi Wastewater Capital Improvement Plan for 2015 to 2017. The Wastewater Department Business Plan and individual WWTP operating budgets, NPDES permits and Discharge Monitoring Reports (DMR) for 2014 and 2015 were also reviewed. In addition, the Team leveraged its knowledge of the facilities, local conditions and relationships with equipment suppliers to evaluate and price the suggested improvements.

As part of the assessment, an Opinion of Probable Cost (OPC) was developed for each process area in each facility based on the Teams assessment on when those systems would need to be upgraded over the next 15-years. These costs were derived from previous reports and the Teams understanding of the local market. Where it was determined that improvements were planned by the City, but not yet under construction, the costs were included in the OPC. **Where a construction contract had been issued by the City, the costs for the upgrades were not included in the physical condition survey cost summary.**

The Williams and Woolridge Lift Stations were also inspected as part of this effort. Both lift stations were constructed in 1981. The Woolridge Lift Station recently added a stand-alone wet weather bypass pump to alleviate wet weather backups into neighboring homes. The

Williams Lift Station has not had any major improvements since being constructed.

A review of the monthly National Pollution Discharge Elimination System (NPDES) Discharge Monitoring Report (DMR) for the years 2014 and 2015 indicated that the facilities have an excellent compliance record. The percent of compliance was calculated using the number of permitted parameters and the frequency of the required testing. Where continuous monitoring is required, it was not used in the calculation, but any exceedances were used. **Table 1-7** outlines the facilities compliance record.

Table 1-7 Monthly DMRs for 2014 and 2015

Facility	Compliance Record 2014			Compliance Record 2015		
	Percent Compliance	Excursions	Parameter(s)	Percent Compliance	Excursions	Parameter(s)
Allison WWTP	99.56%	9	Ammonia	99.90%	2	Ammonia, Enterococcus
Greenwood WWTP	99.84%	3	Enterococcus	99.64%	7	Enterococcus, Copper
Laguna Madre WWTP	100%	0		100.00%	0	
New Broadway WWTP	99.83%	4	Enterococcus	99.87%	3	Enterococcus, Max Flow
Oso WRP	99.96%	1	Enterococcus	100.00%	0	
Whitecap WWTP	99.88%	1	Enterococcus	99.76%	2	Enterococcus

It is a credit to the operating staff at each facility that they have been able to keep the facilities running and in compliance with its NPDES permit over 99% of the time.

1.1.2.2 Assessment Approach

The assessment was conducted using a multidisciplinary approach including process, process mechanical, structural, electrical, instrumentation and controls and HVAC mechanical perspectives. The following WWTP areas were included as part of the assessment and were tailored to meet the processes at each facility.

- Area 01: Site Development / SCADA
- Area 02: Influent Pump Station / Control Building
- Area 03: Grit Removal
- Area 04: Primary Treatment
- Area 05: Secondary Treatment
- Area 06: Effluent Filtration
- Area 07: Disinfection
- Area 08: Outfall
- Area 09: Thickening
- Area 10: Aerobic Digestion
- Area 11: Anaerobic Digestion
- Area 12: Biogas System
- Area 13: Flood Management

The goal of the condition assessment was to identify specific processes and equipment needed to maintain the facility to meet the current NPDES permit requirements and reduce operating costs over the next 15-years.

In preparation for the assessment, Stantec prepared a standardized Facility Assessment Form (FAF) for each facility and process area. Each FAF includes a general cover sheet, condition ratings and description, and individual discipline specific sections that detail the observations of the assessment Team for each process area. Condition ratings and subsequent descriptions are included in **Table 1-8**.

Table 1-8 Physical Condition Ratings and Descriptions

Condition Grade	Description
Very Good	Sound, modern structure or equipment, operable and well-maintained
Good	As "Very Good", but showing some minor signs of deterioration. Routine refurbishment and maintenance required.
Fair	Functionally sound, but appearance significantly affected by deterioration. Structure is marginal in its capacity to prevent leakage. Mechanical and electrical plant and components function adequately but with some reduced efficiency and minor problems.
Poor	Deterioration has significant effect on performance of asset due to leakage or other structural problems. Mechanical and electrical components function but require significant maintenance to remain operational.
Very Poor	Serious structural problems having detrimental effect on performance of the asset. Will require major overhaul/ replacement of the asset in the short term.

All facilities were inspected between January 20, 2016 and January 27, 2016. The purpose of this effort was to evaluate the facility, estimate the costs to upgrade the facility and to allocate those costs based on five year increments beginning in the current year and ending at year fifteen. The following is a summary of the findings. Additional studies that are recommended are also included.

All WWTPs, except New Broadway, Whitecap and Laguna Madre, currently use coarse bubble diffusers in the aeration system. Due to the inherent lower energy efficiency of this technology and the increased operating costs, this technology is proposed to be replaced at each facility. A summary of the assessment results for each facility is presented in the text that follows. Detailed inspection information may be found in the detailed physical condition survey report provided as a stand-alone document.

1.1.2.3 Allison WWTP

The facility was rated as "Poor" overall. The impact of age, the wastewater and local environment, combined with the lack of capital improvements, has taken its toll on the facility.

The most recent capital improvements corrected major deficiencies in the headworks, but did not make modifications to other portions of the process.

The facility continues to be operated using outdated technology which hinders management's ability to implement efficiencies and cost savings in the operations.

1.1.2.4 Greenwood WWTP

The facility is rated as "Poor". The impact of age, the wastewater and local environment, combined with the lack of capital improvements, has taken its toll on the facility.

The facility continues to be operated using outdated technology which hinders management's ability to bring out efficiencies and cost savings in the operations.

The NPDES permit requires the initiation of an "engineering and financial plan" when the plant flows reach 75% of the design capacity. The 2015 flows indicate that this milestone has been achieved.

An evaluation of the current UV disinfection system is proposed.

The facility is subject to flooding. A study is proposed to review and suggest the implementation of a strategy to protect the facility from flooding.

1.1.2.5 Laguna Madre WWTP

The facility is rated as "Fair". This rating is primarily due to the on-going construction which will add state-of-the-art improvements to the headworks. The impact of age, the wastewater and the local environment, combined with the lack of capital improvements, has taken its toll on the remainder of the facility.

The current on-going capital improvements will correct several deficiencies, but will not correct them all. The facility continues to be operated using outdated technology which hinders management's ability to implement efficiencies and cost savings in the operations.

1.1.2.6 New Broadway WWTF

The facility should be rated as "Very Good" when complete. The facility was put into limited service in 2014.

The effluent filter was given a "Poor" rating. It is still operational, but in need of replacement or removal from service. There was one "Very Poor" rating given. A concrete construction joint in the aeration basins was actively leaking. There were also several poor ratings given for concrete expansion joint issues in the aeration basin area.

An evaluation of disinfection alternatives, including UV, Chlorine, and filtration is recommended. The UV system is currently being operated at full capacity, although the facility flows are 58% of design flow.

1.1.2.7 Oso WRP

The facility is rated as "Poor". The impact of age, the wastewater and local environment, combined with the lack of capital improvements, has taken its toll on the facility.

When a change in the NPDES permit required ammonia removal, temporary pumps were set up and a process modification from contact stabilization to conventional activated sludge was initiated. Along with breakpoint chlorination, the facility was in compliance with its NPDES permit 100% of the time. These interim pumping arrangements were still in operation during the inspection.

The facility continues to be operated using outdated technology which hinders management's ability to implement efficiencies and cost savings in the operations.

An evaluation of breakpoint chlorination and ammonia removal and the impacts for bacteria limits is proposed.

1.1.2.8 Whitecap WWTP

The facility is rated as "Poor". The impact of age, the wastewater and local environment, combined with the lack of capital improvements, has taken its toll on the facility.

There are several capital improvements proposed by others. These projects are focused and will correct several deficiencies, but will not correct them all. The facility continues to be operated using outdated technology which hinders management's ability to bring about efficiencies and cost savings in the operations.

1.1.2.9 Williams Lift Station

The facility is rated as "Fair". The impact of age, the wastewater and local environment, combined with the lack of capital improvements, has had an impact on the facility.

1.1.2.10 Woolridge Lift Station

The facility is rated as "Fair". The impact of age, the wastewater and local environment, combined with the lack of capital improvements, has had an impact on the facility.

1.1.2.11 Opinion of Probable Cost (OPC)

As part of the assessment, an Opinion of Probable Cost (OPC) was developed for required upgrades at each facility and each process area within the facility. The OPC is based on the Teams assessment on when those systems would need to be upgraded over the next 15-years. These costs were derived from previous reports and the Teams understanding of the local market.

Where it was determined that improvements were planned, but not yet under construction, the costs were included in the OPC. Where a construction contract had been issued by the City, the costs for the upgrades were not included in the summary.

Where further evaluations were required to better define a solution, an evaluation phase was added followed by an estimated cost. These evaluations are defined by year and are discussed in each facility cost breakdown by year in the Physical Condition Report.

Costs for all intervals are based on 2016 dollar terms and are not inflated. Costs for Engineering Services were assumed to be 15%, City Administrative Services 10%, and a Contingency was applied at 30%. The estimated costs for required upgrades, by facility, are summarized here as **Table 1-9**.

Table 1-9 Summary of Required Upgrade Costs by Facility

Facility/Years	0-5 Years	6-10 Years	11-15 Years	16-20 Years	Total
Allison WWTP	$13,207,000	$3,506,000	$2,467,000	$937,000	$20,117,000
Greenwood WWTP	$14,398,000	$31,011,000	$5,174,000	$10,395,000	$60,978,000
Laguna Madre WWTP	$6,581,000	$408,000	$428,000	$1,306,000	$8,723,000
New Broadway WWTP	$20,624,000	$3,319,000	$173,000	$702,000	$24,818,000
OsoWRP	$53,918,000	$3,431,000	$6,395,000	$17,679,000	$81,423,000
Whitecap WWTP	$18,730,000	$213,000	$1,837,000	$2,154,000	$22,934,000
Williams LS	$452,000		$1,250,000	$56,000	$1,758,000
Woolridge LS	$444,000		$1,250,000	$56,000	$1,750,000
Incremental Costs	$128,354,000	$41,888,000	$18,974,000	$33,285,000	$222,501,000

Detailed tables which outline the capital costs for the recommendations can be found in each of the facility sections of the physical condition report.

1.1.3 Existing Operations Assessment

1.1.3.1 Operations Assessment Overview

The consulting team performed a review of the current operation and maintenance (O&M) practices at the City's six wastewater treatment plants. This assessment did not include the City's lift stations or collection system. The collection system is being assessed by the City under a long term program as discussed in **Section 1.1.4**.

The primary objectives of the operations assessment included reviewing the existing operating and maintenance (O&M) budgets and practices at each of the six plants, benchmarking O&M costs against other similar sized operations in the country, and identifying potential O&M cost savings through operations improvement. In addition, the consulting team conducted a staffing level benchmarking effort at each plant.

1.1.3.2 O&M Cost Drivers

The major costs in providing wastewater treatment services can be broken down into 3 major measurable categories. These categories are: Personnel costs, Power costs, and Chemical costs. These benchmarks were selected because they are typically the largest budget line items and there is sufficient benchmarking data to compare the City's cost to others.

Personnel costs are typically the largest budgeted costs. These costs are driven by Federal, State, and local requirements. Local requirements include City Policy and Department practice. Examples of "Local Requirements" would include such things as the number of holidays per year, the accrual and taking of vacation and sick leave, general training requirements, and employee benefit packages. Examples of "Departmental Practice" would include, plant process staffing and employee callout for overtime. The operations assessment focused on "Departmental Practice".

Power costs are driven by any number of physical restraints. Facility condition and equipment, controls and operating practices were the focus of the operations assessment.

Chemical costs are driven by process requirements and controls available to maximize their effectiveness. Current equipment and operating practices were reviewed. In addition, the age of the equipment and the level of automation needed to control the equipment have a significant impact on the ability to reduce operating costs. In five of the six facilities, equipment and control upgrades have not kept up with current industry standards.

1.1.3.3 Benchmarking

The primary source for benchmarking the City's operation was the National Association of Clean Water Agencies (NACWA) "Opportunities & Challenges in Clean Water Utility Financing and Management – NACWA Financial Survey, July 2015" (NACWA Study). This report contains information reported from over one hundred utilities across the United States for 2013. Additional data from other sources was also used where additional comparisons provided clarity to the parameters measured and recommendations provided.

The comparison data from the City was the 2016 Wastewater Department Amended Budgets and the 2015 actual plant flows. Additionally, power usage for all facilities for the period October, 2014 through September, 2015 was also used.

1.1.3.4 Overall Comparisons

Personnel costs are the largest single treatment cost. These currently account for 23.1% ($4.18 M) of the total facility budgets. The NACWA Study compared the number of staff for treatment and biosolids operations per million gallons per day of wastewater treated. The overall staffing benchmarking is summarized here in **Table 1-10**.

Table 1-10 Overall Staffing Benchmarking

Data Source	Staffing/MG
NACWA Study	1.8
City	2.1 (2015 Flow)
City	1.9 (80% Design Flow)
City	1.45 (Design Flow)

This metric is influenced by the flow into the facilities and the level of automation. The NACWA Study does not differentiate based on the percent of design capacity. Typically staffing levels do not increase due to increased flow. Staffing of small facilities is typically higher on an MGD basis than larger facilities. The City compares favorably to the national average in the aggregate. Possible staffing adjustments are discussed in the text below as well as in the detailed assessment report enclosed in **Appendix A**.

Overall, the amount of day to day maintenance should increase. During the walk through, the condition of the systems indicated that the facilities would be served by an increase in the level of maintenance provided.

Power Costs are the second highest treatment cost. Power currently accounts for 21.3% ($3.682 M) of the total facilities budgets.

The NACWA Study compared the electrical costs per million gallons per day of wastewater treated. The benchmarking of power costs against the national averages is presented in **Table 1-11**.

Table 1-11 Overall Power Benchmarking ($/MG Treated)

Data Source	Electrical Cost ($)/MG Treated
NACWA Study	$202.74
City	$340.00

The City's costs appear to be 40.3% higher than the national average. This is influenced by the unit cost of electricity, the condition and number of facilities, types of aeration and pumping employed and the amount of automation at each facility.

An additional metric is the energy usage per million gallons per day treated (kWh/MGD). This metric provides a more realistic comparison since the unit cost of electricity is not considered. The energy usage per million gallons treated is presented here in **Table 1-12**.

Table 1-12 Overall Power Benchmarking (kWh/MG)

Data Source	Electrical Energy Usage (kWh/MG Treated)
NACWA Study	1,677
Wisconsin Best Practice (1 – 5 MGD)	1,650
Wisconsin Best practice (> 5 MGD)	1,760
City (1 – 5 MGD) (Allison, Laguna Madre, New Broadway, Whitecap)	3,160
City (> 5 MGD) (Greenwood, Oso)	3,234
City (Total)	3,227

These metrics indicate that the City's current average electrical usage is approximately 192% of benchmarked data.

There are numerous metrics available that compare power consumption, both overall and by process. The data varies based on the extent to which energy saving process changes have been implemented. The typical energy usage by process or activity is summarized here as **Table 1-13**.

Table 1-13 Typical Process Energy Usage in a Wastewater Treatment Facility

Process	Typical Energy Usage (% of Total)
Aeration	53% to 67%
Pumping	14% to 21%
Lighting	3% to 8%
Other Loads	4% to 30%

Aeration is the major source of power usage in the wastewater treatment plant. The efficiency of oxygen transfer to water, as well as the efficiency of pumping and controlling the air flow has significant energy impacts. The New Broadway WWTP is equipped with fine bubble diffusion, variable speed blowers, and DO monitoring and control. The Laguna Madre and Whtiecap WWTPs use fine bubble diffusers but no blower modulation or DO control. The remaining facilities have coarse bubble diffusion, no blower modulation and no DO monitoring or control.

Similarly, process pumping is the second major source for power usage. The New Broadway WWTP was installed with variable speed drives on most pumping applications. All other facilities have limited variable speed applications.

Variable speed drives allow for the pumping of process flows to meet the demand of the treatment system. It has been reported that a 20% reduction in speed would reduce power input by 50%. This savings would be realized where speed variation over a day would be significant enough to require a variable speed pumping application.

Motor replacement costs should be reviewed in the context of life cycle costs. Energy efficient motors, although having a higher first cost, have a lower life cycle cost when considering 96% of the life cycle cost are power costs.

Power costs for solids processing and disinfection are reported in the literature as 20% and 1%, respectively.

The results of the operations assessment suggest the City has the potential to reduce power costs by approximately $1.7 M annually. In addition, many electric utilities provide grants to assist wastewater utilities in the study and implementation of energy reduction efforts. These grants further reduce the implementation costs. An energy survey and power usage study should be conducted to better understand where these savings can be achieved and the cost of capital improvements necessary to obtain these savings.

Chemical Costs are the third highest treatment cost. These currently account for 12.9% ($2.342 M) of the total facility budgets.

The NACWA Study compared the Chemical costs per million gallons per day of wastewater treated. The overall chemical cost per million gallons treated is presented here in **Table 1-14**.

Table 1-14 Overall Chemical Cost Benchmark ($/MG Treated)

Data Source	Chemical Cost ($)/MG Treated
NACWA Study	$99.14
City	$216.00

Chemical costs are 218% higher than the national average.

The City uses chemicals in the treatment process for two primary purposes, disinfection to meet the enterococcus permit limit and for sludge conditioning as part of the belt filter press and centrifuge process.

There are various processes employed to meet the permitted bacteria limits. UV disinfection is employed at the Whitecap WWTP. Disinfection via chlorination/ dechlorination is employed at Allison WWTP, Oso WRP and Laguna Madre WWTP, and a combination of UV and chlorination / dechlorination is employed at Greenwood WWTP and New Broadway WWTP. Generally, where chlorination / dechlorination is used control systems should be inspected, repaired or replaced so that optimization efforts can be implemented to reduce chemical usage and associated costs.

An evaluation has been proposed to review the disinfection, and filtration issues at each facility.

1.1.3.5 Summary of Benchmarking Results by Facility

A summary of the benchmarking results by treatment facility is presented here as **Table 1-15**. The detailed assessments of each facility are presented in the assessment report enclosed in **Appendix A**.

Table 1-15 Summary of Benchmarking Results by Facility

Category	NACWA Benchmark	City Comparison	Notes
Allison WWTP			
Staffing	• 1.8/MG	• 2.9/MG • 1.6/MG (design flow)	• Condition of facility and lack of automation controls precludes staff reductions. • Once facility brought up to standard there are opportunities to reallocate staff (potential to go to 5-day work week and reduce staff by 2 FTEs).
Power	• $202.74/MG treated • 1,677 kW-hr/ MG treated	• $430/MG treated • 2,201 kW-hr/MG treated	• With upgrade of plant systems potential savings is $107,000/year.
Chemical	• $99.14/MGD	• $254/MGD	• Chemical costs approximately 218% higher than national average.
Greenwood WWTP			
Staffing	• 1.8/MG	• 1.6/MG (2015) • 1.2/MG (Design flow)	• There are no automated controls and all of the facilities are operated manually • Condition of the facility precludes recommendation for staffing reductions.
Power	• $202.74/MG treated • 1,677 kW-hr/ MG treated	• $294/MG treated • 2,823 kW-hr/MG treated	• With upgrade of plant systems potential savings is $259,000/year. • Further use of biogas could potentially increase the power savings.
Chemical	• $99.14/MGD	• $87/MGD	• Chemical costs are in line with expectations.
Laguna Madre WWTP			
Staffing	• 1.8/MG	• 4.0/MG (2015) • 2.7/MG (Design flow)	• Condition of the facility precludes recommendation for staffing reductions. • Consider going to a 5-day work week at this facility • SCADA upgrades could allow sharing of staff between Laguna Madre and Whitecap
Power	• $202.74/MG treated • 1,677 kW-hr/ MG treated	• $192/MG treated • 2,791 kW-hr/MG treated	• With upgrade of plant systems potential savings is $57,000/year.
Chemical	• $99.14/MGD	• $151/MGD	

Category	NACWA Benchmark	City Comparison	Notes
New Broadway WWTP			
Staffing	• 1.8/MG	• 2.4/MG (2015) • 1.4/MG (Design flow)	• Staffing levels compare favorably with bench mark levels.
Power	• $202.74/MG treated • 1,677 kW-hr/MG treated	• $355/MG treated • 3,224 kW-hr/MG treated	• Power consumption 195% of bench mark. • With optimization of plant systems potential savings is $307,000/year.
Chemical	• $99.14/MGD	• $114/MGD	
Oso WRP			
Staffing	• 1.8/MG	• 1.2/MG (2015) • 1.0/MG (Design flow)	• Staffing levels are below the national average • Consider going to an 8 hr/day 7-day work week. This change could allow the staff to be restructured allocating FTEs toward maintenance activities.
Power	• $202.74/MG treated • 1,677 kW-hr/MG treated	• $356/MG treated • 3,545 kW-hr/MG treated	• Power consumption 201% of bench mark. • With optimization of plant systems potential savings is $850,000/year.
Chemical	• $99.14/MGD	• $333/MGD	• Chemical costs are excessive. Alternatives to breakpoint chlorination need to be investigated.
Whitecap WWTP			
Staffing	• 1.8/MG	• 7.0/MG (2015) • 3.2/MG (Design flow)	• Staffing levels are above the national average • With a modern SCADA system it may be possible to reduce staffing by 2 FTEs.
Power	• $202.74/MG treated • 1,677 kW-hr/MG treated	• $391/MG treated • 4,423 kW-hr/MG treated	• Power consumption 268% of bench mark. • With optimization of plant systems potential savings is $61,000/year.
Chemical	• $99.14/MGD	• $12/MGD	• Chemical feed rates are below the national average.

The primary conclusions that can be drawn for each of the individual facilities can be summarized as follows:

Allison WWTP

- 8 operating staff (operates 7 days per week 8 hours per day – maximum staffing on any given day is 5).
- Belt press operation is 5 days per week
- Operational control of the existing secondary treatment process is limited.
- A review of the current solids retention time (SRT) control practices is recommended.
- The existing sodium hypochlorite system requires replacement or additional maintenance.
- Equipment issues with the thickeners and final clarifiers requires the plant staff to spend an inordinate amount of time dealing with floatables.
- The polymer batching system for the belt filter press needs to be repaired or replaced.
- The overall level of day to day maintenance needs to increase.

Greenwood WWTP

- 10 operating staff (operates 7 days per week 8 hours per day).
- Belt press operation is 5 to 6 days per week.
- Grit and screenings facility are in disrepair and are difficult to operate (rags are a problem throughout the facility).
- The primary clarifiers are in need of rehabilitation to improve reliability.
- The aeration basins use coarse bubble diffusers and there is no aeration control.
- SRT control methods at the facility should be reviewed and improved.
- The DAF unit is currently being used as a sludge holding tank. Primary sludge is pumped here and WAS is pumped directly to the anaerobic digesters (thickening of WAS would increase digester capacity). There are some efficiencies to be released by re-instating sludge thickening.

Laguna Madre WWTP

- 8 operating staff (operates 7 days per week 8 hours per day – maximum number of staff 5).
- Belt press operation is currently on an as needed basis.
- The condition of the existing aeration equipment makes it difficult for the staff to maintain operational control. Failed valves and poor handrail and walkways make it difficult to access and operate the basins.
- The aeration basins use fine bubble diffusers but there is no dissolved oxygen (DO) control or blower control. There are few variable speed drives used at the facility and those that exist, are run in manual.
- A review of current SRT control practices is recommended.
- Overall, the amount of day to day maintenance at the facility should increase.

New Broadway WWTP

- Currently, the facility has 11 employees. The facility is manned 8 hours per day, 7 days per week. The maximum staffing on any day is 5.
- The centrifuge is operated 5 days per week.
- The operations staff took over operation of the facility without the necessary vendor training and completion of the SCADA system, including some field sensors.
- Some of the instrumentation, meant to promote better operation and operational efficiency, is not in working order. This appears to be a result of outstanding deficiencies from the construction phase.
- New Broadway is the only facility to accept hauled waste. During our inspection, materials were dumped that may have caused the aeration DO levels to drop near zero.

Oso WRP

- The facility has 16 employees. The facility is manned 24 hours per day, 7 days per week.
- Skid mounted pumps have been added at various locations throughout the plant to replace failed equipment, add additional capacity, or make process modifications. The headworks are a temporary arrangement with inadequate ventilation which poses a safety hazard for plant staff.
- The grit and screenings facilities are generally ineffective in removing material from the influent.
- The aeration basins use coarse bubble diffusers and there is no DO control or blower control.
- The breakpoint chlorination is a very inefficient method of ammonia control and should be reviewed.
- Overall, the amount of day to day maintenance should increase.

Whitecap WWTP

- Currently, the facility has 8 employees. The facility is manned 8 hours per day, 7 days per week. The maximum staffing on any day is 5.
- The aeration basins use coarse bubble diffusers and there is no DO control or blower control. There are no variable speed drives used at the facility.
- The staff operates the blowers at 100%. This is being done to keep the MLSS and heavier materials, not removed in preceding processes in suspension. MLSS was also being carried above normal in the basins. This practice adds additional costs to the process.
- The staff cleans the UV system every day. This practice is labor intensive. The staff has found that the practice has decreased the likelihood of enterococcus limit failure.

1.1.4 Collection System Remediation

The City completed a city wide hydraulic assessment of the wastewater collection system in 2015 to assist in identifying collection system infrastructure requiring remediation. The analysis results are summarized in the report entitled: “Wastewater Collection System Modelling and Recommendations Final Report” dated April 2015. Sewer lines larger than 10-inches in diameter and smaller critical lines were modeled using field obtained survey data. All other lines were modelled assuming TCEQ minimum sewer slopes. The hydraulic assessment was based upon the 5-year 24-hour storm.

The hydraulic modeling identified potential capacity constraints and provided an estimate of the associated capital cost to eliminate these constraints through pipe replacement. The estimated pipe replacement cost was approximately $311 M based upon 2015 dollars. The report recommended that the identified capacity constraints undergo a remedial measures analysis that considers infiltration/inflow (I&I) reduction, monitoring, rehabilitation, maintenance, and flow diversion in addition to convey and treat. The City has embarked on a remedial measures analysis and implementation program to identify potential I&I reduction, rehabilitation, and maintenance needs. City staff believes the $311 M capital expenditure identified in the hydraulic analysis report is an upper bound on the remediation cost and has prepared a revised estimate for budgeting purposes.

In order to arrive at a realistic remediation budget the City used historical SSO records in conjunction with previous utility department experience. The City compared the sewer system map showing historical SSO locations against the identified potential hydraulic constraints identified in the modeling exercise. Areas where the model predicted a sewer overflow in the design storm and where previous SSOs have been observed (referred to as Type I priorities) were identified for further consideration. Areas where the modeling predicted an overflow but it was not clear if this was truly the result of a capacity constraint (referred to as Type II priorities) were also identified for further consideration. It was assumed that 95% and 75% of the Type I and Type II works would need to be completed based upon historical City experience. The resulting replacement cost for these projects is estimated at $195.5 M. In addition, the City has identified an overall budget of $148.1 M for capacity remediation that includes sewer rehabilitation (pipe lining and repair), ongoing sewer cleaning, and flow monitoring.

The cash flow model for all options considered for this plan development therefore includes the following collection system expenditures:

- Pipe Replacements – $195.5 M
- Capacity Remediation – $148.1 M
- Force mains – $14.3 M
- Lift stations – $8.6 M

The City has had a number of reported sanitary sewer overflows (SSOs) over the last several years and also experienced apparent effluent permit non-compliance events at a number of their treatment facilities. The City is currently negotiating a settlement under a proposed Consent Decree with the state and federal government regarding the City's wastewater collection system and its wastewater treatment plants. The enforcement negotiations began with the issuance of six federal administrative orders (one affiliated with each of the six WWTP discharge permits) in Fall 2011. The negotiations are currently still ongoing and based on having one overall Consent Decree, with both collection system remediation and remedial works at the plants incorporated into this proposed Consent Decree.

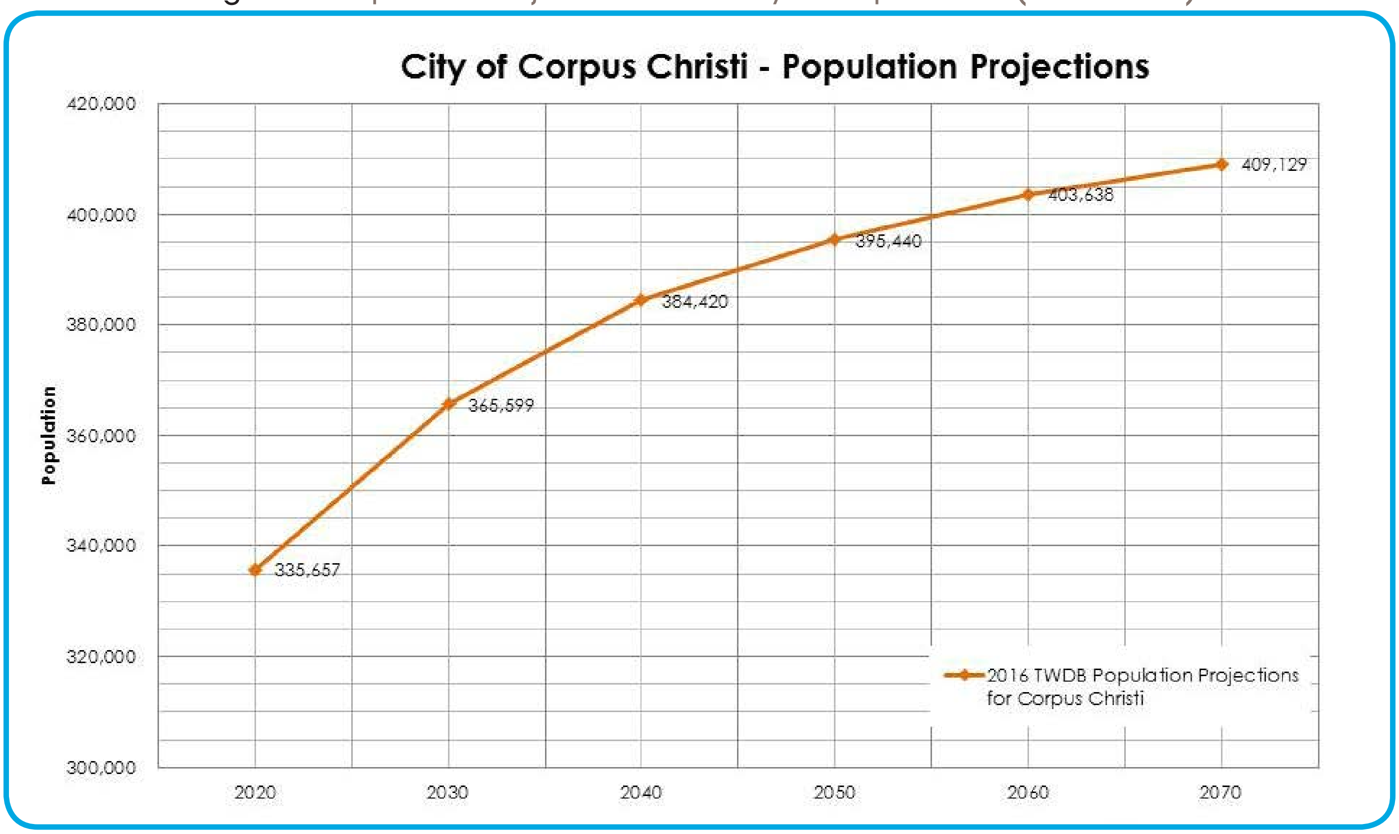
1.2. Future Requirements

The optimal long-range strategy for the wastewater collection and treatment systems must address future requirements including future growth and regulatory requirements. Anticipated development and future population and flow projections are presented in **Sections 1.2.1** and **1.2.2** respectively. Anticipated future regulatory requirements are summarized in **Section 1.2.3**. Future treatment requirements are presented here in **Section 1.2.4**.

1.2.1 Future Population Growth and Development Trends

The US Census 2014 population estimate for the City of Corpus Christi is 320,438. A commonly used organization for population projection is the Texas Water Development Board (TWDB). **Figure 1-8** below indicates the TWDB population forecast for the City of Corpus Christi every 10 years from 2020 to 2070. As shown in the figure, the population for the City is projected to grow to approximately 400,000 persons by around 2055.

Figure 1-8 Population Projections for the City of Corpus Christi (2020 to 2070)



In order to distribute the anticipated population increase by service area, it is necessary to establish where and when growth is anticipated to occur. The City provided mapping of the expected growth areas in the City for the next 10, 20 and 30 years. These GIS maps were then overlaid on the wastewater service areas and the growth per area established for each of these 10-year planning horizons. Details of the methodology are included in the Flow and Load Projection memorandum enclosed in **Appendix B** of this report.

The expected development area and relative percent growth for each of the six existing sewer service areas is presented here in **Table 1-16**. It should be noted that all the wastewater service areas have different growth rates. Some wastewater service areas are limited in the amount of area available to be developed where other wastewater service areas have a large amount of area that is available for development. For example, it is anticipated by the year 2036 the Broadway WWTP service area will have been fully developed and the service area will not contribute any significant growth for the remaining years. On the other hand the Oso WRP has a large service area and is expected to be continually developed farther into the future as the City continues to grow and expand into its Extraterritorial Jurisdiction (ETJ) area.

Strong growth is anticipated in the Greenwood area, particularly in the middle decade under review. Slow initial growth is expected in the Allison service area, picking up considerably during the final decade of the review. The Laguna Madre and Whitecap areas are both expected to see steady modest growth throughout the 30 years.

Table 1-16 Projected Growth by Existing Sewer Service Area

Facility	10 Years		20 Years		30 Years	
	Growth (Acres)	Percent Growth	Growth (Acres)	Percent Growth	Growth (Acres)	Percent Growth
Allison	569	7%	339	4%	2,594	31%
Broadway	98	1%	279	3%	-	0%
Greenwood	1,456	17%	4,399	51%	1,187	14%
Laguna Madre	848	10%	559	6%	1,257	15%
Oso	4,843	56%	2,474	29%	2,244	26%
Whitecap	777	9%	607	7%	1,205	14%
Total	**8,590**	**100%**	**8,656**	**100%**	**8,488**	**100%**

Using the percentage area growth by service area, a population growth estimate was developed for each service area in 5 year increments. The projected population by existing sewer service area is presented here in **Table 1-17**.

Table 1-17 Projected Population by Sewer Service Area

Facility	Year							
	2010	2015	2020	2025	2030	2035	2040	2045
Allison	29,926	30,826	31,726	32,312	32,898	35,774	38,650	40,334
Broadway	38,926	39,082	39,237	39,720	40,202	40,202	40,202	40,202
Greenwood	56,003	58,305	60,607	68,215	75,823	77,139	78,455	79,226
Laguna Madre	19,891	21,232	22,572	23,538	24,505	25,898	27,292	28,109
Oso	151,890	159,549	167,207	171,486	175,765	178,254	180,742	182,199
Whitecap	11,849	13,078	14,307	15,356	16,406	17,742	19,078	19,860
Total	**308,485**	**322,071**	**335,657**	**350,628**	**365,599**	**375,010**	**384,420**	**389,930**

1.2.2 Projected Flow and Load

The annual average flow projections for each facility were derived using the population projection described above and an estimate of the future per capita flow. In order to bracket the potential flow estimates, two levels of per capita flows were used. An upper bound flow estimate was developed based on the highest annual average per capita flow observed in each applicable service area. This HIGH estimate is shown in **Table 1-18** and results in a total annual average wastewater capacity requirement by 2045 of approximately 40 MGD.

Table 1-18 Flow Projection by Service Area (MGD) - High

Facility	Per capita flow (gpcd)	Estimated Flow by Year (MGD) 2015	2020	2025	2030	2035	2040	2045
Allison	100	3.1	3.2	3.2	3.3	3.6	3.9	4.0
Broadway	110	4.3	4.3	4.4	4.4	4.4	4.4	4.4
Greenwood	110	6.4	6.7	7.5	8.3	8.5	8.6	8.7
Laguna Madre	100	2.1	2.3	2.4	2.5	2.6	2.7	2.8
Oso	100	16.0	16.7	17.1	17.6	17.8	18.1	18.2
Whitecap	110	1.4	1.6	1.7	1.8	2.0	2.1	2.2
Total		**33.3**	**34.7**	**36.3**	**37.9**	**38.9**	**39.8**	**40.4**

A second, lower bound estimate was developed using the average per capita flow observed over the last three years. This LOW estimate is shown in **Table 1-19** and shows a total annual average wastewater capacity requirement by 2045 of approximately 34 MGD.

Table 1-19 Flow Projection by Service Area (MGD) - Low

Facility	Per capita flow (gpcd)	Estimated Flow by Year (MGD) 2015	2020	2025	2030	2035	2040	2045
Allison	90	2.8	2.9	2.9	3.0	3.2	3.5	3.6
Broadway	104	4.1	4.1	4.1	4.2	4.2	4.2	4.2
Greenwood	99	5.8	6.0	6.8	7.5	7.6	7.8	7.8
Laguna Madre	78	1.7	1.8	1.8	1.9	2.0	2.1	2.2
Oso	76	12.1	12.7	13.0	13.4	13.5	13.7	13.8
Whitecap	95	1.2	1.4	1.5	1.6	1.7	1.8	1.9
Total		**27.6**	**28.8**	**30.1**	**31.5**	**32.3**	**33.1**	**33.6**

It should be noted that these projections assume that growth density in each of the service areas will be of a similar mix of population per acre and that the flow per capita will remain in a similar range as the recent historical averages. These simplifications are considered appropriate for the purposes of this planning study, but a more rigorous estimate of flow projections would be needed before design of any new facilities.

Using the flow projections developed above, an assessment was made for each facility of the timing for necessary plant expansions. Currently the combined average annual wastewater flow to the six facilities is approximately 30 MGD and the current design capacity for the six WWTPs is 42.7 MGD. **Table 1-20**, shows the current (2015) flows as compared to the design capacity.

Table 1-20 Current Facility Capacities Now and in 2035

Facility	Existing Capacity (MGD)		Actual 2015 Flow		% of Capacity	
	ADF (MGD)	2-HR Peak (MGD)	ADF (MGD)	% of Capacity	Low Estimate	High Estimate
Allison	5.0	15.0	2.7	55%	64%	72%
Broadway	8.0	20.0	4.3	54%	52%	55%
Greenwood	8.0	24.0	6.3	79%	95%	106%
Laguna Madre	3.0	9.0	2.1	69%	67%	86%
Oso	16.2	98	13.3	82%	84%	110%
Whitecap	2.5	7.5	1.4	56%	67%	78%
Totals	**42.7**	**193.5**	**30.1**			

According to the Texas Administrative Code (TAC) 305.126(a) "whenever flow measurements for any sewage treatment plant facility in the state reaches 75 percent of the permitted average daily or annual average flow for three consecutive months, the permittee must initiate engineering and financial planning for expansion and/or upgrading of the wastewater treatment and/or collection facilities." Currently Greenwood WWTP and Oso WRP are beyond the 75 percent threshold and planning will have to take place to satisfy the TAC 305.126(a) ruling. The anticipated priority for facility expansion based solely on current flow projections is therefore: Oso, Greenwood, Laguna Madre, Whitecap, and Allison. On completion, we are not anticipating Broadway will require expansion within the next 20 to 30 years.

1.2.3 Future Regulatory Requirements

The existing treatment facilities will be required to meet future regulatory requirements in addition to accommodating flow and load increases associated with development. We are anticipating future effluent nutrient limits i.e for total nitrogen (TN) and total phosphorus (TP), as the most pressing and likely change to existing effluent requirements. These future limits are expected to eventually impact a wastewater effluent discharge into all of the existing or potential receivers including: Oso Creek, Oso Bay, Laguna Madre, Nueces River, Nueces Bay, Corpus Christi Bay, as well as the Ship Channel.

Currently, the Texas Commission on Environmental Quality (TCEQ) has issued permit limits for TN or TP for a small fraction of the Texas permittees. These limits are based on the protection of narrative water quality standards, not numeric standards. Texas Surface Water Quality Standards (TSWQS) regulate nutrients as follows:

"Nutrients from permitted discharges or other controllable sources must not cause excessive growth of aquatic vegetation that impairs an existing designated, presumed, or attainable use. Site-specific nutrient criteria, nutrient permit limitations, or separate rules to control nutrients in individual watersheds are established where appropriate after notice and opportunity for public participation and proper hearing. Site-specific numeric criteria related to chlorophyll a are listed in Appendix F of §307.10 of this title."

The TSWQS do not currently include numeric nutrient criteria for the receiving waters of the City's WWTPs. A change in water quality standards that includes numeric nutrient standards for the City's WWTP receiving waters would increase the likelihood that nutrient permit limits are incorporated in some or all of the existing WWTPs permits and any new WWTPs being considered in the alternatives. For the existing WWTPs, nutrient limits would require significant investment to modify or add treatment units to consistently remove nutrients from the wastewater. At this time TCEQ has not proposed additional numeric nutrient standards for the 2017 standards revision. In previous standards revision cycles, the Environmental Protection Agency (EPA) and the TCEQ have focused on numeric standards for chlorophyll-a in freshwater reservoirs. Today, some of the State's reservoirs have chlorophyll-a standards, but many still do not. Since these standards were adopted, both the EPA and TCEQ have stepped back from the focus on nutrients. At this time, the TCEQ is still working on its approaches to nutrient standards for reservoirs, rivers, and bays/estuaries. We believe that it will still be some time before the TCEQ or EPA will be able to effectively adopt nutrient standards in bays, estuaries, or tidal segments as are found in the Corpus Christi area.

Whether TCEQ would issue TN limits, TP limits or limits for both TN and TP for the City's WWTPs is unknown. However, such limits are anticipated to begin to appear in permits discharging to marine waters in the next 10 to 15 years. Nitrogen is usually considered the controlling nutrient in saltwater bodies, so nitrogen would likely be the initial focus of such limits. In addition, it might be expected that a moderate range of controls would be implemented initially, such as 8 milligrams per liter (mg/L) TN and 1 mg/L TP. Over subsequent permitting cycles and water quality standards revisions, such limits might be reduced in at least some of the larger discharges or for discharges to more sensitive water bodies. For Texas, a lower limit on TN of around 3 mg/L might be expected. Limits on TP might drop to around 0.3 mg/L, where deemed necessary to protect receiving water bodies.

A more extensive review of future potential regulatory requirements, biosolids management, and odor control management are enclosed here in **Appendix C, D, and E**.

1.2.4 Future Treatment Requirements

The most significant aspect of the treatment requirements evaluation is that all or most of the WWTPs will likely be subject to nutrient limits in the foreseeable future. We are anticipating that moderate nutrient limits would be implemented initially with limits becoming increasingly stringent with time. We would anticipate initial total nitrogen (TN) and total phosphorus (TP) limits of 8 mg/L and 1 mg/L respectively with limits eventually being lowered to limit of technology levels (TN < 3 mg/L and TP <0.3 mg/L). We are anticipating the most sensitive receivers, and the associated treatment facilities, will receive nutrient limits first including Oso Creek, Nueces Bay and estuary, and Oso Bay. This is expected to be followed by the Laguna Madre and Ship Channel over time.

Biosolids management at the six (6) city wastewater facilities consists of aerobic digestion, biosolids dewatering, and trucking to landfill disposal. We are anticipating the current practice will not change under the status quo. However, consolidation at a larger plant site or sites would allow an opportunity to implement anaerobic digestion and realize the associated energy recovery and lower operating costs. The anticipated biosolids treatment train at the consolidation sites would include sludge thickening, anaerobic digestion, centrifuge dewatering, and dewatered cake storage.

The overarching direction of the wastewater industry is towards increased levels of treatment and resource recovery. Newer plants are typically designed to maximize resource recovery through biogas production and installation of a combined heat and power (CHP) system. We are anticipating the pressure to maximize effluent reuse will continue and anticipate industrial reuse will eventually be implemented. Current EPA regulatory initiatives such as the implementation of effluent viral limits will require increased disinfection limits. The land area requirements for all new plant sites should therefore be sufficient to accommodate these future anticipated initiatives. The projected treatment requirements by plant site are summarized here in **Tables 2-21** through **2-23**.

Table 1-21 Anticipated Future Nutrient Removal Requirements

Plant Site	Anticipated Nutrient Requirements			
	0-5 year	5-10 year	10-20 year	20+ years
Allison (existing plant)	none	none	TN<8 mg/L, TP <1 mg/L	TN<3 mg/L, TP<0.3 mg/L
Allison (new consolidated plant site)	TN<8 mg/L, TP <1 mg/L	TN<8 mg/L, TP <1 mg/L	TN<8 mg/L, TP <1 mg/L	TN<3 mg/L, TP<0.3 mg/L
Broadway	none	none	none	none
Greenwood	TN<8 mg/L, TP <1 mg/L	TN<8 mg/L, TP <1 mg/L	TN<8 mg/L, TP <1 mg/L	TN<3 mg/L, TP<0.3 mg/L
Oso	TN<8 mg/L, TP<1 mg/L	TN<8 mg/L, TP <1 mg/L	TN<8 mg/L, TP <1 mg/L	TN<3 mg/L, TP<0.3 mg/L
Laguna Madre (existing plant)	none	none	none	none
Laguna Madre (new consolidated plant site)	TN<8 mg/L, TP <1 mg/L	TN<8 mg/L, TP <1 mg/L	TN<8 mg/L, TP <1 mg/L	TN<3 mg/L, TP<0.3 mg/L
Whitecap	none	none	none	none
Southwest Site	TN<8 mg/L, TP <1 mg/L	TN<8 mg/L, TP <1 mg/L	TN<8 mg/L, TP <1 mg/L	TN<3 mg/L, TP<0.3 mg/L
Southeast Site	TN<8 mg/L, TP <1 mg/L	TN<8 mg/L, TP <1 mg/L	TN<8 mg/L, TP <1 mg/L	TN<3 mg/L, TP<0.3 mg/L
North Site	TN<8 mg/L, TP <1 mg/L	TN<8 mg/L, TP <1 mg/L	TN<8 mg/L, TP <1 mg/L	TN<3 mg/L, TP<0.3 mg/L

Total nitrogen and phosphorus limits of 8 mg/L and 1 mg/L respectively can be met via a number of conventional biological nutrient removal (BNR) technologies including the Modified Ludzack-Ettinger (MLE) process with chemical phosphorus removal, 3-stage Bardenpho, 5-Stage Bardenpho, and Modified Johannesbourg (MJB) processes to name but a few. We are assuming the City would install a 3-stage Bardenpho or MJB process at those plants needing to meet these limits for the purposes of this report.

The lower effluent limits of < 3 mg/L and <0.3 mg/L nitrogen and phosphorus respectively would require exogenous carbon addition and effluent filtration. We are assuming the required process would include post denitrification filters with methanol addition.

Table 1-22 Anticipated Biosolids Management Approach

Plant Site	Anticipated Biosolids Management Approach			
	Sludge Thickening	Digestion	Sludge Dewatering	Energy Recovery
Allison (existing plant)	Gravity thickener	Aerobic	Belt Press	None
Allison (new consolidated plant site)	Rotary Drum Thickener	Anaerobic	Centrifuge	Yes (CHP)
New Broadway	Gravity Thickener	Aerobic	Centrifuge	None
Greenwood	Rotary Drum Thickener	Anaerobic	Centrifuge	Yes (CHP)
Oso (upgraded and expanded)	Gravity Thickener	Anaerobic	Belt Press	Yes (CHP)
Laguna Madre (existing plant)	None	Aerobic	Belt Press	No
Laguna Madre (new consolidated plant site)	Rotary Drum Thickener	Anaerobic	Centrifuge	Yes (CHP)
Whitecap	None	Aerobic	Belt Press	No
Southwest Site	Rotary Drum Thickener	Anaerobic	Centrifuge	Yes (CHP)
Southeast Site	Rotary Drum Thickener	Anaerobic	Centrifuge	Yes (CHP)
North Site	Rotary Drum Thickener	Anaerobic	Centrifuge	Yes (CHP)

The option for maintaining treatment at the existing sites requires flood proofing of the existing Greenwood WWTP site. A review of the associated costs suggests it is most appropriate to build a new flood proofed Greenwood WWTP on the Greenwood site adjacent the existing plant facility. As indicated above, all new plants would include anaerobic digestion facilities due to lower operating costs and associated benefit associated with energy recovery. Further, all new plant sites would include an allowance for resource recovery operations.

Table 1-23 Anticipated Resource Recovery Systems

Plant Site	Anticipated Resource Recovery			
	Effluent Reuse	Phosphorus Recovery	Energy Recovery	Potential Biosolids Amendment
Allison (existing plant)	none	none	none	none
Allison (new consolidated plant site)	Yes	Yes	Yes	Yes
Broadway	none	none	none	none
Greenwood	Yes	Yes	Yes	Yes
Oso	Yes (1)	none	none	none
Laguna Madre (existing plant)	none	none	none	none
Laguna Madre (new consolidated plant site)	Yes	Yes	Yes	Yes
Whitecap	none	none	none	none
Southwest Site	Yes	Yes	Yes	Yes
Southeast Site	Yes (1)	Yes	Yes	Yes
North Site	Yes	Yes	Yes	Yes

(1) – It is assumed effluent reuse will be limited from these sites and confined to non-industrial uses due to the significant distance from the respective site to existing heavy industry.

1.3. Stakeholders and Stakeholder Input

The consultant team and City staff conducted three open house events and several individual stakeholder meetings during the course of this study. The open houses were conducted in "drop-in" format in order to accommodate availability of the public. The three open houses were operated for approximately 5 to 6 hours from early afternoon to early evening. The purpose and objectives of these meetings are summarized here in **Table 1-24**.

Informational materials were presented on display boards at each open house. Comment sheets were provided at each meeting and the project team also set up a project specific web site www.ccwastewaterstudy.com that displayed project information. Stakeholders provided comments on the project at the meetings by submitting written comments directly to project staff and/or through the project web site at their leisure.

The project team prepared an initial stakeholders list at the start of the project which was updated throughout the project duration. The project team sent out targeted invites to project stakeholders in advance of each open house. Along with the targeted invites, the project team used several platforms to promote the public open house:

- Existing City social media sites
- E-newsletter – Utilized existing Plan CC 2035 address list (similar target audience)
- City public access Channel 19
- Digital advertising through Caller Times and Facebook
- City staff employee newsletter and notice to all department heads
- Promotional assistance by local community/civic organizations to increase reach to the public
- Flyers at City facilities such as libraries, senior centers and recreational centers

The media strategy for each event included the following elements:

- Media pitch in advance of each open house: Caller Times, KRIS-TV, KIII-TV, KZTV, KORO-TV Nueces County Record Star and the Corpus Christi Business News.
- Media advisory sent in advance of each open house: Announcing meeting prior to meeting date as invite to briefing.
- Media briefings were held one hour prior to each open house to allow media dedicated time with City staff and materials and interviews.

Table 1-24 Stakeholder Engagement Meetings

Meeting Number	Meeting Description	Date	Meeting Objective
1	Open House 1	March 24, 2016	• Make the stakeholders aware of the study and the study objectives. • Assist in identifying stakeholder groups and their respective comments and concerns. • Collect stakeholder input on the study objectives and approach.
2	Meeting with Chamber of Commerce	April 8, 2016	• Inform Chamber of Commerce members on purpose of study, proposed approach and schedule and update them on progress to date.
3	Open House 2	May 26, 2016	• Update stakeholders on progress made on the study. • Present options under consideration and receive stakeholder input on both the options and proposed assessment methodology.
4	Port Industries Meeting	June 23, 2016	• Update local industry on the project progress. • Discuss requirements for and industry interest in reuse water for industrial purposes.
5	Coastal Bend Bay & Estuaries Program	June 29, 2016	• Update program staff on project progress. • Review program staff's specific concerns associated with maintaining return flows to the Nueces Bay and delta and the potential impact industrial reuse may have on these flows.
6	Greenwood Community Meeting	July 7, 2016	• Update neighbors of the Greenwood WWTP site on the project progress. • Review alternative plans for the Greenwood site and receive comments on the project from local residents.
7	Flour Bluff Community Meeting	July 14, 2016	• Update neighbors of the Laguna Madre WWTP site on the project progress. • Review alternative plans for the Laguna Madre site and receive comments on the project from local residents.
8	Oso Community Meeting	July 20, 2016	• Update neighbors of the Oso WRP site on the project progress. • Review alternative plans for the Oso WRP site and receive comments on the project from local residents.
9	Open House 3	July 28, 2016	• Update stakeholders on options under consideration. • Present pre-screening and evaluation methodology for short listed options. • Present preliminary recommendation and associated rationale. • Provide an opportunity for stakeholders to comment on the recommended alternative and the project in general.
10	WEAT/ TAWWA Joint Meeting	August 4, 2016	• Present study purpose and objectives to local engineering community. • Present preliminary recommendation and associated rationale.

Copies of the handouts, questionnaires, and comments received from each of the open house and neighborhood meetings are provided on the project web site: www.ccwastewaterstudy.com.

The key concerns expressed by the public during the open houses and stakeholder engagement meetings included:

- Minimizing user rates.
- Addressing the flooding issues at the Greenwood WWTP and in the community adjacent the plant.
- Maintaining environmental base flows in specific receiving streams particularly the Nueces River and Bay and the Blind Oso.
- Addressing odor and nuisance issues associated with the Oso WRP.
- Providing a plan that addresses future growth south of Oso Creek.

Key stakeholder concerns and how these were accounted for in the servicing options development and selection are summarized in **Section 1.4.4**. The plan for stakeholder management for future phases of the project is addressed here in **Section 2.5**.

1.4. Summary of Existing Constraints

A number of constraints need to be considered when developing future potential servicing options and prior to selection of a preferred wastewater servicing plan. The consulting team conducted several background studies to identify constraints. These, along with stakeholder comments, served as critical input to developing the recommended servicing plan.

1.4.1 Pending Consent Decree

The City of Corpus Christi is currently in negotiations with the U.S. Department of Justice (DOJ) and the Environmental Protection Agency (EPA) regarding the city's wastewater system. The DOJ and EPA are alleging Corpus Christi violated the Clean Water Act (CWA) with sewer overflows, and a settlement is being negotiated for wastewater improvements.

1.4.2 Existing Treatment Plant Site Capacities

The project team considered a number of potential wastewater servicing options for the City. One of the objectives of the study was to identify and confirm the potential to service some or all of the existing wastewater treatment facilities at one or more sites. Consolidating treatment operations at fewer wastewater facilities is expected to reduce annual O&M costs. One of the first steps in this analysis involved looking at each of the existing sites to confirm current site constraints and available site capacity. The results of these analyses are presented here in **Table 1-25**.

Table 1-25 Site Capacity of Existing Wastewater Treatment Plants

Plant	Current Plant Capacity (MGD)	Estimated Capacity Requirement (MGD) - 2045	Estimated Site Capacity (MGD)	Summary of Site Constraints
Oso WRP	16.2	18.2	24	• None noted
Greenwood WWTP	8	8.7	24	• Existing plant located in the flood plain. • Sustaining capital spend over next 15 + years is approximately equal the cost of plant replacement.
Allison	5	4	73	• The City owns a considerable amount of land adjacent the site.
New Broadway	8	4.4	8	• None noted.
Laguna Madre	3	2.8	30	• The city owns a considerable amount of land adjacent the site. • A portion of the site is susceptible to flooding. The estimated site capacity accounts for the impact of the flood plain on site capacity.
Whitecap	2.5	2.2	5	• None noted.

1.4.3 Summary of Existing System Constraints

Several critical constraints need to be considered when developing the final wastewater servicing plan. The City has identified their key priorities as follows:

- Meet regulatory compliance at all times.
- Minimize user rates as much as practically possible.
- Minimize capital and operating and maintenance (O&M) costs.
- Provide drought resistant water to industry
- Meet needs for planned development

The key constraints to meeting these objectives and the way in which they were addressed in this study are summarized in **Table 1-26**.

Table 1-26 Summary of Key Constraints and Approach to Addressing These

Stakeholder Group	Issue/Constraint	Approach to Addressing Issue/Constraint
City/Public	Continued flooding at Greenwood WWTP	• Build a new 'flood proof' treatment facility on the Greenwood site or transfer Greenwood flows to a new plant. • Transfer some flows from the periphery of the Greenwood to the Broadway service area to reduce flows going to the Greenwood WWTP. • Conduct remedial works in La Volla Creek to reduce flooding potential in the Creek. • Reduce Inflow/Infiltration (I/I) to reduce peak flow into the collection system
City/Public	High sustaining capital spend required for existing plants.	• Prioritize capital projects at each plant and identify appropriate timing to spread out required cash flow. • Consolidate plants with high sustaining capital spend as quickly as possible.
City/Public	Minimize impact upon user rates	• Assume New Broadway WWTP will be in service beyond the 2045 time horizon and transfer additional flow to plant to maximize value from facility. • Assume Whitecap WWTP will stay in service for foreseeable future due to long simple payback period. • Identify operational savings associated with the operation of the existing wastewater treatment facilities reducing costs even under the status quo. • Evaluate several consolidation options and identify options that provide optimal balance between lower O&M cost savings and most attractive capital cost spend.
City	Uncertainty around future of Oso WRP effluent discharge.	• Identify and evaluate options that provide flexibility to consolidate Oso WRP now or at a later time.
City	Significant potential development south of Oso Creek.	• Plan all options so that developments south of Oso Creek can be accommodated in future as/if required.
City	Collection system rehabilitation and upgrades required to support Consent Decree.	• All options considered include upgrades and rehabilitation of collection system.
City/Public	Odor and other nuisance issues associated with Oso WRP.	• All future servicing options considered include upgrading Oso WRP to address nuisance concerns and/or decommissioning of the facility.

Stakeholder Group	Issue/Constraint	Approach to Addressing Issue/Constraint
City	Supply drought proof water supply for industry.	• Future servicing options considered included preliminary plans for providing reuse water to industry.
Public	Public does not want to pay for industrial reuse water out of residential sewer use rates.	• The capital and O&M costs of industrial reuse were not included in the CIP associated with wastewater user rates. • All industrial reuse capital and O&M costs will be paid solely by the benefitting industries.
Public	Members of the public concerned about the potential loss of aquatic habitat should the Oso WRP be taking out of service.	• City is considering construction of a small scalping plant at the Oso site to provide minimal flow to the blind Oso should the plant be taken out of service.

The City would like to provide a drought proof water supply for industry using treated wastewater effluent. The Port Industries group made it clear that they are interested in receiving treated effluent if it meets their process requirements and is provided at a cost equal to or less than potable water. Members of the public voiced concerns that user rates would be used to subsidize industrial reuse water. City staff instructed the consulting team to estimate the capital and O&M cost of additional treatment to support industrial reuse for each of the servicing options under consideration. The city will develop a unit cost of reuse water that includes capital recovery and present the cost to industry. Reuse facilities will be constructed once the appropriate long term contracts have been executed with industry. The consulting team assumed the City would provide a minimum of 10 MGD of industrial reuse water within the next 10-years using reverse osmosis treatment to reduce chloride levels.

1.5. Identification of the Preferred Wastewater Servicing Option

1.5.1 Introduction

The plant upgrading and consolidation options considered for this study are presented here in **Sections 1.5.2** and **1.5.3**. Capital and O&M cost assumptions, estimates, and sensitivity analyses are covered in **Section 1.5.4**. Prescreening criteria and the results of the options pre-screening are presented in **Section 1.5.5**. The recommended servicing option and alternatives for improving upon this option are presented here in **Section 1.5.6**.

1.5.2 Future Plant Siting Options

To evaluate the potential benefit for future wastewater servicing options, a City wide review was undertaken of the current and potential new sites for locating wastewater treatment facilities. In selecting suitable treatment sites the following issues were taken into consideration:

- Existing locations have advantages of existing capital investments; the precedent created by existing neighbors; and established connection to the existing wastewater collection network.
- New locations must have adequate open contiguous land areas that provide at least 50 to 80 acres of available land.
- Neighboring land uses can have a significant impact on the value of vacant land as well as the level of mitigation and buffers needed to avoid nuisance impacts on the public.
- Ideally, new sites would be located closer to projected growth areas to match future wastewater flows.

- New sites must either be near a potential discharge location or must have opportunity to connect to a suitable discharge point. The level of treatment required at a new plant will be materially impacted by the assimilative capacity of the receiving stream at the discharge location.
- Sites need to be free from significant servicing or environmental constraints such as flooding potential, wetlands, railway / highway corridors, and utility easements for gas pipelines or high voltage electrical lines.

An initial desk top survey was undertaken of the larger tracks of land surrounding the existing wastewater service areas. This looked at opportunities for new sites generally located to the north, west and south of the City's built up core. It should be noted that review of potential sites was based on identifying land areas that were under developed or vacant using current aerial mapping. No land ownership records were sourced, nor were any specific parcels identified at this stage of the plan development. Identification of specific land parcel(s) leading to future options or land procurement is not included in this scope and would be completed by the City once a preferred wastewater management plan is established.

Following the desk top screening, a physical street by street survey was undertaken to confirm likely candidate sites. From this field survey, the following three potential new plant sites were identified:

North Site

A new potential treatment plant site has been identified in the northwest quadrant of the City between the CC International Airport and the I-37 highway. This is a suitable area for a number of reasons:

- This site can readily be reached by future transfer of flows from Allison, Greenwood and Broadway service areas.
- A discharge to the Ship Channel is the most practical outlet for the wastewater effluent; however, an effluent discharge to Oso Creek and Nueces River and delta would also be feasible from this site. Treated reuse water could be provided from this location to neighboring industries.
- There are large open areas available generally between Agnes St (Rte 44) and Leopard St. For costing of conveyance options, a future plant site has been assumed to be located along Sedwick Rd.
- The existing land use in this area is mostly agricultural or industrial which is generally compatible with wastewater operations.

Southwest Site

A new potential treatment plant site has been identified in the southwest quadrant of the City south of Oso Creek in the vicinity of the Crosstown Expressway (Hwy 286) which is currently being extended southward by TxDOT. This is a suitable area for a number of reasons:

- This site can readily be accessed by future transfer of flows from Greenwood service area and the significant future development expected south of Oso Creek.
- A discharge to Oso Creek is the most practical outlet for the wastewater effluent.
- The existing land use in this area is mixed, with some institutional uses, some residential and the remainder currently agricultural.
- There are large open areas available and, for costing of conveyance options, a future plant site has been assumed to be located along Hwy 286 midway between Weber Rd and South Staples Rd.

Southeast Site

A new potential treatment plant site has been identified in the southeast quadrant of the City in the vicinity of Yorktown Blvd. to the north of Oso Creek. This is a suitable area for a number of reasons:

- This site can readily be accessed by future transfer of flows from the Greenwood, Oso and Laguna Madre service areas as well as the significant future development expected south of Oso Creek.
- A discharge to Oso Creek at the head of Oso Bay is the most practical outlet for the wastewater effluent.
- There is currently vacant land available, including a City owned parcel at Starry Lane south of Yorktown Blvd. For costing of conveyance options, a future plant site has been assumed to be located along Starry Lane.

These three sites, together with various combinations of the existing treatment plant sites were considered in developing the potential future wastewater servicing options discussed in the next section.

1.5.3 General Wastewater Servicing Options

Using the existing constraints as a guide, 10 wastewater servicing options were developed to address the following City priorities:

1. Meeting regulatory compliance
2. Minimize wastewater user rates
3. Reduce long term Operating and Maintenance (O&M) and capital costs
4. Provide for future drought resistant water to industry
5. Meet future needs for planned development

The servicing options were primarily aimed at establishing the best location, or combination of locations, for the future wastewater treatment plants. Collection system impacts within each of the service areas were not a primary determining factor since these would be required regardless of the consolidation options being considered.

The Broadway WWTP and Whitecap WWTP were considered to stay in operation for the foreseeable future for all of the options considered. However, servicing options that facilitate future consolidation of both Broadway and Whitecap were viewed more favorably in the options evaluation.

The city has recently completed construction of the Broadway WWTP. This new facility, once optimized, should provide cost effective treatment over the next 20 plus years. At this point we are assuming the City will continue to operate the Broadway facility for at least the next 20 years while they focus on other more pressing issues associated with the existing wastewater treatment plants.

The costs to consolidate the Whitecap WWTP is estimated at approximately $30 M. This cost includes a pumping station and pipeline to the Laguna Madre WWTP where it is assumed there would be a new plant to accept the flow or a pumping station to pump the Whitecap flow on to an upgraded and expanded Oso WRP. The estimated capital cost to pump the Whitecap flows to a new Southeast facility are also in the vicinity of $30 M. The maximum potential O&M saving associated with consolidating Whitecap flow at a larger regional facility would be approximately $500,000 per year. The minimum estimated simple payback period to recoup the consolidation costs would therefore be greater than 50 years. The city should reassess the feasibility of consolidation should conditions change.

Table 1-27 Wastewater Servicing Options

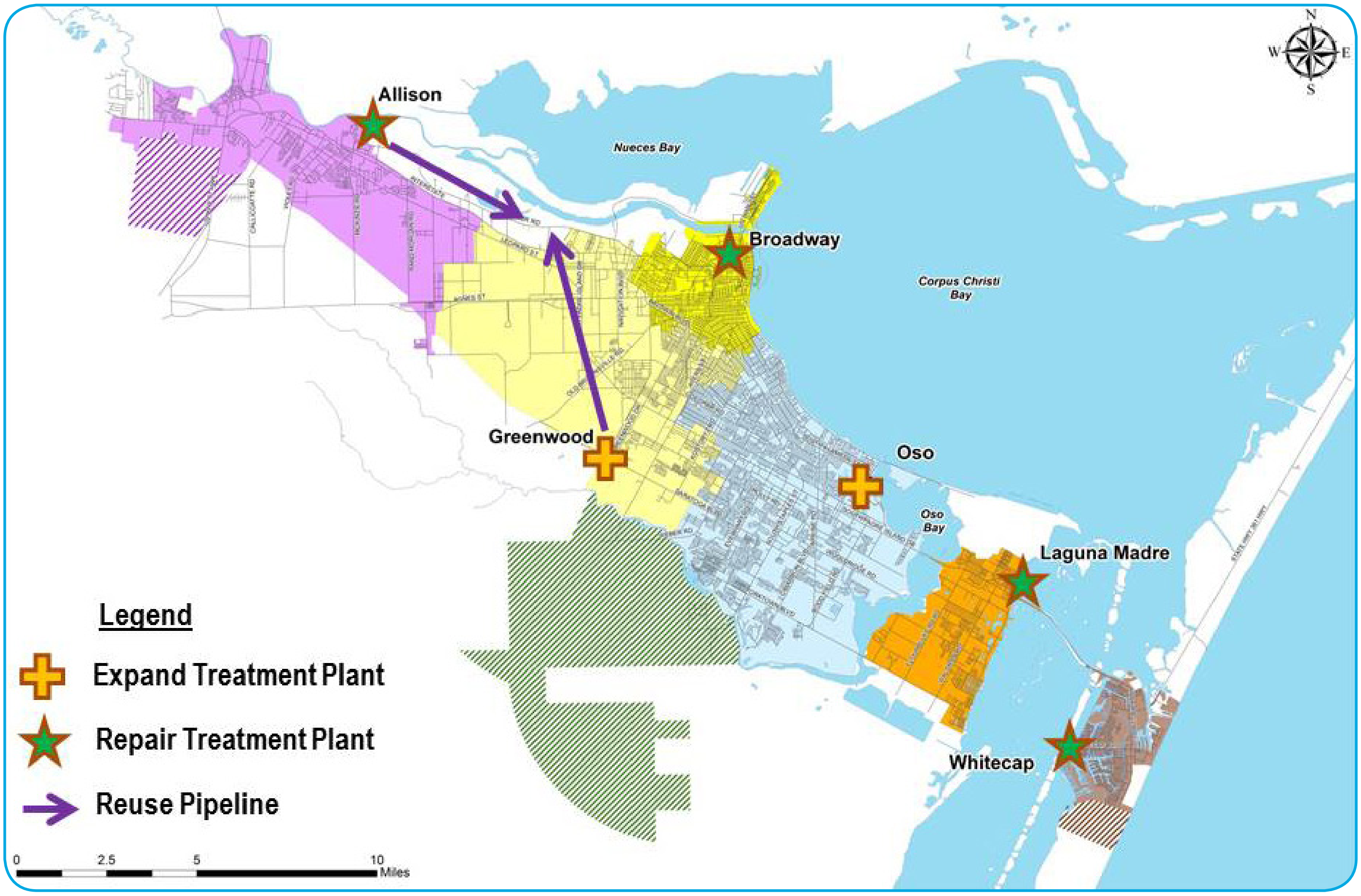
Category	Description	Options
1 – Maintain all Existing sites	• Keep six sites. Replace Greenwood on same site. Continue with current operations and planned maintenance.	• 1 - Maintain Existing Sites
2 - Consolidate at Existing Plant sites	• Keep Broadway & Whitecap. • Consolidate remainder at two of the existing plant sites.	• 2A - Allison + Laguna Madre • 2B - Allison + Oso
3 - Consolidate at New Plant site	• Keep Broadway & Whitecap. • Consolidate remainder at one new plant site.	• 3A - North site • 3B - Southwest site • 3C - Southeast site
4- Combination of New and Existing	• Keep Broadway & Whitecap. • Consolidate remainder at two sites with at least one new site plus an existing site.	• 4A - North + Laguna Madre • 4B - Southwest + Laguna Madre • 4C - North + Southeast • 4D - North + Oso

For each of the wastewater servicing options, required project elements were identified to enable meeting the primary servicing goals. The diagram of the major elements for each identified option plus the necessary capital project elements are summarized as follows.

1.5.3.1 Option 1 – Maintain All Existing Sites

Option 1 involves expansion and repair of the six (6) existing wastewater treatment facilities. The system configuration under Option 1 is presented here as **Figure 1-9**.

Figure 1-9 Option 1 System Configuration



The wastewater generation potential for planned developments south of Oso Creek is expected to be approximately 20 MGD. Therefore, we would anticipate that under Option 1 a seventh wastewater treatment plant may need to be constructed in future.

Two options were evaluated for the Greenwood WWTP including upgrading, flood proofing, and expanding the existing plant. The recommended option is construction of a new 10 MGD 'flood proof' WWTP on the existing plant site. The key infrastructure requirements under option 1 over the next 30-years are presented here as **Table 1-28**. Option 1 (maintain all existing sites) was the benchmark against which all other options have been evaluated.

Table 1-28 Summary of Infrastructure Requirements for Option 1

Plant	Infrastructure Requirements
Collection System	• Repair system in accordance with requirements to reduce overflows • Redirect some flow from Greenwood to Broadway sewer shed in the interim
Allison	• Repair over next 20 years • Upgrade to BNR in 10 years • Provide effluent reuse facilities for industry in next 10 years
Greenwood	• Repair during 0 to 5 year period • Build new 10 MGD 'flood proof' facility • Provide effluent reuse facilities for industry in next 10 years.
Broadway	• Repair over next 20 years
Oso	• Repair plant over next 20 years • Upgrade plant to BNR in next 5 years • Expand plant to 20 MGD in next 8 to 10 years.
Laguna Madre	• Repair over next 20 years
Whitecap	• Repair over next 20 years

The new 10 MGD Greenwood WWTP would include the unit processes summarized in **Table 1-29**.

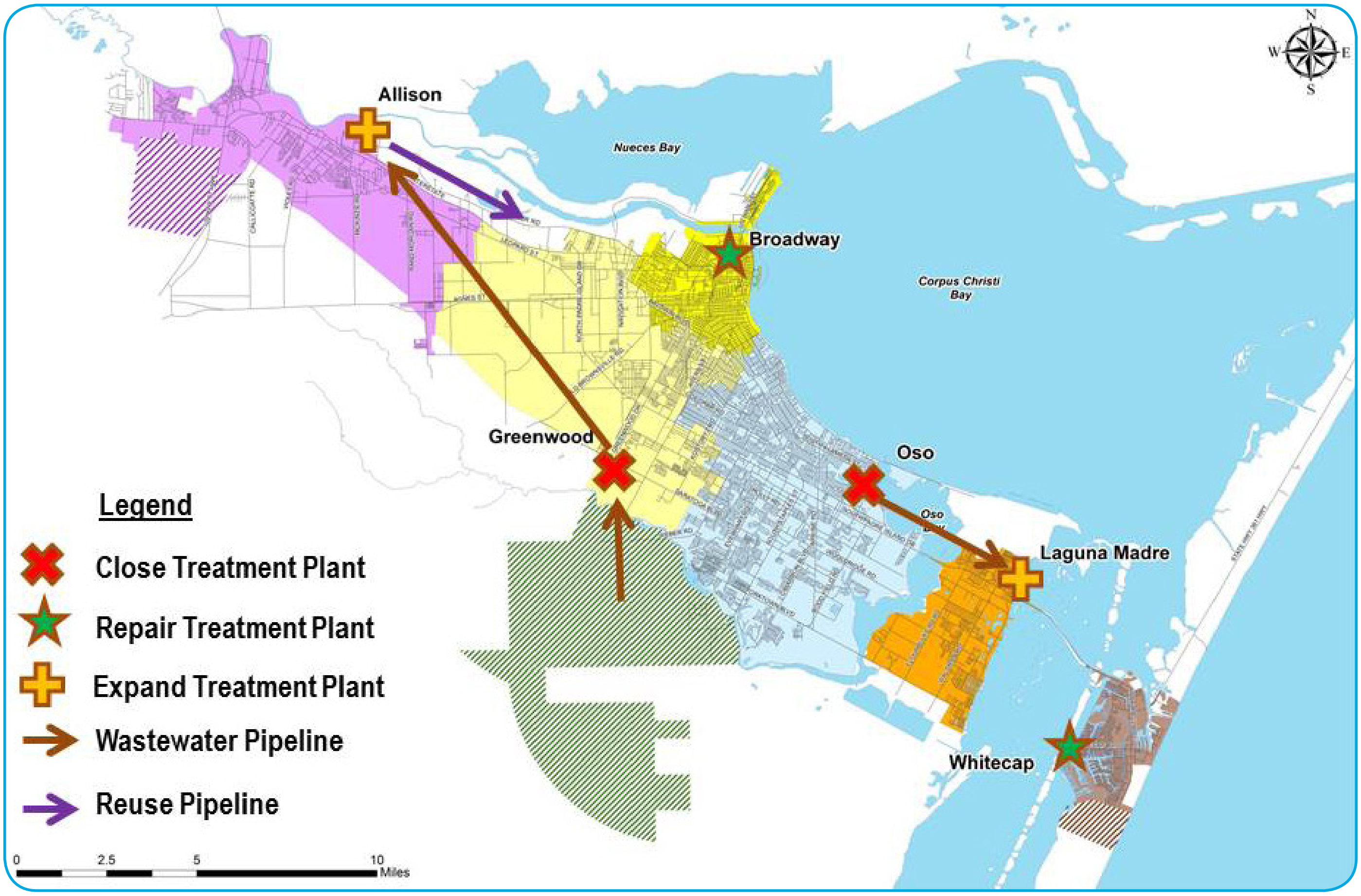
Table 1-29 Proposed Unit Operations for New 10 MGD Greenwood WWTP

Unit Process	Preliminary Assumption
Preliminary Treatment	• 2 mechanically cleaned screens with grinders/washers/compactors • 2 mechanical vortex grit removal systems
Primary Clarifiers	• 3 primary clarifiers
Secondary Treatment	• 3 BNR bioreactors (4 stage Bardenpho) • 3 Secondary clarifiers
Disinfection	• UV disinfection
Sludge Thickening	• 3 Rotary Drum thickeners
Digestion	• 2 Anaerobic Digesters
Sludge Dewatering	• 3 centrifuge units
Miscellaneous	• Headworks odor control (chemical) • Primary odor control • Cogeneration for energy recovery from biogas • Automation and instrumentation

1.5.3.2 Option 2A – Consolidation at Allison and Laguna Madre

Option 2A involves the consolidation of existing plant flows at the Allison and Laguna Madre WWTP sites. Oso and Greenwood would be taken out of service under this alternative and Broadway and Whitecap would stay in service for the foreseeable future although they could be consolidated at a later time. The system configuration under Option 2A is presented here as **Figure 1-10**.

Figure 1-10 Option 2A System Configuration



The key infrastructure requirements under Option 2A over the next 30-years are presented here as **Table 1-30**.

Table 1-30 Summary of Infrastructure Requirements under Option 2A

Plant	Infrastructure Requirements
Collection System	• Repair system in accordance with requirements to reduce overflows • Redirect some flow from Greenwood to Broadway sewer shed in the interim
Allison	• Construct a new 12 MGD facility at the Allison site in the next 5 years. • Provide effluent reuse facilities for industry in next 10 years
Greenwood	• Repair during 0 to 5 year period • Demolish the plant and decommission the existing site after the 5 year time period. • Build a new pumping station at the Greenwood site to transfer wastewater from Greenwood to Allison.
Broadway	• Repair over next 20 years
Oso	• Repair plant over next 10 years • Demolish the plant and decommission the existing site after the 10 year time period. • Build a new pumping station at the Oso plant to transfer wastewater from Oso to the new Laguna Madre facility.
Laguna Madre	• Repair the existing plant over the next 10 years • Build a new 20 MGD plant at the Laguna Madre site to take flows from Laguna Madre and Oso.
Whitecap	• Repair over next 20 years

The new 12 MGD Allison WWTP would include the unit processes summarized in **Table 1-31**.

Table 1-31 Proposed Unit Operations for New 12 MGD Allison WWTP

Unit Process	Preliminary Assumption
Preliminary Treatment	• 2 mechanically cleaned screens with grinders/washers/compactors • 2 mechanical vortex grit removal systems
Primary Clarifiers	• 3 primary clarifiers
Secondary Treatment	• 3 BNR bioreactors (4 stage Bardenpho) • 3 Secondary clarifiers
Disinfection	• UV disinfection
Sludge Thickening	• 3 Rotary Drum thickeners
Digestion	• 2 Anaerobic Digesters
Sludge Dewatering	• 3 centrifuge units
Miscellaneous	• Headworks odor control (chemical) • Primary odor control • Cogeneration for energy recovery from biogas • Automation and instrumentation

The new 20 MGD Laguna Madre WWTP would include the unit processes summarized in **Table 1-32**.

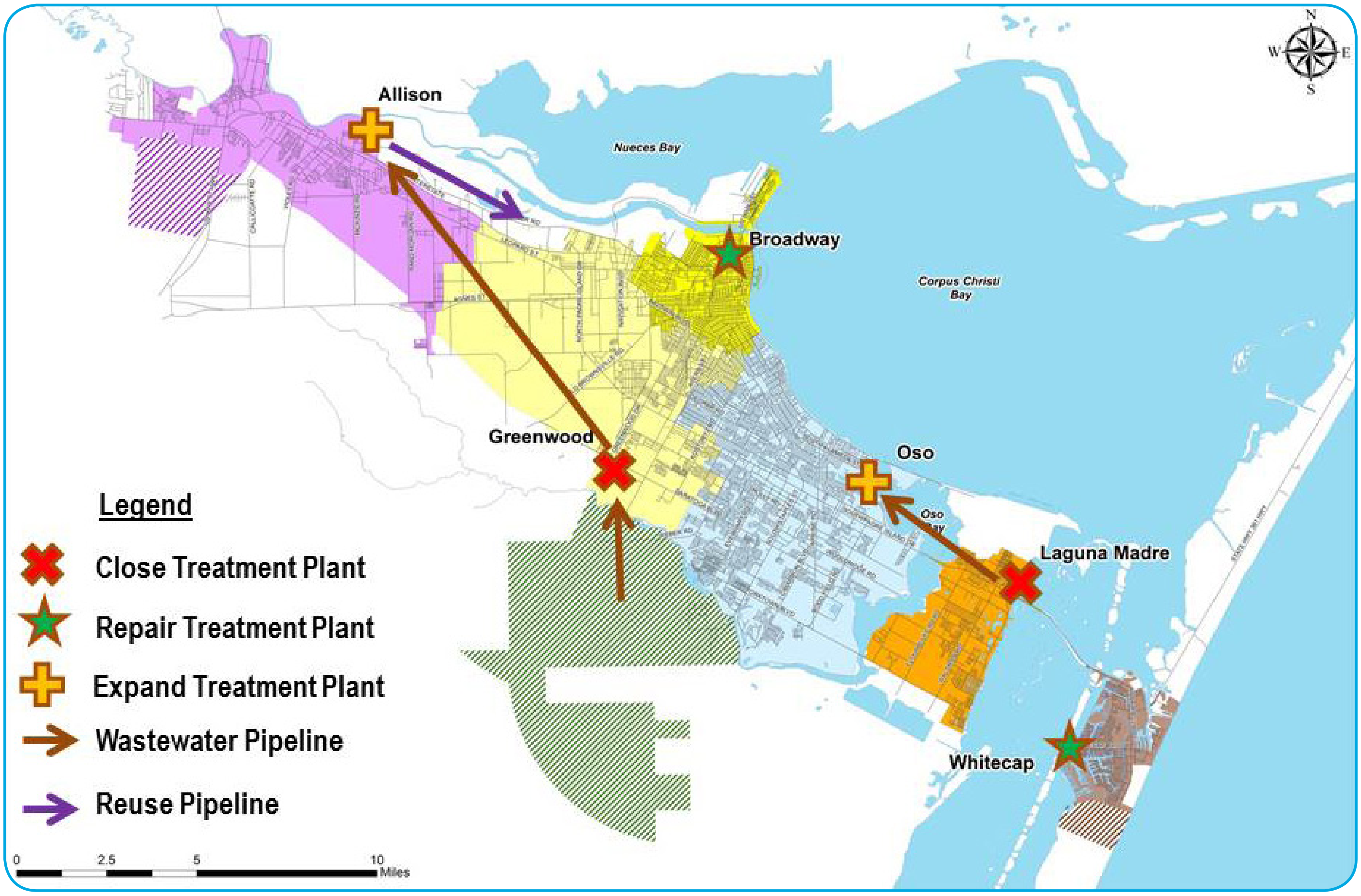
Table 1-32 Proposed Unit Operations for new 20 MGD Laguna Madre WWTP

Unit Process	Preliminary Assumption
Preliminary Treatment	• 4 mechanically cleaned screens with grinders/washers/compactors • 4 mechanical vortex grit removal systems
Primary Clarifiers	• 4 primary clarifiers
Secondary Treatment	• 4 BNR bioreactors (4 stage Bardenpho) • 4 Secondary clarifiers
Disinfection	• UV disinfection
Sludge Thickening	• 4 Rotary Drum thickeners
Digestion	• 4 Anaerobic Digesters
Sludge Dewatering	• 4 centrifuge units
Miscellaneous	• Headworks odor control (chemical) • Primary odor control • Cogeneration for energy recovery from biogas • Automation and instrumentation

1.5.3.3 Option 2B – Consolidation at Allison and Oso

Option 2B involves the consolidation of existing plant flows at the Allison and Oso sites. Laguna Madre and Greenwood would be taken out of service under this alternative and Broadway and Whitecap would stay in service for the foreseeable future although they could be consolidated at a later time. The system configuration under Option 2B over the next 30 years is presented here as **Figure 1-11**.

Figure 1-11 Option 2B System Configuration



The key infrastructure requirements under the Option 2B are presented here as **Table 1-33**.

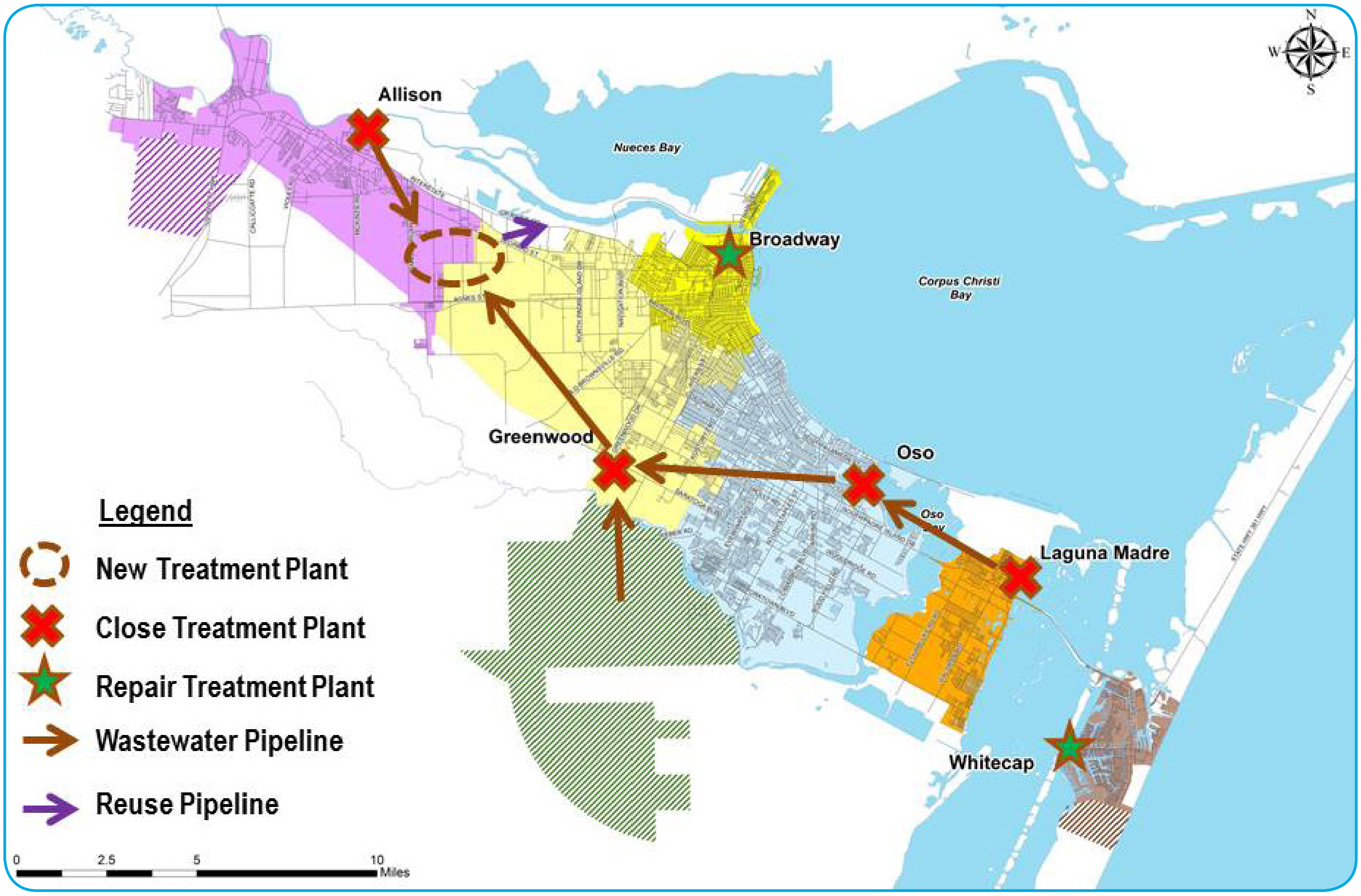
Table 1-33 Summary of Infrastructure Requirements under Option 2B

Plant	Infrastructure Requirements
Collection System	• Repair system in accordance with requirements to reduce overflows • Redirect some flow from Greenwood to Broadway sewer shed in the interim
Allison	• Construct a new 12 MGD facility at the Allison site in the next 5 years. • Provide effluent reuse facilities for industry in next 10 years
Greenwood	• Repair during 0 to 5 year period • Demolish the plant and decommission the existing site after the 5 year time period. • Build a new pumping station at the Greenwood site to transfer wastewater from Greenwood to Allison.
Broadway	• Repair over next 20 years
Oso	• Repair plant over next 20 years • Expand plant capacity to 20 MGD and upgrade to BNR.
Laguna Madre	• Repair the existing plant over the next 10 years • Build a new pumping station at the Laguna Madre site and transfer wastewater from Laguna Madre to the Oso site.
Whitecap	• Repair over next 20 years

1.5.3.4 Option 3A – Consolidate at a new North Plant Site

Option 3A involves the consolidation of existing plant flows at a new North treatment plant site. Allison, Oso, Laguna Madre and Greenwood would be taken out of service under this alternative and Broadway and Whitecap would stay in service for the foreseeable future although they could be consolidated at a later time. The system configuration under Option 3A is presented here as **Figure 1-12**.

Figure 1-12 Option 3A System Configuration



The key infrastructure requirements under the Option 3A over the next 30 years are presented here as **Table 1-34**.

Table 1-34 Summary of Infrastructure Requirements under Option 3A

Plant	Infrastructure Requirements
Collection System	• Repair system in accordance with requirements to reduce overflows • Redirect some flow from Greenwood to Broadway sewer shed in the interim
Allison	• Repair over next 15 years • Decommission the plant after 15-years and build new pumping station to direct flows to the new North treatment plant.
Greenwood	• Repair during 0 to 5 year period • Demolish the plant and decommission the existing site after the 5 year time period. • Build a new pumping station at the Greenwood site to transfer wastewater from Greenwood to the new North treatment plant site.
Broadway	• Repair over next 20 years
North Treatment Plant	• Build new 32 MGD North WWTP in the 0 to 5 year time period.
Oso	• Repair plant over next 10 years • Demolish the plant and decommission the existing site after the 0 to 10 year time period. • Build a new pumping station at the Oso plant to transfer wastewater from Oso to the new North treatment plant.
Laguna Madre	• Repair over next 20 years • Demolish the plant and decommission the existing site after the 0 to 20 year time period. • Build a new pumping station at the Laguna Madre plant to transfer wastewater from Laguna Madre to the new North treatment plant.
Whitecap	• Repair over next 20 years

The new 32 MGD North Site WWTP would include the unit processes summarized in **Table 1-35**.

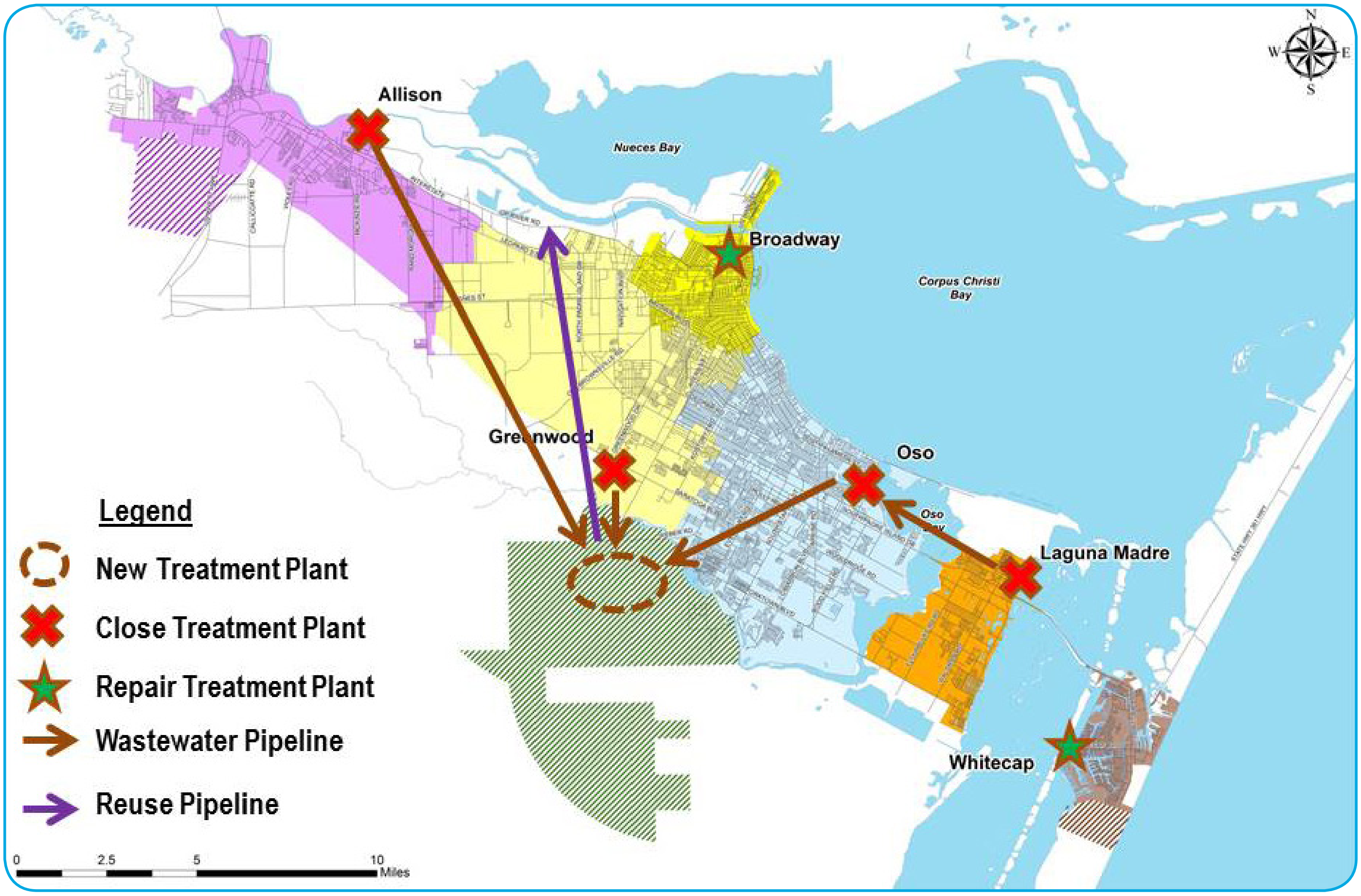
Table 1-35 Proposed Unit Operations for New 32 MGD North Site WWTP

Unit Process	Preliminary Assumption
Preliminary Treatment	• 6 mechanically cleaned screens with grinders/washers/compactors • 6 mechanical vortex grit removal systems
Primary Clarifiers	• 6 primary clarifiers
Secondary Treatment	• 6 BNR bioreactors (4 stage Bardenpho) • 6 Secondary clarifiers
Disinfection	• UV disinfection
Sludge Thickening	• 6 Rotary Drum thickeners
Digestion	• 6 Anaerobic Digesters
Sludge Dewatering	• 6 centrifuge units
Miscellaneous	• Headworks odor control (chemical) • Primary odor control • Cogeneration for energy recovery from biogas • Automation and instrumentation

1.5.3.5 Option 3B – Consolidate at a new Southwest Plant Site

Option 3B involves the consolidation of existing plant flows at a single Southwest WWTP site. Allison, Oso, Laguna Madre and Greenwood would be taken out of service under this alternative and Broadway and Whitecap would stay in service for the foreseeable future although they could be consolidated at a later time. The system configuration under Option 3B is presented here as **Figure 1-13**.

Figure 1-13 Option 3B System Configuration



The key infrastructure requirements under the Option 3B over the next 30 years are presented here as **Table 1-36**.

Table 1-36 Summary of Key Infrastructure Requirements under Option 3B

Plant	Infrastructure Requirements
Collection System	• Repair system in accordance with requirements to reduce overflows • Redirect some flow from Greenwood to Broadway sewer shed in the interim
Allison	• Repair over next 15 years • Decommission the plant after 15-years and build new pumping station to direct flows to the new Southwest treatment plant.
Greenwood	• Repair during 0 to 5 year period • Demolish the plant and decommission the existing site after the 5 year time period. • Build a new pumping station at the Greenwood site to transfer wastewater from Greenwood to the new Southwest treatment plant site.
Broadway	• Repair over next 20 years
New Southwest Treatment Plant	• Build new 35 MGD Southwest Treatment plant in the 0 to 5 year period.
Oso	• Repair plant over next 10 years • Demolish the plant and decommission the existing site after the 0 to 10 year time period. • Build a new pumping station at the Oso plant to transfer wastewater from Oso to the new Southwest treatment plant.
Laguna Madre	• Repair over next 20 years • Demolish the plant and decommission the existing site after the 20 year time period. • Build a new pumping station at the Laguna Madre plant to transfer wastewater from Laguna Madre to the new Southwest treatment plant.
Whitecap	• Repair over next 20 years

The new 35 MGD Southwest WWTP would include the unit processes summarized in **Table 1-37**.

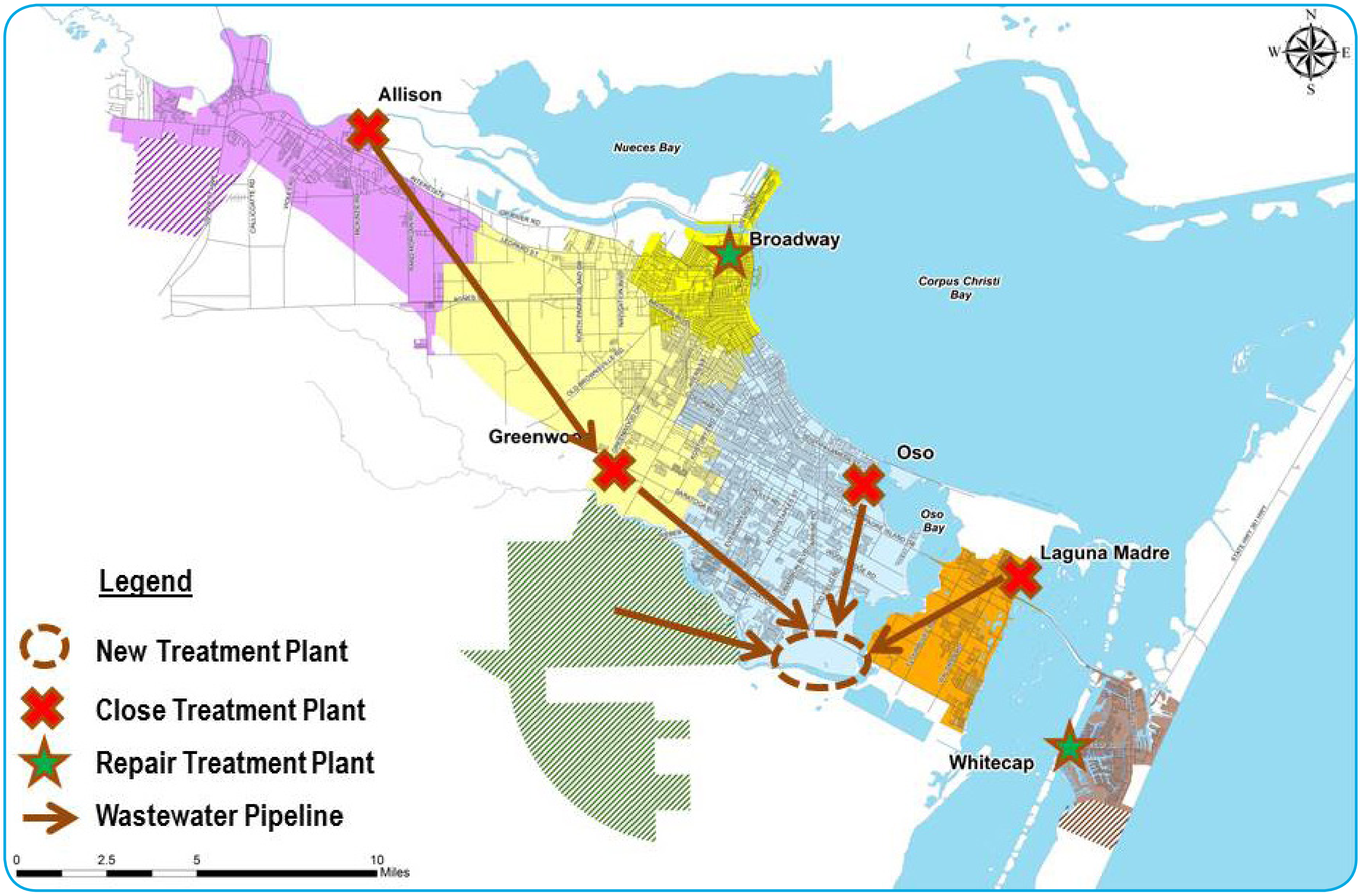
Table 1-37 Proposed Unit Operations for New 35 MGD Southwest WWTP

Unit Process	Preliminary Assumption
Preliminary Treatment	• 6 mechanically cleaned screens with grinders/washers/compactors • 6 mechanical vortex grit removal systems
Primary Clarifiers	• 6 primary clarifiers
Secondary Treatment	• 6 BNR bioreactors (4 stage Bardenpho) • 6 Secondary clarifiers
Disinfection	• UV disinfection
Sludge Thickening	• 6 Rotary Drum thickeners
Digestion	• 6 Anaerobic Digesters
Sludge Dewatering	• 6 centrifuge units
Miscellaneous	• Headworks odor control (chemical) • Primary odor control • Cogeneration for energy recovery from biogas • Automation and instrumentation

1.5.3.6 Option 3C – Consolidate at a new Southeast Plant Site

Option 3C involves the consolidation of existing plant flows at a single Southeast WWTP site. Allison, Oso, Laguna Madre and Greenwood would be taken out of service under this alternative and Broadway and Whitecap would stay in service for the foreseeable future although they could be consolidated at a later time. The system configuration under Option 3C is presented here as **Figure 1-14**.

Figure 1-14 Option 3C System Configuration



The key infrastructure requirements under the Option 3C over the next 30 years are presented here as **Table 1-38**.

Table 1-38 Summary of Key Infrastructure Requirements under Option 3C

Plant	Infrastructure Requirements
Collection System	• Repair system in accordance with requirements to reduce overflows • Redirect some flow from Greenwood to Broadway sewer shed in the interim
Allison	• Repair over next 15 years • Close after 15-years and build new pumping station to direct flows to the new Southeast treatment plant.
Greenwood	• Repair during 0 to 5 year period • Demolish the plant and decommission the existing site after the 5 year time period. • Build a new pumping station at the Greenwood site to transfer wastewater from Greenwood to the new Southeast treatment plant site.
Broadway	• Repair over next 20 years
New Southeast Treatment Plant	• Build new 32 MGD Southeast Treatment plant in the 0 to 5 year period.
Oso	• Repair plant over next 10 years • Demolish the plant and decommission the existing site after the 10 year time period. • Build a new pumping station at the Oso plant to transfer wastewater from Oso to the new Southeast treatment plant.
Laguna Madre	• Repair over next 20 years • Demolish the plant and decommission the existing site after the 0 to 20 year time period. • Build a new pumping station at the Laguna Madre plant to transfer wastewater from Laguna Madre to the new Southeast treatment plant.
Whitecap	• Repair over next 20 years

The new 32 MGD Southeast WWTP would include the unit processes summarized in **Table 1-39**.

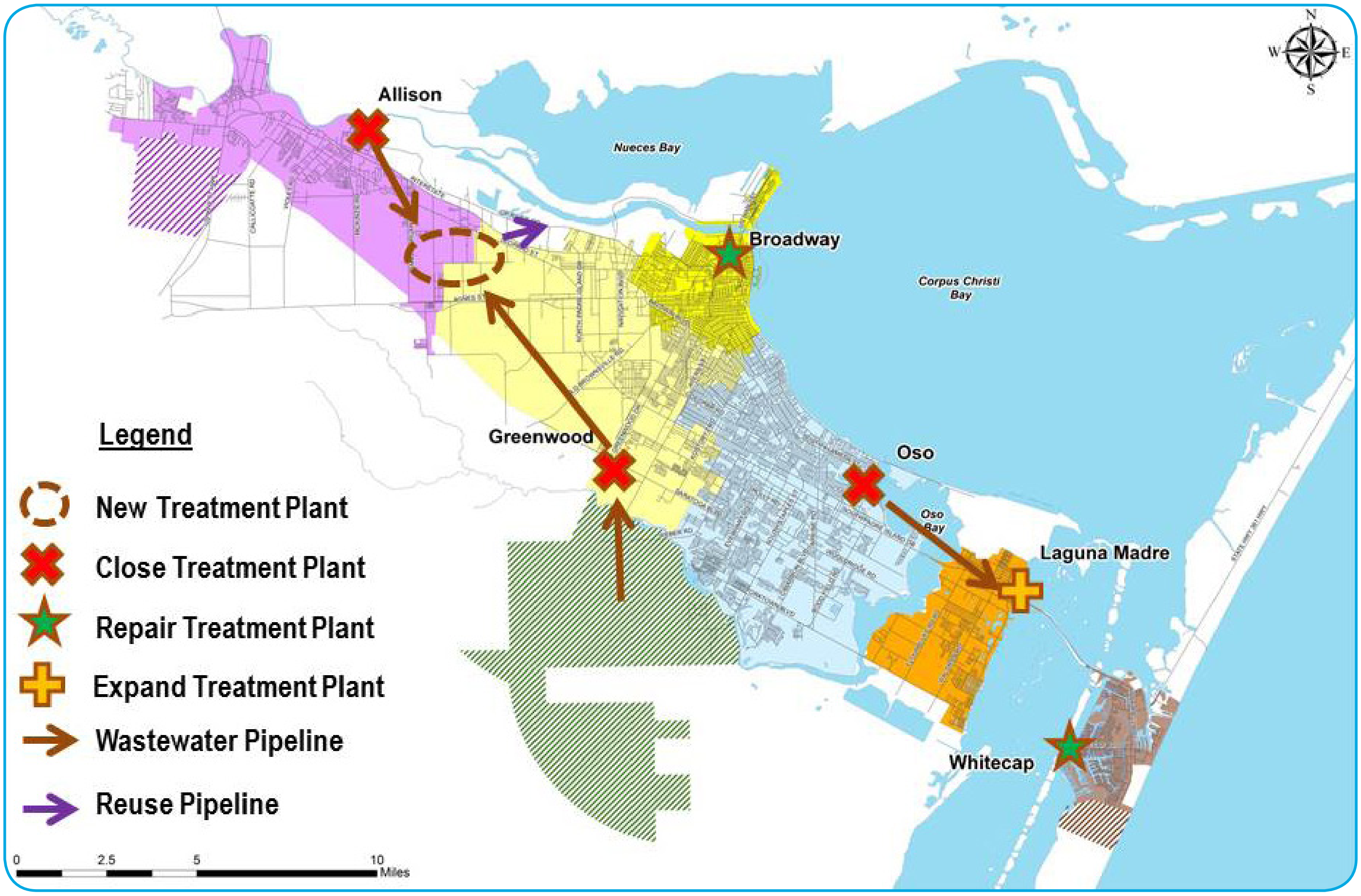
Table 1-39 Proposed Unit Operations for new 32 MGD Southeast Treatment Plant

Unit Process	Preliminary Assumption
Preliminary Treatment	• 6 mechanically cleaned screens with grinders/washers/compactors • 6 mechanical vortex grit removal systems
Primary Clarifiers	• 6 primary clarifiers
Secondary Treatment	• 6 BNR bioreactors (4 stage Bardenpho) • 6 Secondary clarifiers
Disinfection	• UV disinfection
Sludge Thickening	• 6 Rotary Drum thickeners
Digestion	• 6 Anaerobic Digesters
Sludge Dewatering	• 6 centrifuge units
Miscellaneous	• Headworks odor control (chemical) • Primary odor control • Cogeneration for energy recovery from biogas • Automation and instrumentation

1.5.3.7 Option 4A – Consolidate at a new North Plant Site and Laguna Madre

Option 4A involves the consolidation of existing plant flows at two treatment plant sites: a new north plant site and a new plant adjacent the Laguna Madre site. Allison, Oso, Laguna Madre and Greenwood would be taken out of service under this alternative and Broadway and Whitecap would stay in service for the foreseeable future although they could be consolidated at a later time. The system configuration under Option 4A is presented here as **Figure 1-15**.

Figure 1-15 Option 4A System Configuration



The key infrastructure requirements under the Option 4A over the next 30 years are presented here as **Table 1-40**.

Table 1-40 Summary of Key Infrastructure Requirements under Option 4A

Plant	Infrastructure Requirements
Collection System	• Repair system in accordance with requirements to reduce overflows • Redirect some flow from Greenwood to Broadway sewer shed in the interim
Allison	• Repair over next 15 years • Decommission the plant after 15-years and build new pumping station to direct flows to the new North treatment plant.
North Treatment Plant	• Construct a new 12 MGD facility at the North treatment plant site in the next 5 years. • Provide effluent reuse facilities for industry in next 10 years
Greenwood	• Repair during 0 to 5 year period • Demolish the plant and decommission the existing site after the 5 year time period. • Build a new pumping station at the Greenwood site to transfer wastewater from Greenwood to the new North treatment plant site.
Broadway	• Repair over next 20 years
Oso	• Repair plant over next 5 years • Demolish the plant and decommission the existing site after the 5 year time period. • Build a new pumping station at the Oso plant to transfer wastewater from Oso to the new Laguna Madre facility.
Laguna Madre	• Repair the existing plant over the next 5 years • Build a new 20 MGD plant at the Laguna Madre site to take flows from Laguna Madre and Oso.
Whitecap	• Repair over next 20 years

The new 12 MGD North WWTP would include the unit processes summarized in **Table 1-41**.

Table 1-41 Proposed Unit Operations for new North WWTP under Option 4A

Unit Process	Preliminary Assumption
Preliminary Treatment	• 2 mechanically cleaned screens with grinders/washers/compactors • 2 mechanical vortex grit removal systems
Primary Clarifiers	• 3 primary clarifiers
Secondary Treatment	• 3 BNR bioreactors (4 stage Bardenpho) • 3 Secondary clarifiers
Disinfection	• UV disinfection
Sludge Thickening	• 3 Rotary Drum thickeners
Digestion	• 2 Anaerobic Digesters
Sludge Dewatering	• 3 centrifuge units
Miscellaneous	• Headworks odor control (chemical) • Primary odor control • Cogeneration for energy recovery from biogas • Automation and instrumentation

The new 20 MGD Laguna Madre WWTP would include the unit processes summarized in **Table 1-42**.

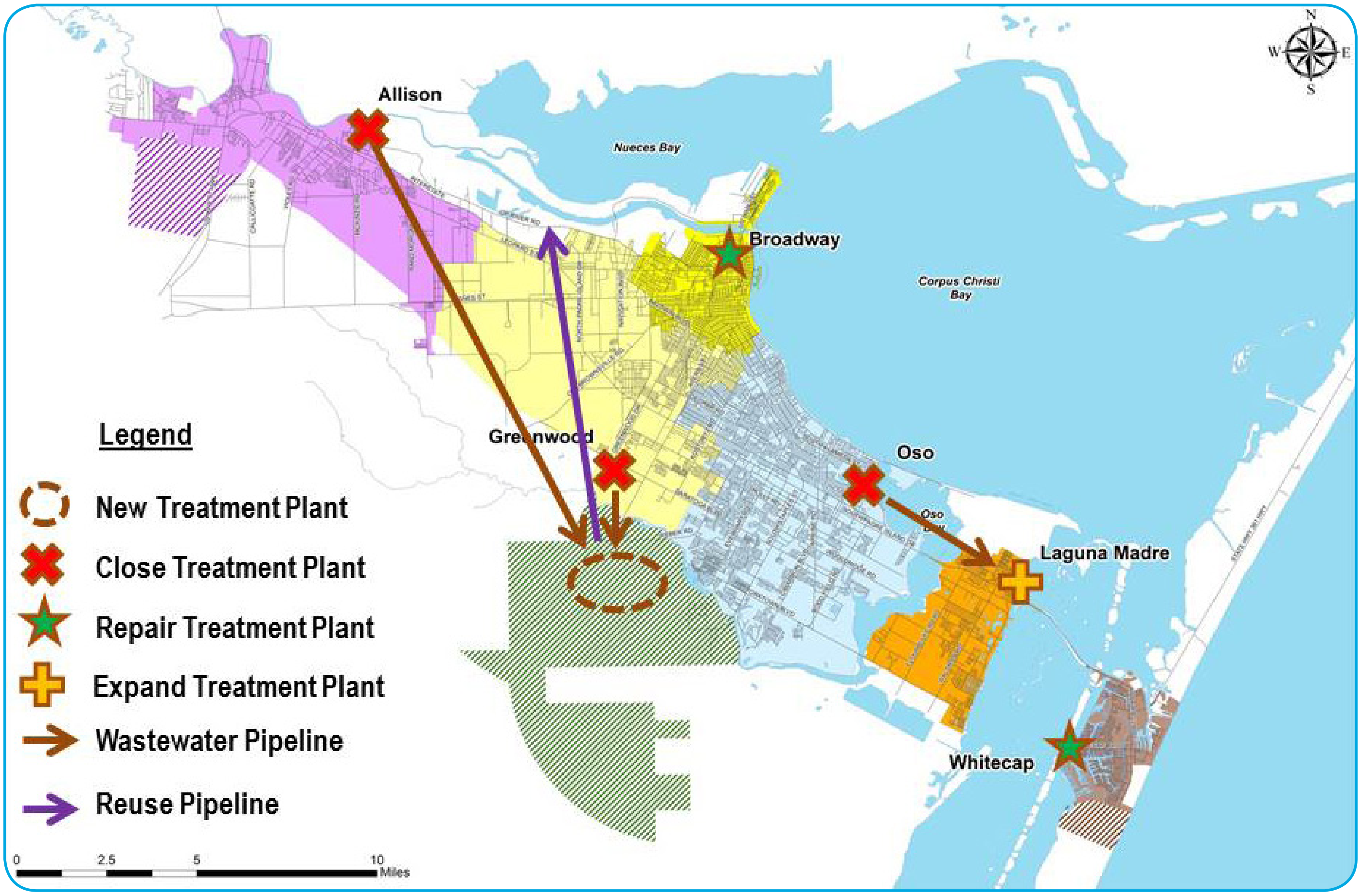
Table 1-42 Proposed Unit Operations for New Laguna Madre WWTP under Option 4A

Unit Process	Preliminary Assumption
Preliminary Treatment	• 4 mechanically cleaned screens with grinders/washers/compactors • 4 mechanical vortex grit removal systems
Primary Clarifiers	• 4 primary clarifiers
Secondary Treatment	• 4 BNR bioreactors (4 stage Bardenpho) • 4 Secondary clarifiers
Disinfection	• UV disinfection
Sludge Thickening	• 4 Rotary Drum thickeners
Digestion	• 4 Anaerobic Digesters
Sludge Dewatering	• 4 centrifuge units
Miscellaneous	• Headworks odor control (chemical) • Primary odor control • Cogeneration for energy recovery from biogas • Automation and instrumentation

1.5.3.8 Option 4B – Consolidate at a new Southwest Site and Laguna Madre

Option 4B involves the consolidation of existing plant flows at two treatment plant sites: a new southwest plant site and a new plant adjacent the Laguna Madre site. Allison, Oso, Laguna Madre and Greenwood would be taken out of service under this alternative and Broadway and Whitecap would stay in service for the foreseeable future although they could be consolidated at a later time. The system configuration under Option 4B is presented here as **Figure 1-16**.

Figure 1-16 Option 4B System Configuration



The key infrastructure requirements under the Option 4B over the next 30 years are presented here as **Table 1-43**.

Table 1-43 Summary of Key Infrastructure Requirements under Option 4B

Plant	Infrastructure Requirements
Collection System	• Repair system in accordance with requirements to reduce overflows • Redirect some flow from Greenwood to Broadway sewer shed in the interim
Allison	• Repair over next 15 years • Decommission plant after 15-years and build new pumping station to direct flows to the new Southwest treatment plant.
Southwest Treatment Plant	• Construct a new 12 MGD facility at the Southwest treatment plant site in the next 5 years. • Provide effluent reuse facilities for industry in next 10 years
Greenwood	• Repair during 0 to 5 year period • Demolish the plant and decommission the existing site after the 5 year time period. • Build a new pumping station at the Greenwood site to transfer wastewater from Greenwood to the new Southwest treatment plant site.
Broadway	• Repair over next 20 years
Oso	• Repair plant over next 5 years • Demolish the plant and decommission the existing site after the 0 to 5 year time period. • Build a new pumping station at the Oso plant to transfer wastewater from Oso to the new Laguna Madre facility.
Laguna Madre	• Repair the existing plant over the next 5 years • Build a new 20 MGD plant at the Laguna Madre site to take flows from Laguna Madre and Oso.
Whitecap	• Repair over next 20 years

The new 12 MGD Southwest WWTP would include the unit processes summarized in **Table 1-44**.

Table 1-44 Proposed Unit Operations for Proposed Southwest Treatment Plant under Option 4B

Unit Process	Preliminary Assumption
Preliminary Treatment	• 2 mechanically cleaned screens with grinders/washers/compactors • 2 mechanical vortex grit removal systems
Primary Clarifiers	• 3 primary clarifiers
Secondary Treatment	• 3 BNR bioreactors (4 stage Bardenpho) • 3 Secondary clarifiers
Disinfection	• UV disinfection
Sludge Thickening	• 3 Rotary Drum thickeners
Digestion	• 2 Anaerobic Digesters
Sludge Dewatering	• 3 centrifuge units
Miscellaneous	• Headworks odor control (chemical) • Primary odor control • Cogeneration for energy recovery from biogas • Automation and instrumentation

The new 20 MGD Laguna Madre WWTP would include the unit processes summarized in **Table 1-45**.

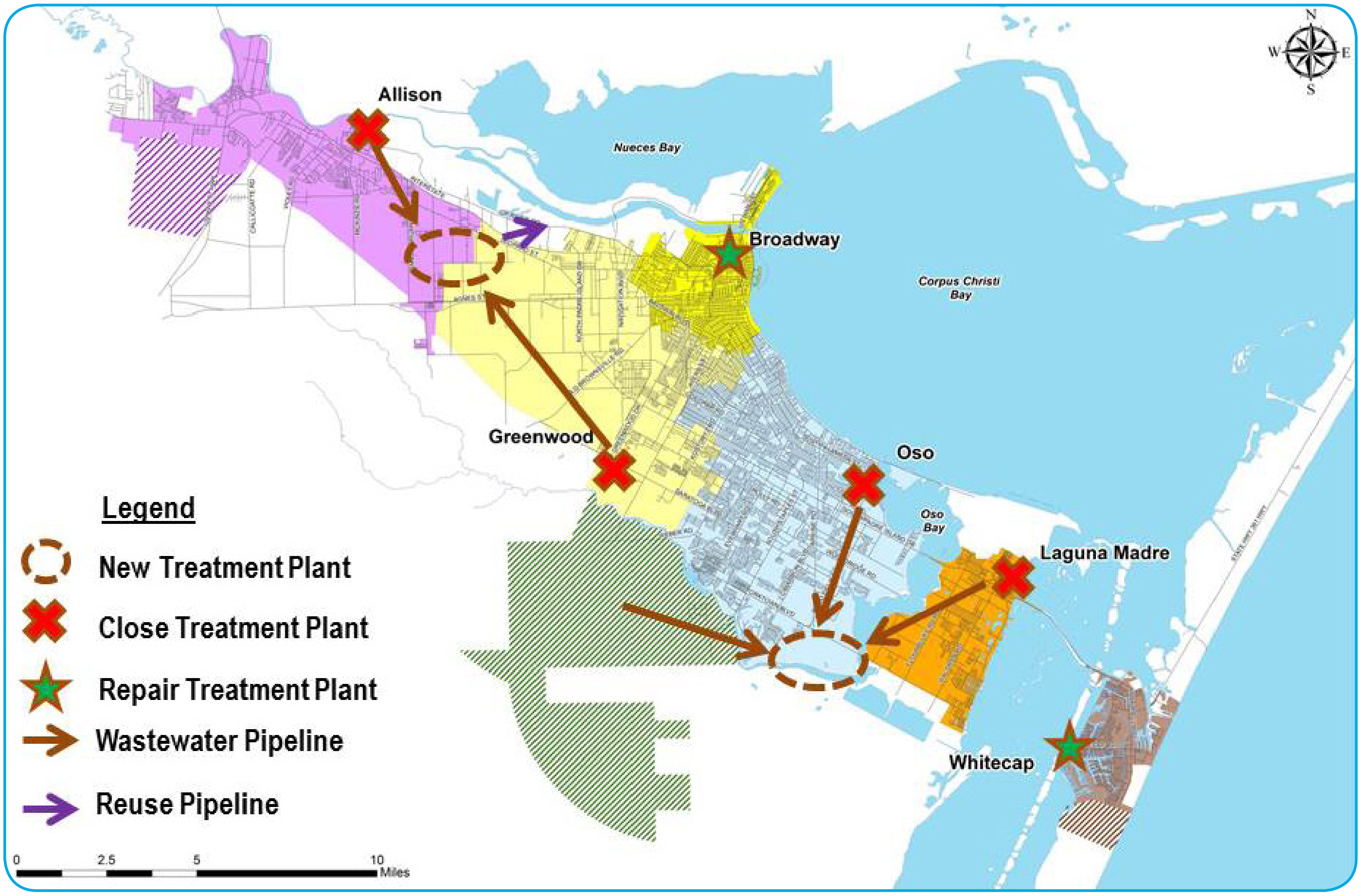
Table 1-45 Proposed Unit Operations for Laguna Madre WWTP under Option 4B

Unit Process	Preliminary Assumption
Preliminary Treatment	• 4 mechanically cleaned screens with grinders/washers/compactors • 4 mechanical vortex grit removal systems
Primary Clarifiers	• 4 primary clarifiers
Secondary Treatment	• 4 BNR bioreactors (4 stage Bardenpho) • 4 Secondary clarifiers
Disinfection	• UV disinfection
Sludge Thickening	• 4 Rotary Drum thickeners
Digestion	• 4 Anaerobic Digesters
Sludge Dewatering	• 4 centrifuge units
Miscellaneous	• Headworks odor control (chemical) • Primary odor control • Cogeneration for energy recovery from biogas • Automation and instrumentation

1.5.3.9 Option 4C – Consolidate at a new North Plant Site and a New Southeast Plant Site

Option 4C involves the consolidation of existing plant flows at two treatment plant sites: a new southeast plant site and a new north plant site. Allison, Oso, Laguna Madre and Greenwood would be taken out of service under this alternative and Broadway and Whitecap would stay in service for the foreseeable future although they could be consolidated at a later time. The system configuration under Option 4C is presented here as **Figure 1-17**.

Figure 1-17 Option 4C System Configuration



The key infrastructure requirements under the Option 4C over the next 30 years are presented here as **Table 1-46**.

Table 1-46 Summary of Key Infrastructure Requirements under Option 4C

Plant	Infrastructure Requirements
Collection System	• Repair system in accordance with requirements to reduce overflows • Redirect some flow from Greenwood to Broadway sewer shed in the interim
Allison	• Repair over next 15 years • Decommission the plant after 15-years and build new pumping station to direct flows to the new North treatment plant.
North Treatment Plant	• Construct a new 12 MGD facility at the North treatment plant site in the next 5 years. • Provide effluent reuse facilities for industry in next 10 years
Greenwood	• Repair during 0 to 5 year period • Demolish the plant and decommission the existing site after the 0 to 5 year time period. • Build a new pumping station at the Greenwood site to transfer wastewater from Greenwood to the new North treatment plant site.
Broadway	• Repair over next 20 years
Oso	• Repair plant over next 5 years • Demolish the plant and decommission the existing site after the 0 to 5 year time period. • Build a new pumping station at the Oso plant to transfer wastewater from Oso to the new Southeast treatment plant facility.
New Southeast Plant	• Build a new 20 MGD plant at the Southeast site to take flows from Oso and ultimately Laguna Madre.

Plant	Infrastructure Requirements
Laguna Madre	• Repair the existing plant over the next 20 years • Transfer flow to Southeast plant after 20 years.
Whitecap	• Repair over next 20 years

The new 12 MGD North WWTP would include the unit processes summarized in **Table 1-47**.

Table 1-47 Proposed Unit Operations for New 12 MGD North Plant under Option 4C

Unit Process	Preliminary Assumption
Preliminary Treatment	• 2 mechanically cleaned screens with grinders/washers/compactors • 2 mechanical vortex grit removal systems
Primary Clarifiers	• 3 primary clarifiers
Secondary Treatment	• 3 BNR bioreactors (4 stage Bardenpho) • 3 Secondary clarifiers
Disinfection	• UV disinfection
Sludge Thickening	• 3 Rotary Drum thickeners
Digestion	• 2 Anaerobic Digesters
Sludge Dewatering	• 3 centrifuge units
Miscellaneous	• Headworks odor control (chemical) • Primary odor control • Cogeneration for energy recovery from biogas • Automation and instrumentation

The new 20 MGD Southeast WWTP would include the unit processes summarized in **Table 1-48**.

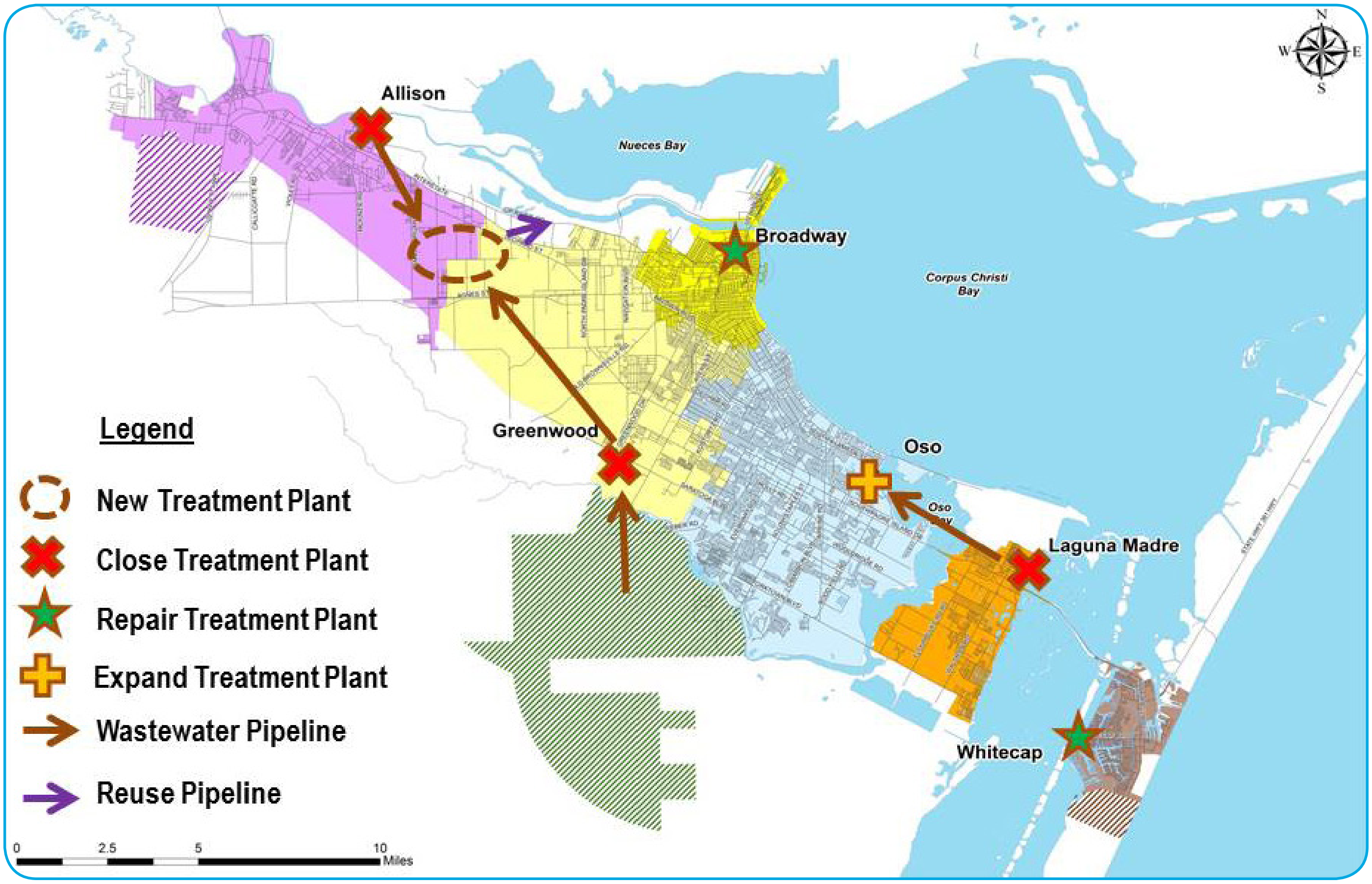
Table 1-48 Proposed Unit Operations for New 20 MGD Southeast Plant Under Option 4C

Unit Process	Preliminary Assumption
Preliminary Treatment	• 4 mechanically cleaned screens with grinders/washers/compactors • 4 mechanical vortex grit removal systems
Primary Clarifiers	• 4 primary clarifiers
Secondary Treatment	• 4 BNR bioreactors (4 stage Bardenpho) • 4 Secondary clarifiers
Disinfection	• UV disinfection
Sludge Thickening	• 4 Rotary Drum thickeners
Digestion	• 4 Anaerobic Digesters
Sludge Dewatering	• 4 centrifuge units
Miscellaneous	• Headworks odor control (chemical) • Primary odor control • Cogeneration for energy recovery from biogas • Automation and instrumentation

1.5.3.10 Option 4D – Consolidate at a new North Plant Site and the Existing Oso WRP Site

Option 4D involves the consolidation of existing plant flows at two treatment plant sites: a new north plant site and an expanded and upgraded plant on the Oso WRP site. Allison, Oso, Laguna Madre and Greenwood would be taken out of service under this alternative and Broadway and Whitecap would stay in service for the foreseeable future although they could be consolidated at a later time. The system configuration under Option 4D is presented here as **Figure 1-18**.

Figure 1-18 Option 4D System Configuration



The key infrastructure requirements under the Option 4D over the next 30 years are presented here as **Table 1-49**.

Table 1-49 Summary of Key Infrastructure Requirements under Option 4D

Plant	Infrastructure Requirements
Collection System	• Repair system in accordance with requirements to reduce overflows • Redirect some flow from Greenwood to Broadway sewer shed in the interim
Allison	• Repair over next 10 years • Decommission the plant after 10-years and build new pumping station to direct flows to the new North treatment plant.
North Treatment Plant	• Construct a new 12 MGD facility at the North treatment plant site in the next 5 years. • Provide effluent reuse facilities for industry in next 10 years
Greenwood	• Repair during 0 to 5 year period • Demolish the plant and decommission the existing site after the 5 year time period. • Build a new pumping station at the Greenwood site to transfer wastewater from Greenwood to the new North treatment plant site.
Broadway	• Repair over next 20 years
Oso	• Repair plant over next 20 years • Upgrade plant to BNR and expand to 20 MGD over next 5 years.
Laguna Madre	• Repair the existing plant over the next 5 years • Demolish the plant and decommission the existing site after the 0 to 5 year time period. • Build a new pumping station at the Laguna Madre plant to transfer wastewater from Laguna Madre to the Oso treatment plant.
Whitecap	• Repair over next 20 years

The new 12 MGD North WWTP would include the unit processes summarized in **Table 1-50**.

Table 1-50 Proposed Unit Operations for 12 MGD New Plant under Option 4D

Unit Process	Preliminary Assumption
Preliminary Treatment	• 2 mechanically cleaned screens with grinders/washers/compactors • 2 mechanical vortex grit removal systems
Primary Clarifiers	• 3 primary clarifiers
Secondary Treatment	• 3 BNR bioreactors (4 stage Bardenpho) • 3 Secondary clarifiers
Disinfection	• UV disinfection
Sludge Thickening	• 3 Rotary Drum thickeners
Digestion	• 2 Anaerobic Digesters
Sludge Dewatering	• 3 centrifuge units
Miscellaneous	• Headworks odor control (chemical) • Primary odor control • Cogeneration for energy recovery from biogas • Automation and instrumentation

1.5.4 Capital and O&M Cost Analyses

1.5.4.1 Introduction

One of the primary reasons for conducting this study was to confirm the potential benefits of consolidating flows from the six existing wastewater treatment facilities into a lesser number of newer larger treatment plants. The unit operating costs for larger wastewater treatment plants tend to be lower than for smaller facilities. This is primarily due to the facts staffing levels, measured as full-time equivalents (FTEs) per million gallon (MG) treated, and unit power costs measured as kilowatt hours (kW-hr) per million gallon treated decline with increasing plant capacity. The decline in unit power costs tends to level off at a design flow of approximately 20 MGD.

As indicated in **Section 1.1.2**, the city is facing an estimated sustaining capital spend at the six existing wastewater treatment facilities of approximately $220 M. The majority of the capital requirements are for the Greenwood (approximately $61 M) and Oso (approximately $81 M) facilities. The contributing sewer shed for these two plants is coincidentally where the majority of anticipated demand growth is expected to occur.

The currently planned capital improvement plan for which current rates are based (estimated capital spend to 2035 of approximately $524 M) is already considered unaffordable based upon EPA affordability criteria. User rate increases are driven in large part by increases in capital spend. The increase in capital spending can be partly offset by reductions in annual O&M spend. Options requiring a large upfront capital spend over the next 5 to 10-years will have a significant further negative impact upon wastewater user rates if not offset by O&M cost efficiencies.

The implementation of any of the options presented in the previous section needs to strike the appropriate balance between minimizing the sustaining capital spend on existing facilities destined to be taken out of service, consolidating existing facilities as soon as possible in order to realize annual O&M savings associated with economies of scale sooner rather than later, while staging planned capital spending for new facilities in order to minimize the impact upon user rates.

The best way to assess the options under consideration was to construct a detailed cash flow model for each. The consulting team constructed detailed capital and O&M cost models for each of the options presented in **Section 1.5.3**. All of the options were compared against Option 1 – Maintain existing six plants which was treated as the benchmark. The team then conducted sensitivity analyses on each of the options considered to determine how changing conditions might impact costs as well as the recommended servicing option.

1.5.4.2 Capital and O&M Cost Assumptions

The capital and O&M cost estimates for each of the 10 options considered are presented in **Appendix F**. Three spreadsheet models were constructed for these analyses: a wastewater treatment plant staffing model, an estimate of power usage at each plant, and the overall cash flow model summarizing estimated capital and O&M costs.

The following assumptions were used in developing the cost models:

- All of the optimization measures identified to reduce existing O&M costs in the Operations assessment were assumed to be applied to all options including Option 1 – Maintain Six Existing Treatment Plants.
- All works identified in the physical condition survey were carried out for all plants until such time as they were identified as being taken out of service. For example, a number of options assumed Greenwood will be taken out of service in year 5 therefore all works identified in the physical condition survey for Greenwood in the 0 to 5-year period were included in the cash flow analysis.
- Staffing level estimates were based upon the assessment methodology outlined in the "Northeast Guide for Estimating Staffing at Publicly and Privately Owned Wastewater Treatment Plants" dated November 2008 prepared by the New England Interstate Water Pollution Control Commission.
- Preliminary power usage estimates for all treatment plant facilities were based upon guidance provided in the publication entitled "Electricity Use and Management in the Municipal Water Supply and Wastewater Industries" dated November 2013 and published by Water Research Foundation and Electrical Power Research Institute.
- Non-process electrical loads will be approximately one third of those referenced in the above-noted guidance to account for the warmer climate in Texas.
- Chemical costs under optimal conditions were taken as equal the average amount as indicated in the NACWA study.
- Hauling costs were based upon an average solids generation of 0.59 dry tons/MG treated and a unit cost of $57.16/wet ton (2016) inflated at 2% per year.
- The existing plants were assumed to maintain their current sludge dewatering performance with new plants assumed to achieve a minimum of 24% solids.
- Preventative maintenance costs were estimated at 1.5 % per year of the replacement cost of the process mechanical and electrical equipment. Process mechanical and electrical equipment was assumed to account for 35% of the overall capital cost for all vertical works.
- Approximately 20% of the aeration requirements required for nitrification will be recovered via denitrification when biological nutrient removal (BNR) is installed at any plant.
- The current practice of disposing of sludge at a co-disposal landfill will continue into the foreseeable future.
- Existing effluent limits at the Broadway and Whitecap plants will stay into effect for the foreseeable future and will not change over the 30-year planning horizon.
- All new and expanded plants will need to be converted to BNR.
- All new plants will convert to anaerobic digestion with energy recovery.
- The capital and O&M costs associated with industrial reuse will be paid for through a take or pay contract with interested industries and are not included in the cash flow and therefore the user rates.
- Current electricity prices are $0.088/kW-hr and 2018 through 2022 prices will be $0.03883/kW-hr with 1% energy price inflation after 2021.
- Average burdened labor cost is $68,448/year per FTE. Future wage inflation was assumed as 2% per year.
- The cost of chemicals was $99/MG treated unless otherwise noted based upon actual plant operating records. Future chemical costs were assumed to increase by 1.5% per year.
- Inflation on sludge haulage and preventative maintenance were both assumed as 2% per year.
- Operating and maintenance costs other than labor, energy, chemicals, sludge hauling, and preventative maintenance were assumed to account for 25% to 30% of the overall total cost.

1.5.4.3 Capital and O&M Cost Analyses

Capital and O&M cost estimates were completed for each of the 10 options previously presented. The cost models are enclosed in **Appendix F** and summarized here in **Table 1-51**.

Table 1-51 Summary of Capital and O&M Costs by Option

Option	Description	Capital Cost (2016-2045) (2016 Constant Dollars)	Capital Cost Industrial Reuse (2016 Constant Dollars)	Inflated O&M Costs (2016 to 2045)
1	Maintain six existing plants	$734 M	$108 M	$521 M
2A	Consolidate at Allison and Laguna Madre	$950 M	$50 M	$502 M
2B	Consolidate at Allison and Oso	$836 M	$50 M	$467 M
3A	Consolidate at a new North Plant	$1,053 M	$48 M	$504 M
3B	Consolidate at a new Southwest Plant	$1,047 M	$63 M	$505 M
3C	Consolidate at a new Southeast Plant	$1,012 M	TBD	$516 M
4A	Consolidate at a new North Plant and Laguna Madre	$944 M	$48 M	$484 M
4B	Consolidate at a new Southwest Plant and Laguna Madre	$1,021 M	$48 M	$494 M
4C	Consolidate at a new North Plant and a new Southeast Plant	$958 M	$63 M	$493 M
4D	Consolidate at a new North Plant and Oso	$826 M	$48 M	$466 M

1.5.4.4 Sensitivity Analyses

The project team conducted a sensitivity analysis of the various options considering the impact of changes in both energy and labor costs. The relative impact of various inflation rates on difference in O&M costs between the options is summarized here in **Tables 2-52** and **2-53**.

Table 1-52 Difference in O&M Cost between Servicing Options for Various Labor Inflation Rates

Option	Description	O&M Costs		O&M Costs	
		(2% Labor Inflation)	Diff. Relative to Option1	(4% Labor Inflation)	Diff. Relative to Option1
1	Maintain six existing plants	$521 M	-	$622 M	-
2A	Consolidate at Allison and Laguna Madre	$502 M	$19 M	$575 M	$47 M
2B	Consolidate at Allison and Oso	$467 M	$54 M	$529 M	$93 M
3A	Consolidate at a new North Plant	$504 M	$18 M	$562 M	$60 M
3B	Consolidate at a new Southwest Plant	$505 M	$17 M	$580 M	$42 M
3C	Consolidate at a new Southeast Plant	$516 M	$5 M	$585 M	$37 M
4A	Consolidate at a new North Plant and Laguna Madre	$484 M	$37 M	$548 M	$73 M
4B	Consolidate at a new Southwest Plant and Laguna Madre	$494 M	$27 M	$570 M	$53 M
4C	Consolidate at a new North Plant and a new Southeast Plant	$493 M	$28 M	$562 M	$61 M
4D	Consolidate at a new North Plant and Oso	$466 M	$55 M	$529 M	$93 M

Table 1-53 Difference in O&M Costs between Options for Various Power Inflation Rates

Option	Description	O&M Costs (1% Electricity Inflation)	Diff. Relative to Option1	O&M Costs (5% Electricity Inflation)	Diff. Relative to Option1
1	Maintain six existing plants	$521 M	-	$546 M	-
2A	Consolidate at Allison and Laguna Madre	$502 M	$19 M	$528 M	$18 M
2B	Consolidate at Allison and Oso	$467 M	$54 M	$492 M	$54 M
3A	Consolidate at a new North Plant	$504 M	$18 M	$541 M	$15 M
3B	Consolidate at a new Southwest Plant	$505 M	$17 M	$542 M	$14 M
3C	Consolidate at a new Southeast Plant	$516 M	$5 M	$543 M	$3 M
4A	Consolidate at a new North Plant and Laguna Madre	$484 M	$37 M	$509 M	$36 M
4B	Consolidate at a new Southwest Plant and Laguna Madre	$494 M	$27 M	$520 M	$26 M
4C	Consolidate at a new North Plant and a new Southeast Plant	$493 M	$28 M	$519 M	$27 M
4D	Consolidate at a new North Plant and Oso	$466 M	$55 M	$491 M	$55 M

1.5.4.5 Rate Impacts

The consulting team estimated the impact of a number of the proposed servicing options on future wastewater rates using the city's existing rate model. The existing rate model calculates rates out to 2035. The estimated increase in user rates for options 1, 2B, 4D, and 3A are presented here in **Table 1-54**. In comparison, it is noted that the historical wastewater user rate increased by approximately 110% between 2005 and 2015.

Table 1-54 Supplemental Wastewater User Rate Calculations

Option	Description	Relative Increase in Wastewater User Rates (2016 to 2035)
1	Maintain six existing plants	81%
2B	Consolidate at Allison and Oso	85%
3A	Consolidate at a new North Plant	99%
4D	Consolidate at a new North Plant and Oso	84%

1.5.4.6 Cost Analysis Conclusions and Recommendations

The financial analysis suggests Option 1 – Maintain the six existing plants has the lowest overall capital cost associated with treatment and pumping infrastructure given that it takes maximum advantage of existing infrastructure. Option 1 however has the highest capital cost for industrial reuse water given reuse water would likely have to be provided from two treatment plants as opposed to one under other options. Option 1 also has the highest O&M costs of the options considered.

The cost analyses suggest Options 2B and 4D are competitive with Option 1from an overall cost perspective considering capital costs for treatment and reuse as well as cumulative O&M costs. The relative impact on user rates for options 1, 2B, and 4D is essentially equal. Option 3A would have a statistically significant impact on user rates relative to the Option 1 benchmark.

Sensitivity analysis demonstrates that the difference in O&M cost savings is most sensitive to labor costs and labor cost inflation. The consolidation options each result in significant staff reduction relative to the bench mark Option 1 even after optimizing existing plant operations. Higher future labor costs and increased labor inflation will favor the consolidation options, particularly options 2B and 4D, relative to the benchmark (Option 1).

The difference in 2045 staffing levels between the group 3 options (3A, 3B, and 3C) is only 4 or 5 staff relative to the group 2 and 4 options. The group 2 and 4 consolidation options are less affected by energy cost inflation and release O&M cost savings sooner than the group 3 options at much lower capital cost.

1.5.5 Prescreening Criteria and Options Prescreening

Prior to evaluating the Options, the City staff and their consultant teams engaged with the citizens and other stakeholders to hear what issues and concerns needed to be considered in selecting the optimum future wastewater configuration. As can be expected, there was a wide range of opinions expressed by the general public, neighborhood associations, agencies, business professionals and other interested parties. These issues of concerns were then grouped into preliminary evaluation criteria to cover the Economic, Social, Natural and Technical environments. The preliminary criteria were presented to City staff at an evaluation workshop where the team could confirm that these fully covered the range of relevant issues and also establish the relative priorities. Three priority levels and associated weightings were proposed: normal items were unweighted (level 1), important items were given a double weighting (level 2) and the most critical items were given a triple weighting (level 3).

The final evaluation criteria and selected weightings are shown in **Table 1-55**.

Table 1-55 Evaluation Criteria and Weighting Factors used for Options Evaluation

Category	Sub-Topic	Considerations for Evaluation	Weighting
Cost	Total Capital Cost	Overall 30 year capital cost	3
	Total O&M Cost	Overall 30 year operating and maintenance costs	2
	Cash Flow	Maximum peak annual capital and O&M costs	3
Receiving Streams	Maintaining base flow	Providing minimum low flow conditions for streams	1
	Effluent requirements	Ability to meet the expected future treatment requirements	3
	Local eco systems	Support locally established eco systems	2
Schedule	Phasing potential	Opportunity for staging work to meet flow projections	2
	Immediate start to work	Early access to complete critical R&R needs at facilities	1
Plant Sites	Neighboring land use	Is the land use compatible with new/expanded facility	2
	Land ownership	Is new land acquisition required	1
	Existing impacts	Does this reduce existing odor, noise or traffic issues	1
	Flooding potential	Is the site vulnerable to flooding	2
Construction Impacts	Restoration requirements	Length of new pipeline under established road ways	1
	Traffic disruption	Duration of pipeline construction under major roadways	2
Operational Flexibility	Potential for Reuse	Ease of providing reuse water for industry and other users	1
	Servicing new Development	Ease of providing servicing of future developments	1
	Efficiency of O&M	Efficiency provided by centralized operations and maintenance	2
	Flexibility for future consolidation	Ability to consolidate with remaining plants in future	2

Having established the evaluation criteria, each of the 10 Wastewater Servicing Options was evaluated using a qualitative five-point scale that ranged from strongly negative to strongly positive with a neutral midpoint level. It should be emphasized that the evaluation is subjective in nature and seeks to determine the relative performance or predicted impact under each criteria of an option as compared to the performance or impact of the other servicing options. To reinforce that the evaluation is qualitative in nature, symbols rather than numbers were used to represent the "score" under each criteria. The evaluation of options is presented here in **Figure 1-19**.

Based on this evaluation, the highest ranked wastewater servicing options (in order of preference) are:

- Option 4D – Consolidate at new North Plant & Oso
- Option 2B – Consolidate at Allison and Oso
- Option 1 – Upgrade at the Existing Sites

Figure 1-19 Options Evaluation Matrix

Category	Sub-Topic	1	2A	2B	3A	3B	3C	4A	4B	4C	4D
											
Cost	Total Capital Cost	Strongly positive – capital cost less than $800M	Neutral - mid level capital cost of $900M to $1,000M	Positive - capital cost less than $900M	Negative - capital cost more than $1,000M	Negative - capital cost more than $1,000M	Negative - capital cost more than $1,000M	Neutral - mid level capital cost of $900M to $1,000M	Neutral - mid level capital cost of $900M to $1,000M	Neutral - mid level capital cost of $900M to $1,000M	Positive - capital cost less than $900M
Cost	Total O&M Cost	Negative - high level O&M cost more than $550M	Neutral - mid level O&M cost of $525M to $550M	Strongly positive - low O&M cost less than $500M	Neutral - mid level O&M cost of $525M to $550M	Neutral - mid level O&M cost of $525M to $550M	Neutral - mid level O&M cost of $525M to $550M	Positive - lower O&M cost of $500M to $525M	Neutral - mid level O&M cost of $525M to $550M	Neutral - mid level O&M cost of $525M to $550M	Strongly positive - low O&M cost less than $500M
Cost	Cash Flow	Strongly positive - max annual spend of approx $100M	Neutral - max annual spend of approx $200M	Neutral - max annual spend of approx $200M	Negative - max annual spend of approx $250M	Negative - max annual spend of approx $250M	Negative - max annual spend of approx $250M	Negative - max annual spend of approx $250M	Strongly negative - max annual spend of approx $300M	Strongly negative - max annual spend of approx $300M	Neutral - max annual spend of approx $200M
Receiving Streams	Maintaining base flow	Neutral - keeps all flows at status quo	Negative - reduce flows to Oso Bay	Neutral - keeps critical flows at status quo	Negative - reduce flows to Oso Bay	Strongly negative - reduce flow to Oso Bay, increase to Oso Creek	Negative - reduce flows to Oso Bay	Negative - reduce flows to Oso Bay	Strongly negative - reduce flows to Oso Bay, increase to Oso Creek	Negative - reduce flows to Oso Bay	Neutral - keeps critical flows at status quo
Receiving Streams	Effluent requirements	Negative - continues challenges in Oso Bay and Nueces River	Neutral - continues challenges in Nueces River	Negative - continues challenges in Oso Bay and Nueces River	Positive - allows lower treatment requirements	Neutral - continues challenges in Oso Creek	Neutral - continues challenges in Oso Creek	Positive - allows lower treatment requirements	Neutral - continues challenges in Oso Creek	Positive - allows lower treatment requirements	Neutral - lower treatment in north, challenges in Oso Bay
Receiving Streams	Local eco systems	Neutral - keeps status quo	Negative - potential impact at Blind Oso from loss of flow	Neutral - keeps status quo	Negative - potential impact at Blind Oso from loss of flow	Negative - potential impact at Blind Oso from loss of flow	Negative - potential impact at Blind Oso from loss of flow	Negative - potential impact at Blind Oso from loss of flow	Negative - potential impact at Blind Oso from loss of flow	Negative - potential impact at Blind Oso from loss of flow	Neutral - keeps status quo
Schedule	Phasing potential	Positive - can proceed with multiple projects at one time	Neutral - can proceed at two sites and with pipelines	Neutral - can proceed at two sites and with pipelines	Negative - requires all projects to be completed at same time	Negative - requires all projects to be completed at same time	Negative - requires all projects to be completed at same time	Neutral - can proceed at two sites and with pipelines	Neutral - can proceed at two sites and with pipelines	Neutral - can proceed at two sites and with pipelines	Neutral - can proceed at two sites and with pipelines
Schedule	Immediate start to work	Neutral - challenges at Oso, remainder available	Positive - can work adjacent to both existing plants	Neutral - challenges at Oso, remainder available	Negative - requires acquisition of land	Negative - requires acquisition of land	Positive - can work independently on new plant	Negative - requires acquisition of land	Negative - requires acquisition of land	Negative - requires acquisition of land	Negative - requires acquisition of land and working at Oso

Legend

Strongly Negative | Negative | Neutral | Positive | Strongly Positive

Category	Sub-Topic	1	2A	2B	3A	3B	3C	4A	4B	4C	4D
											
Plant Sites	Neighboring land use	Neutral - continues residential conflicts at Oso and Greenwood	Positive - uses sites with good buffers	Neutral - continues residential conflicts at Oso	Strongly positive - new plant in industrial area	Negative - new plant in generally residential area	Negative - new plant in generally residential area	Positive - uses sites with good buffers	Negative - new plant in generally residential area	Neutral - Continues residential conflicts at Oso and Greenwood	Neutral - Continues residential conflicts at Oso
Plant Sites	Land ownership	Positive - no new land required for 20 years	Strongly positive - no new land required for >30 years	Strongly positive - no new land required for >30 years	Negative - land required for new plant	Strongly negative - new land required in residential area	Strongly positive - no new land required for >30 years	Negative - land required for new plant	Negative - land required for new plant	Negative - land required for new plant	Negative - land required for new plant
Plant Sites	Existing impacts	Neutral - continues status quo	Positive - removes impacts at Greenwood and Oso	Neutral - Continues impacts at Oso	Positive - removes impacts at Greenwood and Oso	Neutral - continues impacts at Oso Creek	Neutral - continues impacts at Oso Creek	Positive removes impacts at Oso Creek	Neutral - continues impacts at Oso Creek	Neutral - continues impacts at Oso Creek	Neutral - continues impacts at Oso Creek
Plant Sites	Flooding potential	Negative - requires new flood wall at Greenwood	Positive - removes impact from flooding at Oso Creek	Positive - removes impact from flooding at Oso Creek	Positive - removes impact from flooding at Oso Creek	Neutral - requires additional flood protection along Oso Creek	Neutral - requires additional flood protection along Oso Creek	Positive - removes impact from flooding at Oso Creek	Neutral - requires additional flood protection along Oso Creek	Neutral - requires additional flood protection along Oso Creek	Positive - removes impact from flooding at Oso Creek
Construction Impacts	Restoration requirements	Strongly positive - minimal new pipelines required	Negative - new pipelines required	Negative - new pipelines required	Strongly negative - requires extensive pipeline construction	Strongly negative - requires extensive pipeline construction	Strongly negative - requires extensive pipeline construction	Negative - new pipelines required	Negative - new pipelines required	Negative - new pipelines required	Negative - new pipelines required
Construction Impacts	Traffic disruption	Strongly positive - minimal new pipelines required	Neutral - new pipelines in generally open areas	Neutral - new pipelines in generally open areas	Negative - pipelines cross built up areas	Negative - pipelines cross built up areas	Negative - pipelines cross built up areas	Neutral - new pipelines in generally open areas	Neutral - new pipelines in generally open areas	Negative - pipelines cross built up areas	Neutral - new pipelines in generally open areas
Operational Flexibility	Potential for Reuse	Negative - Long distance to servicing industry	Positive - Allison plant close to industry	Positive - Allison plant close to industry	Strongly positive - North plant close to industry	Negative - Long distance to servicing industry	Strongly negative - Longest distance to servicing industry	Positive - North plant close to industry	Negative - Long distance to servicing industry	Positive - North plant close to industry	Positive - North plant close to industry
Operational Flexibility	Servicing new Development	Negative - needs a new plant to service new growth	Neutral - requires expansion of pumping and plant	Neutral - requires expansion of pumping and plant	Neutral - requires expansion of pumping and plant	Strongly positive - close to new growth	Strongly positive - close to new growth	Positive - can readily provide capacity for new growth	Strongly positive - close to new growth	Strongly positive - close to new growth	Positive - can readily provide capacity for new growth
Operational Flexibility	Efficiency of O&M	Strongly negative - continues operations at 6 sites	Neutral - consolidate to two main plants, one new	Neutral - consolidate to two main plants, one new	Strongly positive - consolidate to one main new plant	Strongly positive - consolidate to one main new plant	Strongly positive - consolidate to one main plant	Positive - consolidate to two main plants, both new	Positive - consolidate to two main plants, both new	Positive - consolidate to two main plants, both new	Neutral - consolidate to two main plants, one new
Operational Flexibility	Flexibility for future consolidation	Negative - does not facilitate future consolidation	Neutral - can consolidate Whitecap but not Broadway	Neutral - can consolidate Whitecap but not Broadway	Neutral - can consolidate Broadway but not Whitecap	Negative - does not facilitate future consolidation	Neutral - can consolidate Whitecap but not Broadway	Positive - can consolidate both Whitecap and Broadway	Neutral - can consolidate Whitecap but not Broadway	Positive - can consolidate both Whitecap and Broadway	Positive - can consolidate both Whitecap and Broadway
Overall Rating		102	101	104	95	78	86	100	84	92	106

1.5.6 Recommended Wastewater Servicing Option

The highest ranked wastewater servicing option (identified as 4D) is to consolidate future wastewater treatment around two main facilities – a new North plant and the Oso plant. This is the recommended option.

The components of this recommended Option 4D are shown on **Figure 1-20** and summarized in **Table 1-57**.

Figure 1-20 System Configuration of Recommended Option - Option 4D

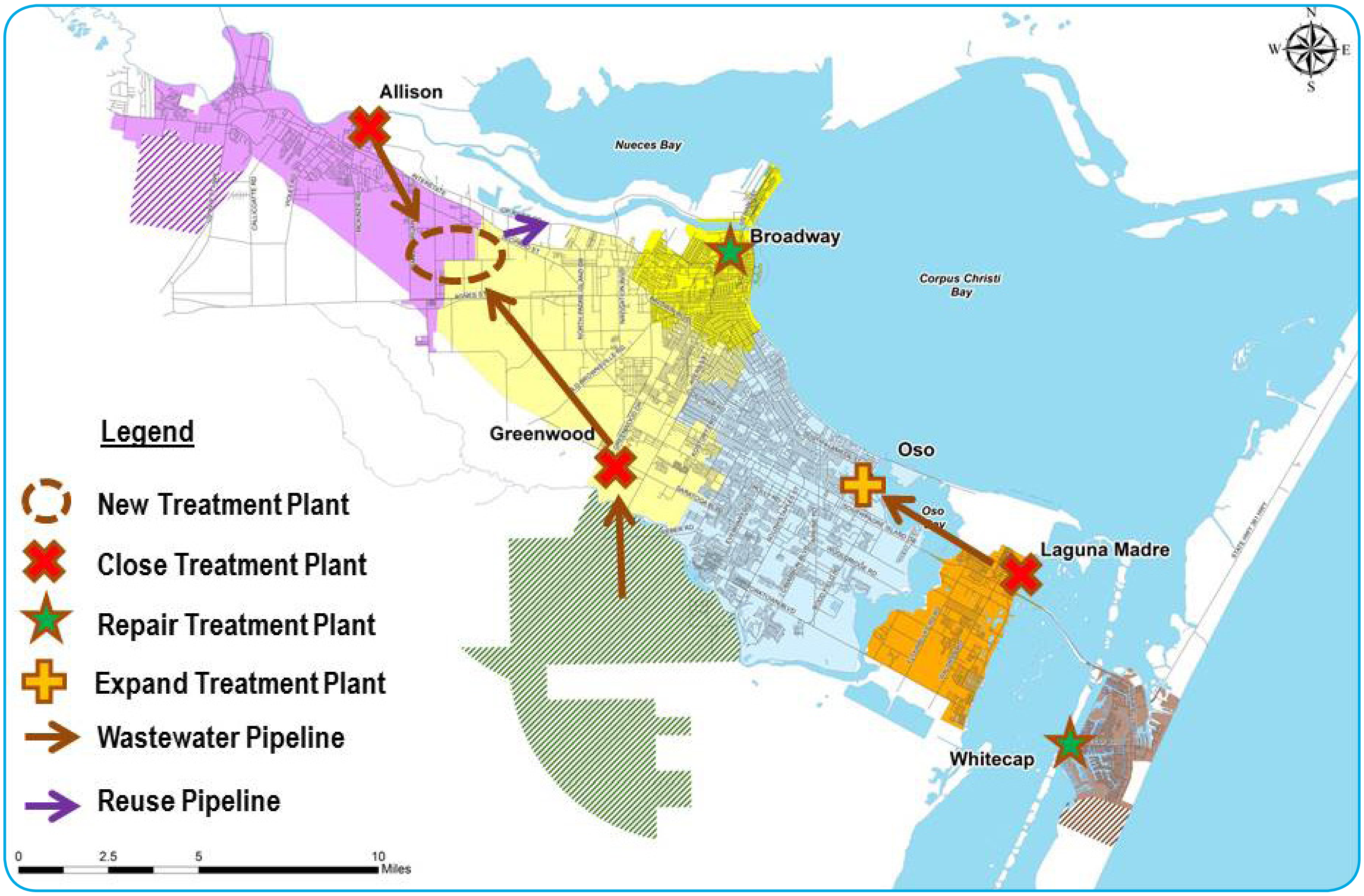


Table 1-56 Key Infrastructure Requirements for recommended Option 4D

Plant	Infrastructure Requirements
Collection System	• Repair system in accordance with requirements to reduce overflows • Redirect some flow from Greenwood to Broadway sewer shed in the interim
Allison	• Repair over next 10 years • Decommission the plant after 10-years and build new pumping station to direct flows to the new North treatment plant.
North Treatment Plant	• Construct a new 12 MGD facility at the North treatment plant site in the next 5 years. • Provide effluent reuse facilities for industry in next 10 years
Greenwood	• Repair during 0 to 5 year period • Demolish the plant and decommission the existing site after the 5 year time period. • Build a new pumping station at the Greenwood site to transfer wastewater from Greenwood to the new North treatment plant site.
Broadway	• Repair over next 20 years
Oso	• Repair plant over next 20 years • Upgrade plant to BNR and expand to 20 MGD over next 5 years.
Laguna Madre	• Repair the existing plant over the next 5 years • Demolish the plant and decommission the existing site after the 5 year time period. • Build a new pumping station at the Laguna Madre plant to transfer wastewater from Laguna Madre to the Oso treatment plant.
Whitecap	• Repair over next 20 years

Implementation Phasing Plan

2.0 Implementation Phasing Plan

2.1. Introduction

Implementation of the wastewater management servicing plan is recommended to be undertaken over a series of phases in order to balance the use and availability of critical resources over a number of years. These critical resources including access to capital to fund the work; access to engineering and program management expertise; ability of City staff to administer the plan while other capital programs are ongoing; access to adequate contractors and trades; availability of key construction material inputs; and ability of operational staff to maintain the system while being trained on new or upgraded facilities.

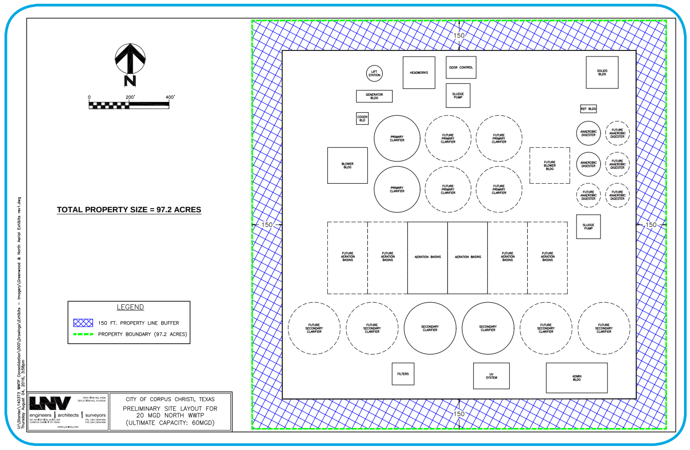
An outline of the preliminary proposed phasing is provided in the following sections.

2.1.1 First Phase

North

The new North treatment plant would be constructed in the northwest quadrant of the City in an area located between the CC International airport and the I-37 Highway. A specific property for this new plant has not been identified and it is recommended that the City investigate available parcels of approximately 80 acres or more in area, which would support an ultimate future site capacity of 60 MGD. The construction of this North plant would be staged to coincide with decommissioning of other facilities and increased flow from planned growth. The first phase of the North plant is expected to be a 12 MGD facility that would allow for decommissioning of the Allison and Greenwood plants. The new North plant would be provided with state of the art equipment allowing for an advanced level of treatment including screening and grit removal, primary clarification, fine bubble aeration, tertiary filtration, UV disinfection, anaerobic sludge digestion and thickening. A conceptual site plan for this new North plant is provided in **Figure 2-1**.

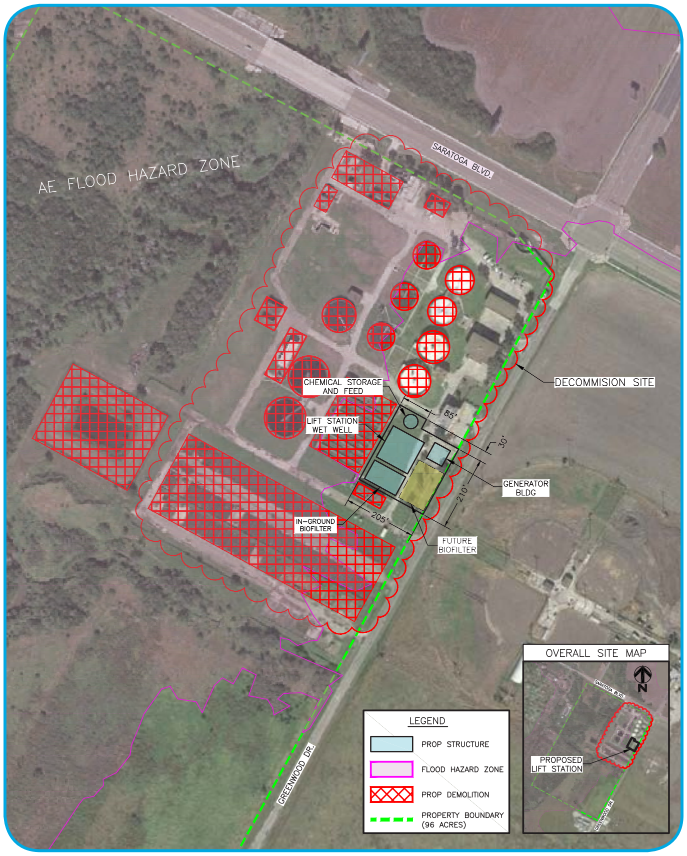
Figure 2-1 Conceptual Site Plan for New North Treatment Plant



Greenwood

For the Greenwood service area, there is the potential for considerable future flow to occur depending on the City's policies with respect to planned new development. It is therefore proposed that the Greenwood pump station be located on the site of the Greenwood wastewater plant and planned in a flexible manner to allow construction in phases to match future flows. The first phase has been conceptually sized as a 30 MGD pump station with 42" diameter force main which is adequate for conveying the existing peak flows from the Greenwood facility to the North plant. The site layout plan will allow for an ultimate 90 MGD pump station and additional twinned force main which will be needed prior to future servicing of new developments south of Oso Creek. After the first phase of the pump station is commissioned, the remainder of the existing Greenwood plant will be decommissioned and the site can be made available for other uses. A conceptual layout of Greenwood and decommissioning of the existing treatment plant is provided in **Figure 2-2**.

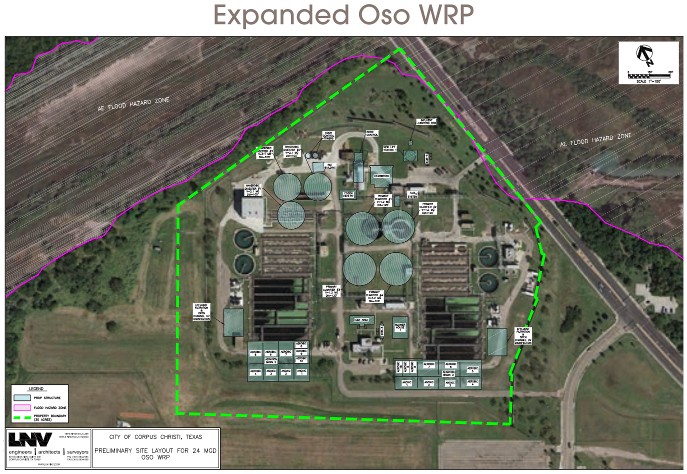
Figure 2-2 Greenwood Pumping Station Site Plan



Oso

The expansion and upgrade of the Oso facility is proposed to include a full overhaul of all unit processes to bring these up to state of the art technology, providing for advanced levels of treatment with nutrient removal capability. The final treatment configuration will be determined after verification of the permitted effluent standards by TCEQ. In addition to upgrading with new technologies, the plant will be expanded to a 20 MGD average annual flow capacity initially and ultimately 24 MGD within the existing fence line. A conceptual site plan for the expanded Oso plant is shown on **Figure 2-3**.

Figure 2-3 Preliminary Layout for Upgraded and Expanded Oso WRP



Laguna Madre

After the Oso plant is upgraded and expanded, a pump station and force main will be constructed for conveyance of the wastewater from the Laguna Madre service area to Oso. It is proposed that the pump station be located on the existing site of the Laguna Madre wastewater plant and is expected to require a 10 MGD pump station with a 20" diameter force main to convey the peak wastewater flow to the Oso Plant. This initial conceptual sizing for this Laguna Madre PS and force main assume that it would be sized for the future anticipated peak flow from this service area. It is noted that the preferred route for the force main is through the NAS lands which are currently serviced with an independently owned and operated wastewater facility. The City and NAS are currently in discussion over potential opportunities to rationalize their separate wastewater operations, and this will be reviewed further prior to finalizing the size and route for the Laguna Madre force main. After the pump station is commissioned, the existing Laguna Madre plant will be decommissioned and the remaining site area can be made available for other uses.

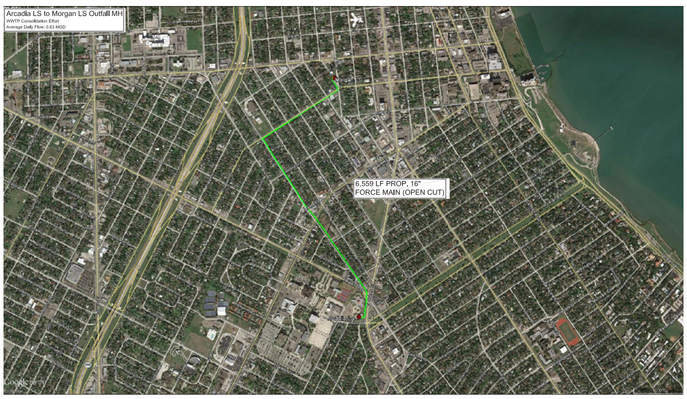
Collection System

During the initial phase of the wastewater servicing plan, a range of collection system improvements will be undertaken as outlined in the Consent Decree currently under negotiation between the City and EPA. Many of these improvements will be located in the Broadway, Oso and Greenwood service areas and address existing deficiencies with service laterals, sewers and force mains via local pipeline rehabilitation, repair or replacement. Following these improvements, it is expected that the City will see a reduction in the extraneous flows due to inflow/Infiltration (I/I) and an associated reduction in the peak flows arriving at these facilities. The New Broadway facility has been constructed to meet an 8 MGD average annual capacity and a 20 MGD peak capacity. The design allowed for future capital improvements to increase the peak flow capacity to 40 MGD, but this work is currently on hold and will be deferred pending a review of the actual observed peak flows observed following the collection system improvements.

Additional collection system modifications are under consideration that can rationalize the service area boundaries and provide best use of existing available treatment capacity. These potential projects include flow diversion from one or more of the Port/Pearse, McBride and Arcadia Lift Stations to the Broadway plant to reduce pressure on the Greenwood plant and better use the new Broadway Treatment facilities. The total potential for diversion from the Greenwood to the Broadway sewer sheds is estimated as 2 MGD on an annual average flow basis. Preliminary conceptual routing and associated infrastructure requirements for two of these potential flow diversions are presented here on **Figures 2-4** and **2-5**.

Figure 2-4 Potential Force Main Routing for Flow Diversion from McBride Lift Station to Broadway WWTP

Figure 2-5 Potential Force Main Routing for Flow Diversion from Arcadia Lift Station to Broadway WWTP



Similarly, the existing Woodridge and Williams lift stations both currently pump to the Oso plant. These can readily be modified and provided with flexibility to pump flow over to the Greenwood plant site to relieve flow in the Oso service area. These and other collection system boundary adjustments will be implemented progressively as needed to balance flows during the time while the North plant is under construction.

2.1.2 Second Phase

The second major phase of the management servicing plan is proposed to include the consolidation and decommissioning of the Allison WWTP. For purposes of this report, it has been assumed that the preferred strategy is for this work to be undertaken following construction and commissioning of the North plant.

Allison

Following construction of the North plant, pump stations and force mains will be constructed to allow conveyance of the wastewater from the Allison service area to the new facility. It is proposed that the Allison pump station be located on the existing site of the Allison wastewater plant and is expected to require a 15 MGD pump station with a 30" diameter force main to convey the peak wastewater flow from Allison to the North Plant. This initial conceptual sizing for this Allison PS and force main assume that it would be sized for the future anticipated peak flow from this service area. Further analysis can be undertaken prior to detailed design to determine if either additional future force mains, a booster pump stations or similar alternative strategy may be desirable. After the pump station is commissioned, the existing Allison plant will be decommissioned and the site can be made available for other uses.

2.1.3 Future Phases

One major advantage of the preferred wastewater servicing plan is that it provides the City with considerable flexibility to adjust to future servicing requirements or regulatory conditions. Some of the scenarios are discussed below. Note that these potential capital projects have not been considered in the cash flow projections, since the timing and nature of these alternatives is uncertain.

Greenwood

As noted above, the Greenwood Pump Station will be planned to allow future expansion up to an expected ultimate 90 MGD peak capacity. This additional future flow could come from a variety of areas including new planned development south of Oso Creek or diversion of additional excess flow from new development in the existing Oso service area. Expansion of the Greenwood PS and construction of new force main capacity will be phased in as needed by these growth scenarios. Capital cost for these projects would need to be assessed against the new benefitting developments.

Broadway

The Broadway plant is about 5 years old and typically mechanical and electrical equipment is expected to last in the range of 20 to 30 years. That means that a major upgrade or rebuild may be needed in approximately 20 years. Rather than invest in a significant capital upgrade, the City may at that time prefer to transfer the flow over to the North Plant and expand that facility. This would have operational advantages and could provide a longer time savings through additional consolidation.

Whitecap

The Whitecap facility is located on a barrier island and is remote from the other larger mainland facilities. Consolidation of this service area as part of the wastewater servicing plan is not considered cost effective and the plant is appropriately sized for the projected future flow. It is therefore recommended that it be maintained in its current location with occasional upgrading or repair as required. However, it is recognized that this location is vulnerable to catastrophic damage should a major hurricane strike the area. If such a disaster caused significant damage to the Whitecap facility, the City may prefer to construct a pump station and force main to connect to the mainland wastewater system rather than invest in a replacement plant. A conceptual route for this potential force main crossing of Laguna Madre would follow the route of New Humble Channel up to Bluffs Landings on Flour Bluff. Based on analysis done previously by the City for a water main crossing, this route provides an advantage since it is along disturbed boating channels and would minimize impacts on sea grasses

Reuse

The preferred option identifies potential for producing reuse quality water for sale to industry along the Ship Channel. There are currently a variety of competing projects under consideration for additional process and cooling water to industry, including a pilot desalination facility. It is therefore proposed that the design of the North plant allow for future addition of the necessary polishing treatment processes for industrial reuse water production but that these elements are not included until and unless the City has assurance that there is a means for cost recovery through sale of water to industry.

2.2. Project Risk Assessment

2.2.1 Introduction to Risk Assessment

Many communities are using risk assessment to identify and quantify the severity of risk associated with capital projects. Each project has a different risk profile.

Typical risk categories for infrastructure service delivery projects in general and in joint public-private projects are:

- Site risk - a collection of risks that flow through the project land. An example of site risk is land acquisition, geotechnical, archaeological, existing condition, etc.
- Design, construction and commissioning risk – all risks leading to liabilities and costs related to the design, construction and commissioning of the project on budget and on schedule.
- Sponsor and financial risk – risks related to the sponsor's financial stability and security to protect the project on behalf of the public sector.
- Operating risk – the consequence of operating risk related to the cost of operating the facility exceeding projections and/or the performance of the facility not meeting projections.
- Market risk – risks related to the demand or price of the service resulting in not meeting the revenue projections etc.
- Network and interface risk – risks related to the point of intersection between privately provided services and government controlled networks or services and where there is an interdependency of performance.
- Industrial relations risk – risks related to labor disputes or action during construction and operational phases of the projects.
- Legislative and government risk – risks related to changes in legislation, government policy and the election of a new government that could impact the project.
- Force majeure risk – risks outside the control of either party that impedes the provision of services during the contract period.
- Asset ownership risk – risks related to the technical life of the project, or damage or destruction or premature obsolescence are some examples of this risk category.

Quantification of risks can assist decision makers in the selection of options and identification and mitigation of project specific issues. For the wastewater management plan the use of risk assessment provides a good technique to highlight the risks that are known at this time. As the project develops and more information becomes available the risk assessment can be updated. Proposed mitigation strategies are presented in **Section 4.4** of this report.

2.2.2 Risk Matrix

A preliminary risk matrix (**Table 2-1**) has been prepared for Option 4D. A variety of risk factors have been considered. These include siting risks, construction cost risk, constructability and a number of others. Each of these risks is ranked using a simple probability of occurrence using a 1 to 3 ranking. The risk impact is also ranked 1 to 3 with 1 being low impact and 3 being high impact. The factor of the probability and impact provides an overall risk factor. This technique is useful in providing a high level screening of risk factors. As the project develops more detailed risk assessment and workshops can be completed with various stakeholders and city staff.

2.2.3 Risk Ranking

The project was ranked in consideration of the risk categories applicable to each of the major project components. The risks associated with each site under consideration for construction of facilities have been assessed. It also considers the risk associated with the various conveyance systems, social risks and construction risks.

Table 2-1 Preliminary Risk Matrix

RISK IDENTIFICATION		RISK ASSESSMENT		
Category	Risk	PROB. HIGH = 3 MED = 2 LOW = 1	IMPACT HIGH = 3 MED = 2 LOW = 1	RISK FACTOR HIGH > 5 MED 4 - 5 LOW < 4
Risk Option 4D				
	Greenwood WWTP site			
Site	• Flooding may occur before new North plant is constructed.	3	2	6
	• Nuisance impacts on neighbors before new plant is constructed.	2	2	4
	• New North plant construction delayed increasing sustaining capital spend at Greenwood.	2	2	4
	• Local stakeholders and/or regulator objects to ceasing discharge into Oso Creek.	1	3	3
	• Unable to get easements for the proposed force mains	1	3	3
	New North Plant			
Site	• City unable to find a suitable site in the proposed area.	1	3	3
	• Significant public opposition to a new North plant	2	3	6
	• Plant construction delayed.	2	3	6
	• Discharge permit to ship channel is delayed or denied.	1	3	3
	• Impact of new plant on adjacent residents	1	2	2
	Oso WRP			
Site	• TCEQ denies new effluent permit for plant	2	3	6
	• Adjacent residents oppose the expansion of the plant	3	2	6
	• Plant constructability negatively impacted by existing configuration	3	3	9
	• Expansion cost higher than estimated	2	3	6
	Allison WWTP			
Site	• Environmentalists oppose the cessation of the current effluent discharge.	2	2	4
	• Neighborhood impacts associated with proposed pipeline construction to new North plant.	2	3	6
	• Increased sustaining capital spend due to delay in transferring flow to North plant.	2	2	4
	Laguna Madre			
Site	• Neighborhood impacts associated with proposed pipeline construction to Oso WRP	2	2	4
	• Increased sustaining capital spend due to delay in transferring flow to Oso.	2	2	4

RISK IDENTIFICATION		RISK ASSESSMENT		
Category	Risk	PROB. HIGH = 3 MED = 2 LOW = 1	IMPACT HIGH = 3 MED = 2 LOW = 1	RISK FACTOR HIGH > 5 MED 4 - 5 LOW < 4
Stakeholders	• General Public Acceptance of plan	2	2	4
	• Mitigation Strategies / Costs higher than anticipated	2	2	4
	• Loss of reuse water at locations that currently receive it.	2	1	2
	• Social Concerns (concern with rate increases even though plan is one of least expensive)	2	2	4
Engineering	• Treatment Technology Selection	2	1	2
	• Resource Recovery	2	2	4
	• Foundation / Site Conditions	2	1	2
Financial	• Capital Cost / Affordability	2	3	6
	• Anticipated Operations / Maintenance Costs savings not realized	2	3	6
	• Lack of Available Funding	2	3	6
	• Funding Conditions / Restrictions	2	2	4
	• Cost Escalation	2	2	4
	• Contingency Items	2	2	4
	• Financing Costs	1	1	1
Procurement	• Procurement Strategy	2	1	2
Construction	• Cost higher than anticipated	2	3	6
	• Market Conditions not conducive to competitive bidding	1	3	3
	• Schedule / Delays delaying O&M savings.	2	3	6
	• Changes / Claims	2	2	4
Other	• Natural Disaster (hurricane)	1	3	3
	• City doesn't have sufficient staff to administer the wastewater capital program according to the schedule	2	3	6
	• Treatment System Failure (existing plants)	3	2	6
	• Archaeological Conditions	1	2	2

2.3. Proposed Implementation Plan and Project Delivery

2.3.1 Project Delivery Options

The use of terms and processes related to project delivery models are in the end all related to the degree of risk transfer or level of risks assumed by the private sector versus those retained by the public sector. Project risk is defined as the probability of an unfavorable event having a negative impact upon a project investment. Risk can be managed and/or mitigated. The selection of the appropriate project delivery method is based upon mitigation or delegation of project specific risks to those best able to manage them. A summary of available alternative delivery methods is summarized in the text that follows.

Design/Bid/Build (DBB) is the traditional method of project delivery being used successfully for most water and wastewater capital projects in the United States. This method involves three basic participants: design professional (DP), general contractor and City (operating agency). Typically, a sequential approach is utilized for the design, construction and operation. In an attempt to integrate expertise of the participants, techniques including constructability reviews, operability reviews and value engineering are incorporated into the design bid build process. After construction, facilities are operated by City staff.

The first step of this method is to retain a design professional through a qualifications based selection (QBS) process. The design professional's responsibilities include determining facility requirements for the City, and defining (implicitly) many of the risk elements of the project. The design professional is responsible for the engineering design of the facility and the development of contract documents for competitive bidding by the City.

In the second step, bids are tendered in conformance with the contract documents and the lowest responsive, responsible bidder is selected, without negotiations, to construct the facilities. Either the design professional, an independent engineer, or City staff assures that the builder's performance is in compliance with the contract documents and assists in resolving any issues or conflicts or both. The City retains design liability.

Construction Manager at Risk (CMAR) has two major participants in the contract with the City. The design professional is contracted by the City through a qualifications based selection (QBS) process and is responsible for the design. The construction manager is contracted by the City and is placed at risk early in the project for delivering the work within a guaranteed maximum price. The construction manager provides coordination services in lieu of a general contractor and provides design phase input and assistance. At some point in the design process, the construction manager and the City establish a Guaranteed Maximum Price (GMP) to which the construction manager is contractually bound. The design professional provides conceptual and detailed requirements for the project use in developing a GMP. The City is involved during the design phase by bringing operations expertise into the project; however, once the GMP is established, changes in the project scope may impact the GMP. The construction manager provides design phase consultation in evaluating costs, schedule, implications of alternative designs and systems, and materials; and assumes the risk of construction after the GMP is established. The construction manager self performs portions of the construction and selects qualified construction subcontractors for the remaining portions to complete the work.

The contract between the City and CM is typically structured to include an "off-ramp" at the GMP stage. This allows the City to terminate the contract with the CM, direct the design professional to complete the design, and bid the project as a DBB if the GMP is considered too high.

The selection of the CMAR by the City is based on their qualifications and generally occurs shortly after the selection of the design professional. The construction subcontractors are usually not selected until after the design phase is complete and are not involved in the design phase of the project.

This method is best suited for large, new or rehab projects that are schedule driven, are difficult to define, or require construction input during the design phase. This method is least suited for small projects, or where projects are very well defined.

Design/Build with City Operations involves a single entity contracted to provide both design and construction services. The City usually develops performance requirements for use in securing a design-builder. The design-builder contracts directly with subcontractors and is responsible for delivery and performance of the project, and specifically assumes design as well as construction liability. Selection of the design-builder is based on the proposal offering the best value to the City, in terms of qualifications, technical and business merit, and project costs. Independent technical, legal and/or financial consultant(s) may serve as City's agent(s) in managing the procurement process, establishing performance criteria and monitoring performance. A conceptual to preliminary design (10 to 30 percent) may be prepared at the direction of the City to detail the prescriptive and performance requirements of the project. The design/build contract is negotiated based on a formal Proposal.

The City can also execute the project under what is referred to as a progressive design build (PDB). The City has more input to the design under a progressive design build and can make changes as design progresses. Although the DB team provides an indicative price upon proposal submission the Contractor is not bound to this price. However, like CMAR the DB team will produce a GMP at a defined point in the design process (typically 60 to 70% design) which the team will be responsible for meeting. There is typically an opportunity for an "off ramp" at the GMP stage if the submitted price is not acceptable to the City.

This delivery method requires the City to be knowledgeable of its needs and objectives for the project and be directly involved in the process. A key element to success is trust between the City and the design-builder, and the opportunity and necessity for the design professional and contractor to work closely together to develop the winning Proposal. For this method, the design-builder is provided with a description of the desired end-product or project outcome. The design-builder is responsible for developing the detailed design and specifications, selection of material and equipment, constructing the facility and meeting performance requirements.

Proposers, oftentimes a team of design professional(s) and contractor(s), respond to a Request for Qualifications (RFQ). A short-listed group of qualified proposers responds to a Request for Proposals (RFP) by submitting technical, price and business proposals. The competition process, established early on in the procurement process by the City, ensures an award; which is primarily based on price, technical and financial qualifications.

Design/Build/Operate (DBO) is similar to the design/build method except that the long-term operation and maintenance (typically 20 years) of the facility is combined with the design and construction into a single service contract. A variation to the long term operations and maintenance contract is to have a period of performance of less than 5 or 10 years, although the trend in today's market is for 20-year contract operation periods. As with D/B, independent technical, legal and/or financial consultant(s) may serve as City's agent(s) in managing the procurement process, establishing performance criteria and monitoring performance.

In the DBO method, the City has the ability to transfer a significant amount of responsibility and risk associated with a project to a single point of responsibility. That single party is responsible for the integration of design, construction, operation and maintenance expertise for the development of the facility in accordance with performance criteria established by the City.

The primary purpose for combining the design, construction, operation and maintenance into a single contract is to effectively integrate all three areas of expertise and responsibility during all phases of the project. The single party, who will guarantee the performance of the full service contract, has the incentive to balance cost efficiencies and long-term operation and maintenance costs and establish an optimum lifecycle analysis. At the end of the contract cycle when the facilities are converted to City operations, contract requirements will need to state and prove that the facilities are fully functional, systems can continue to achieve permit compliance and condition of the equipment is appropriately maintained during the life of the contract.

Proposers, generally a team of a design professional(s), contractor(s) and an operation and maintenance organization, respond to a Request for Qualifications (RFQ). A short listed group of qualified proposers then respond to a Request for Proposals (RFP) by submitting technical, commercial and legal proposals. The negotiation process, established early on in the procurement process by the City, ensures an award, which is primarily based on price, technical and financial qualifications. Contract negotiations are permitted, and it is not required that the lowest price proposer be selected if another proposer offers the best value overall.

During the contract period, the City retains the ownership of the asset and responsibility for rate setting, billing, collection and administrative services.

The **Design/Build/Maintain (DBM)** method is similar to DB, except that the longer term maintenance of the facility is combined with the design and construction into a single contract with the City operations. An independent consultant(s) may serve as the City's agent by assisting in establishing performance and maintenance requirements along with process performance and monitoring performance. The primary purpose for including an extended maintenance period (5 to 20 years) is to assure that the quality of equipment provided and the quality of installation are paramount. It moves the project delivery method closer to design/build/operate, except it allows for continued operation by the City.

In the DBM method, the City has the ability to transfer significant responsibilities and risks associated with a constructed project to a single point of responsibility. The single party is responsible for the integration of design, construction and maintenance of the facility for a significant period of time in accordance with performance criteria established by the City. The City relinquishes significant project control to the DBM for design, construction and maintenance aspects of the facility. Since selection of the design-builder is not generally based solely on price, the City has the opportunity to consider qualifications and experience in the selection process. Since the City will own and operate the facilities, it must carefully evaluate standards of proposed predictive, preventive and corrective maintenance, as well as repair and replacement to ensure that the facilities operate efficiently and that the condition of equipment is appropriately maintained during the life of the contract. Standards need to be established so that at the end of the contract period, equipment is left in satisfactory condition.

Proposers, generally a team of a design professional(s), contractor(s) and maintenance organization, respond to a Request for Qualifications (RFQ). A short listed group of qualified proposers then respond to a Request for Proposals (RFP) by submitting technical, commercial (business) and financial proposals. The negotiation process, established early on in the procurement process by the City, ensures an award, which is primarily based on price, technical and financial qualifications.

The **Design/Build/Finance/Operate (DBFO)** method is similar to the DBO Method described previously except that the facility is financed by the DBFO entity during the design, construction and long-term operations period of the facility. DBFO is also sometimes referred to as **P3 (Public-Private-Partnership)**. As with the DB method, independent technical, legal and/or financial consultant(s) may serve as the City's agent(s) in managing the procurement process, establishing performance criteria and monitoring performance.

Service fee includes an allowance for construction debt service (as well as its operating and maintenance costs), and as a result the City will have no direct bond or debt service liability. If the contractor fails to provide service, the City can withhold the periodic service payments from the contractor, which includes the repayment of capital and interest. In extreme circumstances of default, the City can terminate the service contract.

During the contract, the City retains ownership of the asset and also the responsibility for rate setting, billing, collection and administrative services.

The **Design/Build/Finance/Own/Operate (DBFOO)** method is similar to the DBFO Method described above except that the facility is owned by the DBFOO entity during the long-term operations period of the facility. With this delivery method, the project is financed by the DBFOO entity. Again as with the DB method, independent technical, legal and/or financial consultant(s) may serve as the City's agent(s) in managing the procurement process, establishing performance criteria and monitoring performance.

The DBFOO contractor, as the tax beneficial owner, will depreciate the project and contribute equity, which will reduce the amount of debt needed to finance the project. As a tradeoff, the contractor will own the project when the service contract expires, and the City must then purchase or rent the facilities at fair market value if it wishes to continue to receive service from the plant.

The service fee includes an allowance for the contractor's debt service (as well as its operating and maintenance costs), and the City will have no direct bond or debt service liability. If the contractor fails to provide service, the contractor does not receive payment. If a resolution cannot be reached between the involved entities, termination of the service contract may occur with the project ownership reverting to the City without cost. The potential for such a provision can take the place of a service contract guarantee by the contractor.

During the contract, the City retains the responsibility for rate setting, billing, collection and administrative services.

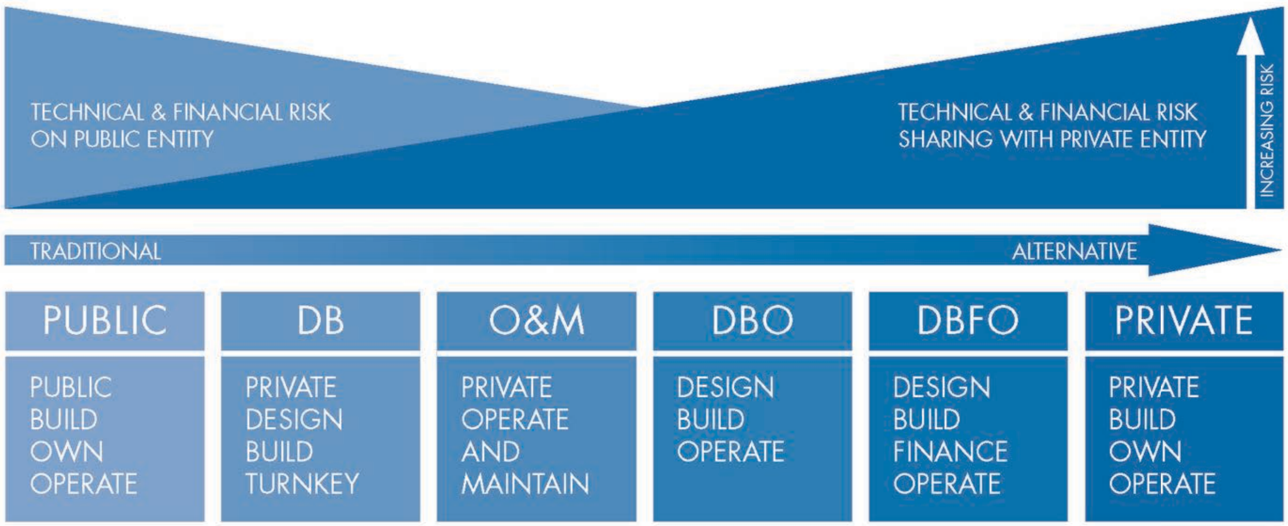
The potential "value for money" increases with increasing private participation in the project. This comes with reduced owner control and higher procurement costs. The key to delivery of any project is to ensure that the "value-for-money" benefits outweigh the cost impact of that delivery. Therefore, it becomes important for the public sector to fully appreciate the risks related to the project and objectives the project is seeking to meet. **Table 2-2** provides at a glance the sources for "value for money" or increased cost impact under each delivery model

Table 2-2 Comparison of Project Delivery Options - Value for Money and Increased Cost

Source For:	Project Delivery Method			
	DBB	DB	DBO	DBFO (P3)
Value for Money				
Better allocation of Risk Transfer	Very low	Low	Medium	High
Reduced Whole Life Cycle Costs	Low	Low	Medium	High
Better Incentive to Perform	Low	Medium	High	Very High
Acceleration of Infrastructure Provision	Low	Some	Some	Medium
Faster Implementation	Low	Medium	High	Very High
Increased Costs				
Procurement Costs	Low	Medium	High	High
Private Finance Premium	None	Low	Low	High
Tax Leakage	None	None	Medium	High
Profit Taking	Medium	Medium	High	High

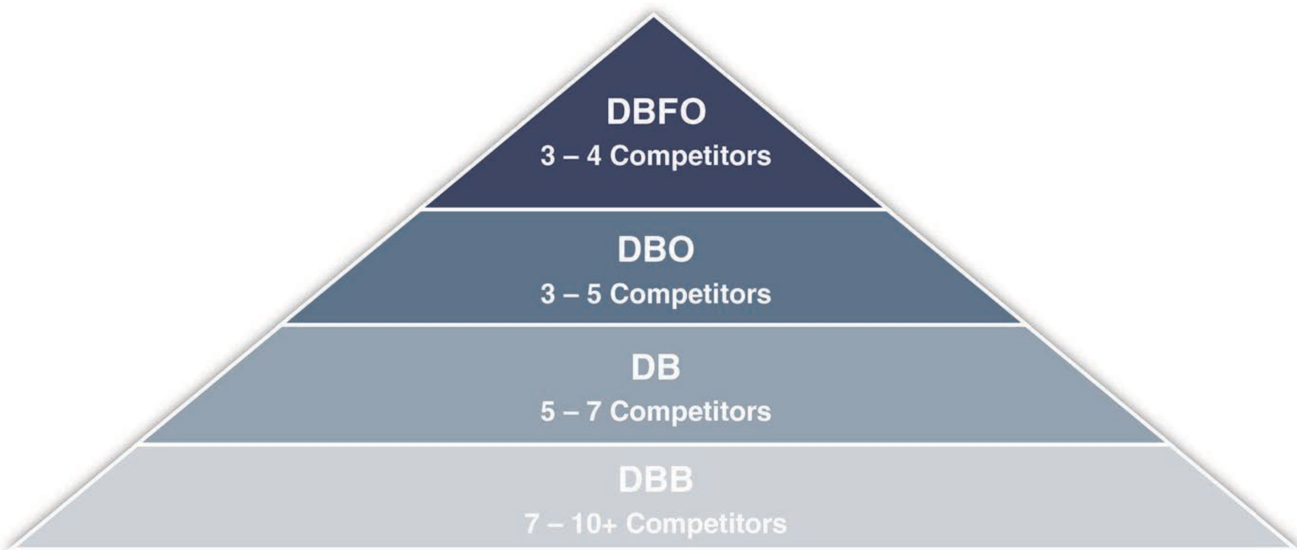
A public entity gives up greater control over a project as they transfer risk to a private enterprise. This is illustrated in **Figure 2-6**.

Figure 2-6 Relative Risk Transfer with Various Alternative Delivery Approaches



In our experience the number of bidders on a project is driven by the chosen delivery method. We have typically seen more competitors bid DBB projects with fewer bidding DBFO or P3 pursuits. However, the more sophisticated delivery approaches tend to attract larger more sophisticated entities. The relative number of bidders typically bidding alternative water delivery projects is as indicated here in **Figure 2-7**.

Figure 2-7 The Project Triangle - Anticipated Number of Bidders for Various Project Delivery Approaches



The Texas Legislature enacted enabling legislation starting around 2011 to allow delivery of civil projects, including water infrastructure projects, using alternative delivery methods such as Construction Manager at-Risk (CMAR), Design Build (DB), and Public Private Partnership (P3) and their variations. A number of water projects have been undertaken via alternative delivery in the last few years and interest is growing among water utilities to use these methods. A summary of some recent Texas water project undertaken via alternative delivery is summarized as **Table 2-3**.

Table 2-3 Examples of Recent Alternative Delivery Water Projects in Texas

City/Utility	Project	Project Size	Delivery Method	Primary Driver for Selected Delivery Method
SAWS	Vista Ridge Water Supply Project	$450 M	P3	Transfer of risk of capital funding to private sector eliminating the need to bond the project.
City of Midland	T-Bar Well Field	35 MGD well field	P3	City was essentially out of water due to drought. Project timing drove decision to go P3.
City of Houston	North East Water Treatment Facility	$1 Billion 240-mgd expansion	PDB	City needs to be off groundwater by 2024 so timing was the driver.
Austin	80-mgd North Water Treatment Plant	$500 M	CMAR	One of the primary drivers was to better manage constructability risks.
San Jacinto River Authority	30-mgd WTP	$150M	CMAR	Primary driver was to minimize constructability risks and minimize construction cost overruns.

2.3.2 Proposed Implementation Plan

2.3.2.1 Summary of Key Project Elements and Associated Risks

The key project elements associated with implementation of Option 4D along with the key implementation risks are summarized here in **Table 2-4**. Rehabilitation and small upgrade projects identified in the physical condition survey would likely be delivered under traditional DBB delivery or some form of job order contracting (JOC) arrangement.

Table 2-4 Key Project Elements and Associated Critical Implementation Risks

Project	Time Frame	Estimated Cost ($M)	Key Risk Elements
Oso WRP BNR upgrade and Expansion	0-5 year	$72 M	• Constructability associated with existing plant • Impact of construction on existing plant operations. • Inability to secure discharge permit. • Higher cost due to unforeseen circumstances. • Estimated operations cost savings not achieved.
Greenwood PS and Force main	0-5 year	$73 M	• Ability to secure required easements for force main. • Delay in PS and force main construction delays flow transfer to North plant and increases Greenwood WWTP sustaining capital spend. • Traffic impacts during construction. • Flooding of construction site.
Laguna Madre PS and Force main	6-10 year	$18 M	• Ability to get permit for Oso Bay pipeline crossing. • Securing required easements for force main. • Traffic impacts during construction.
New North WWTP	0-5 year	$103 M	• Ability to secure suitable project site. • Delay in getting effluent discharge permit for new plant. • New plant construction not completed on time resulting in additional sustaining capital spend at Greenwood. • Greenwood PS and force main not ready in time to commission new plant. • Operations cost savings not attained post construction.
Allison PS and Force main	11-15 years	$22 M	• Securing required easements for force main. • Traffic impacts during construction.

The key risks for the Laguna Madre PS and force main, Allison PS and force main and similar projects are related to securing easements and neighborhood issues such as traffic impacts. The City is likely in the best position to deal with these risks and a DB contractor would likely charge a significant risk premium to deal with these risks. In addition, all of these projects can be constructed by smaller contractors and none is particularly time sensitive. For these reasons, a competitive DBB procurement is most appropriate for these four projects.

The Greenwood PS and force main, North WWTP, and Oso WRP projects are time sensitive. The North WWTP will also not be able to be started up until the Greenwood PS is operational. This suggests the most appropriate approach to constructing these two projects is to execute these in parallel or as one large project. The most appropriate approach from a timing perspective would be to bid these projects as two separate projects allowing contractors and contracting teams to bid both and offer potential cost and schedule efficiencies to the City.

2.3.2.2 Multiple Criteria Analysis

The Multi-Criteria Analysis (MCA) is a qualitative analysis evaluation method which uses criteria based on the project goals and procurement objectives to compare the procurement models. A matrix evaluation is used to score and rank each of the alternatives. The projects that were evaluated via MCA included:

- Greenwood PS and Force Main
- New North WWTP
- Oso WRP BNR Upgrade and Expansion

The MCA matrix was constructed and presented during a workshop with City staff. In the dedicated workshop, qualitative criteria were reviewed for inclusion in the analysis and finalized. Weightings and scoring was then reviewed and finalized. The use of the Multiple Criteria Analysis helped determine the alternative that maximizes overall value of the project and also meets established project criteria compared against the others and leads to the recommended procurement model.

The following project delivery methods are recommended based upon the results of the MCA analyses:

- Greenwood PS and Force Main (DB)
- New North WWTP (DBO)
- Oso WRP BNR Upgrade and Expansion (CMAR)

The City plans to offer industrial reuse water to interested industries in the next 10-years. The timing for providing reuse water depends upon interest and ability to bring a minimum number of industries under contract to support the capital investment. The market risk and associated implementation is something the private sector is better equipped to manage than the City. For these reasons, we are recommending Industrial Reuse be implemented as a P3 project.

2.4. Interim Operations Plan

2.4.1 Introduction

The transition from the existing six plant operation to a four plant operation over the next 20 years requires careful planning to reduce the risk of over-spending on facilities destined to be taken out of service while maximizing O&M savings associated with anticipated staffing reductions.

The currently proposed project schedule allows the City to reduce the existing treatment plant upgrading costs presented in **Table 2-9** by approximately $133 M. As the facilities are improved, replaced, or removed from service, current staffing levels need to be adjusted to provide acceptable levels of operation and improved levels of maintenance. We are estimating an overall staffing reduction of 13 full-time equivalents (FTEs) during the first 15 years of the plan.

The estimated reduction in repair costs quoted previously were based on the facilities being removed from service in the first 5 years. Schedule slippage will require additional sustaining capital spend to keep existing facilities in service. Should schedule slippage occur, a review of the proposed projects should be conducted and implementation of deferred projects should be initiated.

2.4.2 Optimization of Existing Plant Repair Program

The consulting team met with senior plant operations staff to critically review the list of upgrading and repair projects identified during the physical condition survey and summarized in **Section 1.1.2**. The primary objectives of these meetings was to identify the most critical projects required to allow safe and reliable operations and ongoing permit compliance until such time as the facility is taken out of service. This optimization exercise reduces the capital cost for Option 4D by a further $ 50 M. The revised overall capital spend for Option 4D would therefore be $ 776 M. These projects should be reviewed with City senior staff prior to finalizing the overall capital program.

2.4.3 Staffing Transition Plan

The primary driver for selecting Option 4D was the potential for O&M cost savings through a reduction in current staffing levels. The consulting team reviewed existing labor categories as part of this assessment to confirm the City has the appropriate mix of skills on staff and in future. Our initial review suggests the City has a large number of staff working in operations and very few if any maintenance related staff. A transition plan is therefore required to begin transitioning plant staffing from a primarily operations oriented focus to a combination of operations and maintenance staffing. As vacancies occur in the facility staffing, a long term view of filling vacancies based on future skill needs should be utilized.

A preliminary recommendation on staffing levels by employment category over the next 15 years is presented in **Table 2-5**. The information provided in the table serves as the basis for development of a staffing transition plan in consultation with the City. The final plan needs to take into account anticipated attrition rates, existing skill levels and future skills requirements. Job descriptions need to be developed for each of the identified employment categories as part of the final staffing plan development.

Table 2-5 Preliminary Recommendation on Staffing Levels by Employment Category

FTE Classification	Existing	Proposed Year 5	Proposed Year 10	Proposed Year 15	Final Change from Existing
Lead Operator	4	3.5	3.5	3	-1
Operator	57	31	31	27	-30
Maintenance Mechanic		12	12	11	+11
Electrician		3	3	3	+3
Instrument Tech		3	3	3	+3
Laborer		1	1	1	+1
TOTAL	61	53.5	53.5	48	-13

Several assumptions were made concerning staffing levels. Staffing at New Broadway WWTP and Whitecap WWTP were maintained at current levels until such time as facility and equipment improvements were made and an extensive SCADA system has been implemented. SCADA allows for remote monitoring and control and is an integral part of the cost reduction plan. New facilities include extensive SCADA control, energy efficient systems and energy recovery where appropriate.

The staffing plan will need to include a significant increase in maintenance staffing levels. During the Facility and Operational assessments it became evident that required maintenance levels at all the facilities were not being met. In order to obtain cost savings over the study period, maintenance levels at the facilities must increase.

Maintenance staffing must be accomplished through skill based assessments of existing staff with reassignment and/or retraining and hiring from outside where required.

It should be noted, that the current recommendation is based upon completing the North WWTP as a DBO with operations provided by a private operator. This use of a private operator will reduce the overall staff contingent by a further 14 staff for the duration of the operating portion of the DBO contract. This issue requires further discussion with City management staff.

2.4.4 Operations During Construction

The three primary construction projects associated with Option 4D include the Greenwood PS and force main, new North WWTP, and Oso WRP upgrade and expansion. We are proposing the following during the construction phase of each project:

- The existing plant operations staff will continue to operate the Oso WRP during construction. The CM will prepare a detailed bypass and shut down plan in consultation with the City and design engineer to minimize the impact upon existing plant operations.
- The DBO contractor for the new North Treatment Plant will operate the new facility for a minimum of two years post-construction. We are proposing the operations of the new Greenwood PS be included in the DBO contractors scope of operation. The Greenwood PS and North WWTP operations would be transferred over to the City at the end of the operations contract.
- All other plants would continue to be operated by existing City O&M staff.

2.5. Stakeholder Management Plan

Although a great deal of information and knowledge has been gathered from stakeholders in this exploratory phase of the project, there is more to be learned as it relates to the development of a stakeholder management plan as we prepare for the planning and implementation phases of the project.

An effective stakeholder management plan is built upon a process that is values-based, decisions-oriented and goal-driven. Some of the key elements of a successful stakeholder engagement plan include:

- Effective stakeholder engagement acknowledges the desire for humans to participate in decisions that affect them.
- Effective stakeholder engagement facilitates understanding.
- Effective stakeholder engagement improves decisions by
  - bringing all perspectives to the table,
  - identifying critical issues early; and,
  - promoting opportunities for the building of understanding and balanced review of the problem or opportunity.

We are recommending a follow-up workshop to determine the stakeholder management plan elements for the next phase of the project once the City has adopted the proposed long term servicing option and associated program elements. This workshop will establish critical components to implement as part of the stakeholder engagement plan. Some of these elements may include:

- Stakeholder Baseline Data
- Background review of stakeholder groups
- Review and assessment of stakeholder issues and expectations
- Decision scope and timeline, as it relates to stakeholder engagement
- Stakeholder engagement process objectives
- Determine the level of engagement and promise the following to the stakeholders:
  - INFORM
    - > "We will keep you informed."
  - CONSULT
    - > "We will keep you informed, listen to your concerns and provide feedback on decisions made."
  - INVOLVE
    - > "We will ensure your concerns are directly reflected in the alternatives developed and provide feedback on decisions made."
  - COLLABORATE
    - > "We will look to you for the advice and innovation in formulating solutions and incorporate your advice and recommendations in to the decisions made."
  - EMPOWER
    - > "We will implement what you decide."
- Stakeholder Engagement Techniques
- Information required by stakeholders, related to (1) process and (2) content
- Input needed from stakeholders
- Engagement technique selection (some potential techniques for this projects below)
  - Public Information Campaign
  - Project Advisory Committee
- Feedback required from stakeholders
- Stakeholder Engagement Evaluation
- Evaluate each technique.
- How did it contribute to achieving the technique objective?
- Analyze each stakeholder engagement objective.
- How did it contribute to achieving the stakeholder management plan objectives?
- Evaluate the contribution of the overall stakeholder engagement process to the project planning and implementation phases of the project.
  - How did it contribute to achieving the overall project objective?

The project team recommends this stakeholder engagement planning workshop take place in early September, so the plan can be utilized and implemented during all future phases of the project. Workshop participants should include City staff and stakeholders who have been actively engaged in the WWMP project thus far.

Implementation Programming Schedule

3.0 Implementation Programming Schedule

3.1. Introduction

The proposed program implementation schedule is presented in this section. The main objectives were to:

- Identify the trigger factors for each of the key project elements.
- Identify critical risk factors associated with project implementation and the appropriate risk mitigation plan to address these.
- Present the final capital improvement plan schedule and projects.

3.2. Project Implementation Triggers

The City has asked that the consulting team identify implementation triggers for each of the key projects. It should be noted that reasonable implementation triggers have long passed for most if not all of the key projects identified in this report. The rationale for this statement is summarized as follows:

- The majority of future growth is anticipated to occur in both the Oso and Greenwood sewer shed. The 2015 flow for the Oso and Greenwood plants are at 82% and 79% of the plants respective rated capacities. According to the Texas Administrative Code (TAC) 305.126(a) "whenever flow measurements for any sewage treatment plant facility in the state reaches 75 percent of the permitted average daily or annual average flow for three consecutive months, the permittee must initiate engineering and financial planning for expansion and/or upgrading of the wastewater treatment and/or collection facilities." Currently Greenwood WWTP and Oso WRP are beyond the 75 percent threshold and planning will have to take place to satisfy the TAC 305.126(a) ruling. Plant expansion is required at both Oso and Greenwood now.
- The Greenwood plant is located within the floodplain and the site has flooded twice this year. This has indirectly resulted in a spill to nearby La Volla Creek. The existing plant is in poor physical shape and requires over $60 M in repair. The existing plant needs to be replaced now. Therefore, construction of the new North WWTP needs to proceed as soon as possible.
- Building a new plant to replace the existing Greenwood facility will take approximately five years meanwhile the site and local residents are susceptible to flooding impacts. Doing nothing for the next five years while residents wait is not recommended. The redirection of flows from the McBride and Arcadia Pumping Stations to the Broadway WWTP will reduce the flow to Greenwood in the short term reducing flooding potential. These projects will also increase the use of reserve capacity at the Broadway WWTP which the City paid over $50 M for only three years ago.
- Priority projects (0 to 5 year time period) identified during the physical condition survey need to be reviewed with City staff and the most critical projects need to proceed now.
- The work plan for the collection system outlined in the upcoming consent decree cannot wait and the City needs to proceed with the identified program in an expeditious manner.

Key projects that can be delayed, and the associated trigger factor for these include:

- Construction of the Allison PS and force main to direct flow from the Allison sewer shed to the new North Plant. The trigger for this work is completion of the North plant construction.
- Construction of the Laguna Madre PS and force main to direct flow from the Laguna Madre sewer shed to the upgraded and expanded Oso WRP. The trigger for this work is completion of the planned plant expansion at Oso.

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3.3. Proposed Program Implementation Schedule

The proposed implementation schedule for the key projects is summarized here in **Table 3-1** measured from the point of decision for start of the wastewater management plan. The implementation schedule is presented in five year increments. The detailed cash flow spend is presented in the cash flow model enclosed here as **Appendix F**.

Table 3-1 Program Implementation Schedule

Program Element	Cost	Implementation Time Frame			
		0-5 yr.	6-10 yr.	11-15 yr.	16-20 yr.
Collection System Upgrades Associated with Reducing Overflows	$382 M				
Allison WWTP Repair and Rehab	$17 M				
Allison PS and Force main	$22 M				
Broadway WWTP Repair and Rehab	$15 M				
Oso WRP Repair and Rehab	$81 M				
Oso WRP BNR Upgrade & Expansion	$72 M				
Greenwood Repair and Rehab	$14 M				
Greenwood PS and Force main	$73 M				
Laguna Madre Repair and Rehab	$7 M				
Laguna Madre PS and Force main	$18 M				
New North WWTP	$103 M				
Whitecap WWTP Repair and Rehab	$23 M				

3.4. Risk Management Plan

A wide range of risks can impact the successful execution of this overall wastewater servicing program. The full range of these risks was highlighted in **Section 3.3**. These risks can generally be grouped into two broad categories – those that impact the scope through project planning and those that impact results of the project execution.

As noted in the **Section 3.4**, dividing the program into suitable sized projects and selecting an appropriate project delivery method for each project can manage the risks associated with the execution including the procurement, design, construction, operation and maintenance. Assigning responsibility for each element of the project execution to the team or professionals most able to control the outcomes will typically result in an overall lower risk to the City.

However, the planning level risks such as site selection, permitting, and regulatory compliance are of a fundamental nature that remain with the City and cannot easily be transferred to a DB, DBO or P3 partner. In particular, there is a considerable degree of uncertainty with respect to the regulatory regime and future treatment requirements for both existing and new plants. Each of the existing facilities operates under a permit from TCEQ which is renewable every five years. Of the six existing facilities, one permit renewal (Oso) is administratively complete but is still under review; two permits (Laguna Madre and New Broadway) have recently expired and need renewal; and three permits (Greenwood, Whitecap and Allison) expire within the next 18 months. There is no certainty that renewal will be given in a timely manner or with similar conditions to current permits. The City currently is experiencing considerable increased costs to meet new permit requirements at aged facilities that were never designed to provide that level of treatment. The risk of continued changes to future treatment requirements is one of the primary drivers leading the City to consider consolidation of their facilities.

The evaluation of the wastewater servicing options has considered this regulatory uncertainty and higher weighting was given to options that were flexible to adapt to future requirements. The identified project elements of the preferred Option 4D as described above are the most likely outcomes based on the consultant team's evaluation of the current and future requirements. These outcomes may however need to be adapted to meet future changes in conditions and it is recommended that a range of potential alternative strategies should be identified.

The highest priority elements for the Option 4D are the expansion of the Oso plant and construction of the new North plant. A summary of potential risk elements, assessed risk factor (Low, Medium or High) and alternative strategies for these two sites are provided in **Table 3-2**. It should be noted that any high risk elements have already been addressed in the proposed project elements for the preferred option.

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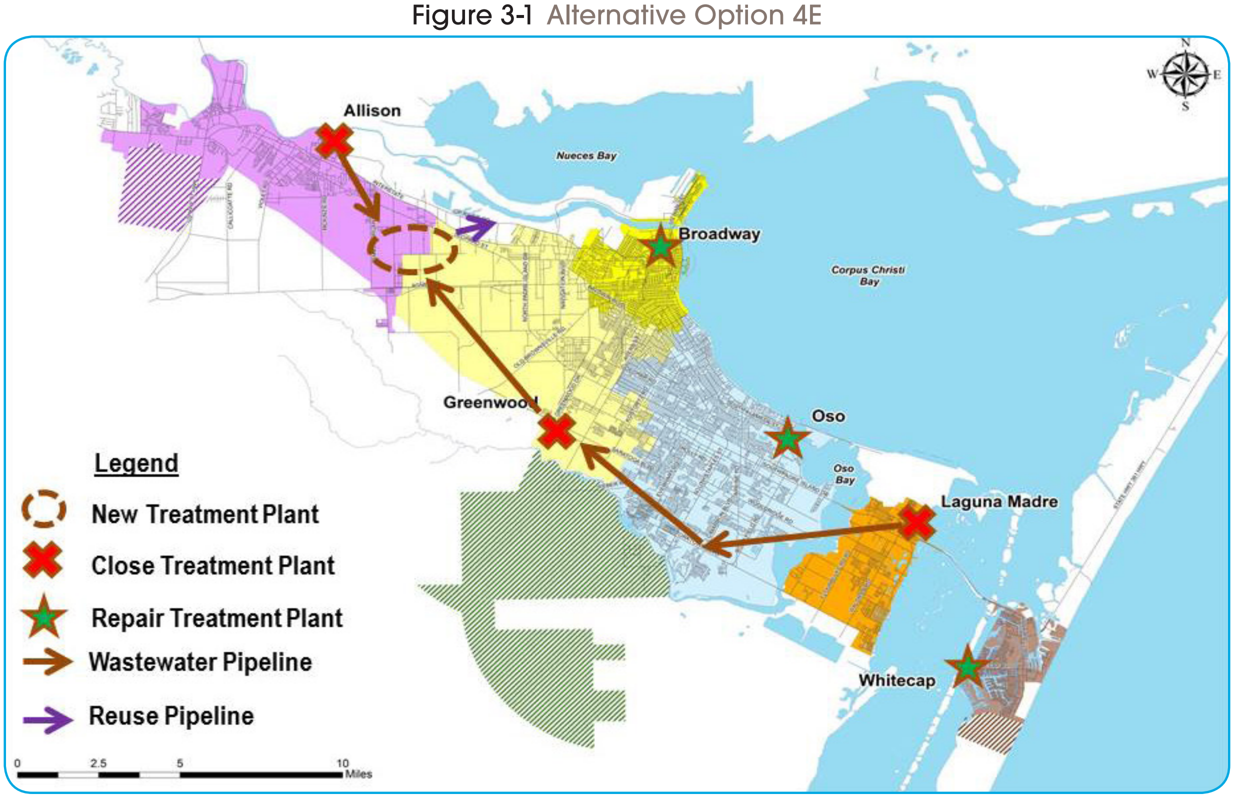
Table 3-2 Potential Alternative Strategies

Project/Site	Key Risk Elements	Risk	Alternative Strategy
Oso WRP BNR upgrade and Expansion	Unable to continue use of existing site	Low	• Pump flow to Laguna Madre and build new plant on that site (as per Option 4A)
Oso WRP BNR upgrade and Expansion	Unable to renew permit for existing discharge to Oso Bay	Med	• Keep Oso plant on site but consider alternative outfall discharge such as Corpus Christi Bay or Laguna Madre OR • Pump flow to Laguna Madre and build new plant on that site (as per Option 4A)
Oso WRP BNR upgrade and Expansion	Unable to secure permit for expanded discharge to Oso Bay	Med	• Keep Oso plant at existing size, redirect south portion of service area and Laguna Madre to Greenwood PS and pump to North Plant (Alternative Option 4E)
Oso WRP BNR upgrade and Expansion	Unable to secure permit for any discharge to either Oso Bay or Laguna Madre	Low	• Pump flow from Oso to North plant and build larger new plant (as per Option 3A)
New North WWTP	Unable to secure a new site	Low	• Build new plant on existing Allison site (Option 2B)
New North WWTP	Unable to secure a permit for discharge into Ship Channel	Low	• Consider discharge to one or combination of Oso Creek and/or Nueces River

As noted above, many of the Alternative Scenarios incorporate elements of the other wastewater servicing options considered earlier during the evaluation process. There will be opportunity to refine these strategies further once more clarity is available on some of these risk elements, especially regarding the permit renewal for Oso WRP. For instance, one "hybrid" option that can be implemented is to split the Oso service area roughly in half along the line of the SPID. The new development and growth in the southern half can be pumped to the new North Plant via the Greenwood PS and the northern half can continue to flow to and be treated at the existing Oso WRP. This Alternative – called Option 4E is depicted in **Figure 3-1**.

Figure 3-1 Alternative Option 4E



3.5. Fund Requirement Schedule

The estimated cash flow requirements for the recommended servicing plan are summarized here in **Table 3-3**. All capital costs are presented here in 2016 constant dollars. The capital spend by project and year is included with the cash flow models presented in **Appendix F**.

Table 3-3 Summary of Fund Requirements

Program Element	Implementation Time Frame			
	0-5 yr.	6-10 yr.	11-15 yr.	16-20 yr.
Collection System Upgrades Associated with Reducing Overflows	$127 M	$127 M	$127 M	
Allison WWTP Repair and Rehab	$13 M	$4 M		
Allison PS and Force main			$22 M	
Broadway WWTP Repair and Rehab	$11 M	$3 M		$1 M
Oso WRP Repair and Rehab	$54 M	$3 M	$6 M	$18 M
Oso WRP BNR Upgrade & Expansion	$72 M			
Greenwood Repair and Rehab	$14 M			
Greenwood PS and Force main	$73 M			
Laguna Madre Repair and Rehab	$7 M			
Laguna Madre PS and Force main		$18 M		
New North WWTP	$103M			
Whitecap WWTP Repair and Rehab	$19 M		$2 M	$2 M
TOTALS	**$493 M**	**$155 M**	**$157 M**	**$21 M**

The total estimated capital spend for Option 4D is approximately $826 M with O&M savings over the next 30-years of approximately $60 M relative to the benchmark option of maintaining the six existing wastewater treatment plants.

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