Planning Level Study for Alternative Surface Water Pipeline Routing in Montgomery County

May 2008

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for

Lone Star Groundwater Conservation District

and

San Jacinto River Authority

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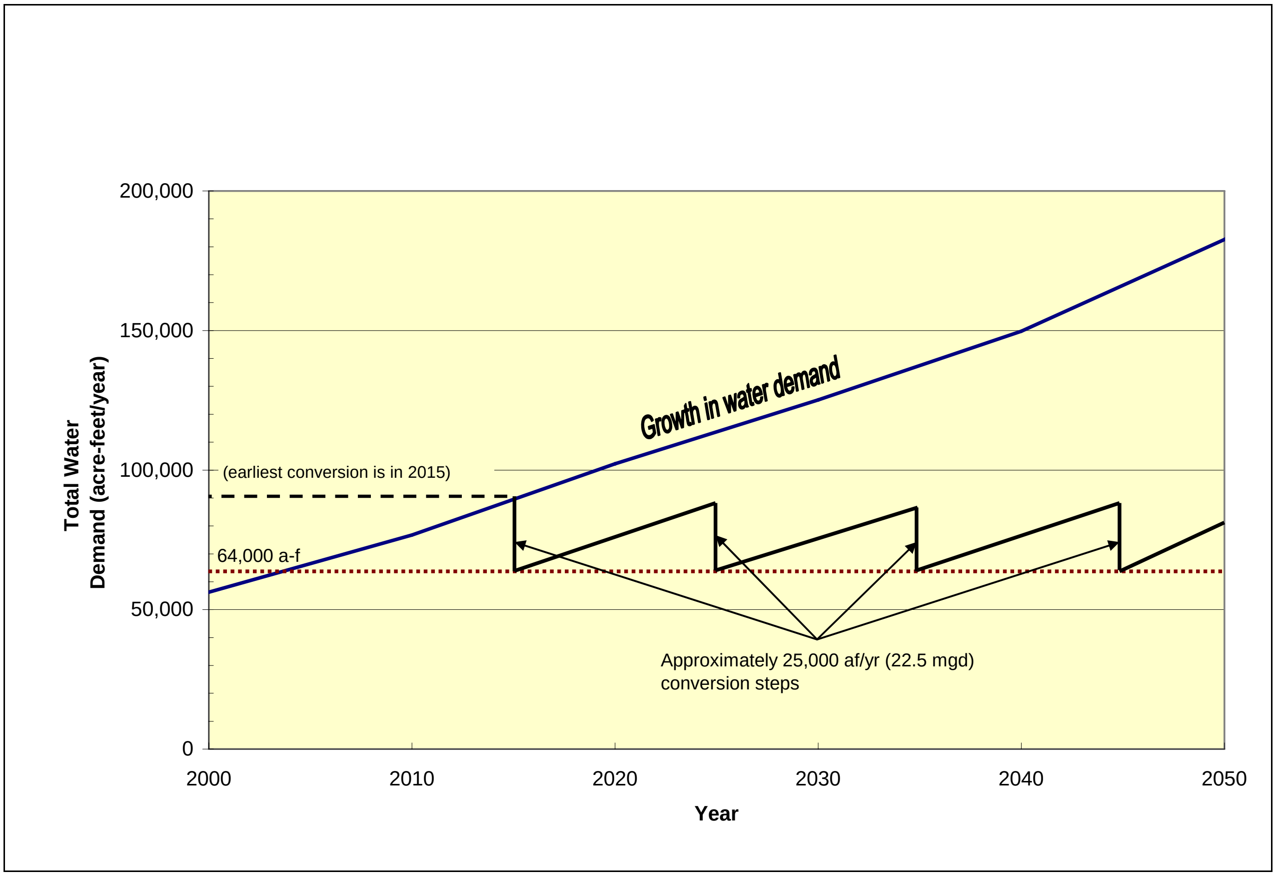
Executive Summary

In March 2006, the Texas Water Development Board (TWDB), the Lone Star Groundwater Conservation District (the District), and the San Jacinto River Authority (SJRA) entered into a joint planning activity to conduct the current study, a follow-on to the *Regulatory Study and Facilities Implementation Plan for Lone Star Groundwater District and San Jacinto River Authority* published in June 2006 (the Phase I Study). Building on the concept of distributing treated Lake Conroe water to the high-demand areas of Montgomery County to meet the District's regulatory goal of reducing groundwater withdrawal to at or below 64,000 ac-ft/yr by 2015, the primary objectives of the current study are to: identify the most efficient surface water pipeline alignment; size the transmission pipelines; determine the treatment plant location(s) and layout; and perform cost and rate analyses based on a set of assumptions for this study. Identifying the preferred pipeline routes and treatment plant location(s) will assist the implementer of the system, SJRA, in determining where potential additional rights of way and easements may be required for the set of assumptions. Developing probable costs, water rates, and financing options will allow SJRA and the District to work with stakeholders to identify the funding mechanisms required.

The District has set a date of January 1, 2015 by which Montgomery County total groundwater withdrawal must be at or below 64,000 ac-ft/yr. Currently, the permitted groundwater withdrawal from all District Historic Use Permits (HUPs) and Operating Permits (OPs) is nearly 80,000 ac-ft/yr. By 2015 the total water demand is projected to be nearly 90,000 ac-ft/yr. The surface water system proposed herein to meet the regulatory requirements will be constructed in four phases; the initial system in 2015 and system expansions in 2025, 2035, and 2045. This study adopts a "minimum conversion" approach consistent with the Phase I Study; groundwater consumption must be reduced to the target at each conversion point, but increased demands due to growth between conversion points can be met by groundwater. This concept is illustrated in *Figure 1* below. This approach reduces the size and cost of the initial system since it requires the least amount of treated water to be delivered. As the District regulatory plan evolves this approach may require modification.

It is extremely important to note that the research and preparation of this report, including the project and facilities contemplated herein, largely predate the adoption of Phase 1 and Phase 2 of the District's District Regulatory Plan (DRP), and were predicated on certain specific assumptions regarding water availability, countywide participation, anticipated regulations, implementation timelines, technical aspects, and financing methodologies. A change in any one or more of these or other factors will significantly impact the cost, design, and feasible implementation schedule of the project.

Figure 1 Conversion Phasing



The required conversion volumes were calculated using the 2006 Region H Regional Water Plan (RWP) water demand projections. *Table 1* shows the total demands and minimum conversion amounts by phase.

Table 1 Minimum Conversion Requirements by Phase

	2015 (I)	2025 (II)	2035 (III)	2045 (IV)
Total Demand (ac-ft/yr) from 2006 RWP[1]	89,543	113,716	137,435	166,175
Demand Met By Surface Water (ac-ft/yr)[2]	7,840	7,840	7,840	7,840
Demand Met By Groundwater (ac-ft/yr)	81,703	105,876	129,595	158,335
Minimum Conversion Amount (ac-ft/yr)	17,703	41,876	65,595	94,335
Minimum Conversion Amount (mgd)	15.8	37.4	58.6	84.2

1. Demands prorated from published decadal values (e.g. 2015 demands are an average of 2010 and 2020 demands)
2. Steam-electric contract amount

The required conversion volumes range from approximately 18,000 ac-ft/yr for Phase I to approximately 94,000 ac-ft/yr in Phase IV. SJRA currently owns the rights to approximately 22,000 ac-ft/yr for municipal uses, 9,500 ac-ft/yr for industrial uses, and 1,833 ac-ft/yr for mining uses in Lake Conroe which limits the amount of surface water available to meet the Phase I conversion. A basic assumption of this study is that all the water supply in Lake Conroe, 100,000 ac-ft/yr, will ultimately be available to this system, which would satisfy the anticipated conversion requirements through 2045. However, if this assumption fails to materialize, the design and implementation schedule of the project and its cost would be substantially impacted.

The assumed future conditions and needs related to the system are discussed in Section 3 of the main body of the report. The overall alignment corridor encompassing both of the planning alternatives was evaluated in terms of water demands on the system, environmental and historical impacts, right of way requirements, existing utilities and other factors. The water treatment plants and transmission pipelines were sized for the ultimate conditions in 2045, and the water treatment considerations are described.

Delivering treated water to the high-demand areas along the I-45 corridor minimizes the size of the initial transmission system. Some of the largest water users are in this corridor: The Woodlands and City of Conroe represent the top two consumers of groundwater in the County. Enough high-demand users exist in the corridor such that both the Phase I and Phase II conversions can be met with a relatively small transmission system. *Table 2* lists the potential Public Water Systems (PWSs) that together could receive treated water in sufficient quantity to satisfy the anticipated Phase I and II conversion requirements if the water availability and user participation assumptions of this project are realized. The locations of these entities are shown in Exhibits 1 – 4.

Table 2 Conversion Area Water Demands: 2015 - 2025

PWS	Projected Demand (ac-ft/yr)	
	2015 (I)	2025 (II)
The Woodlands	25,270	28,330
City of Conroe	10,400	13,510
Rayford Road MUD	2,090	2,070
Southern Montgomery County MUD	1,970	2,140
City of Oak Ridge North	720	830
City of Shenandoah	510	510
Montgomery County MUD #19	460	460
Chateau Woods MUD	280	370
Woodlands Oaks Subdivision	320	320
TOTALS:	**42,020**	**48,540**

Surface water will be delivered to agreed-upon delivery points. The delivery points will typically be ground storage tanks owned and operated by the purchasing entity. Water will be delivered to the top of each tank through an air gap. Each entity in *Table 2* would convert 60% of their water demand to surface water in 2015, and 90% in 2025. In Phases III and IV, system expansions would deliver water to the east and west sides of Lake Conroe, the areas west and south of the City of Conroe, the area west of The Woodlands, and the areas east and south of Rayford Road MUD. The areas served by the ultimate 2045 system are shown in Exhibit 6. These areas are anticipated to collectively convert 90% of their demand.

Two planning alternatives are presented to achieve the desired conversions; a single-plant system (one treatment plant operating at the Lake Conroe Dam) and a dual-plant system (one treatment plant operating at the Lake Conroe Dam and one off-channel plant operating downstream of Lake Conroe on the West Fork San Jacinto River. The details of the alternatives are presented in Section 4 of the main body of the report. For the single-plant alternative, eight equal 11.25 mgd trains are recommended, as shown in *Table 3*.

Table 3 Single Plant Treatment Capacity by Phase

Phase (Year)	Added Capacity per Phase	Total Plant Capacity
I (2015)	22.5 MGD (2 train @ 11.25 MGD)	22.5 MGD (2 train @ 11.25 MGD)
II (2025)	22.5 MGD (2 train @ 11.25 MGD)	45 MGD (4 trains @ 11.25 MGD)
III (2035)	22.5 MGD (2 train @ 11.25 MGD)	67.5 MGD (6 trains @ 11.25 MGD)
IV (2045)	22.5 MGD (2 train @ 11.25 MGD)	90 MGD (8 trains @ 11.25 MGD)

The recommended capacity phasing for the dual-plant option is shown in *Table 4* through *Table 6* below.

Table 4 Dual Plant Treatment Capacity by Phase – North Plant

Phase	Added Capacity per Phase	Total Plant Capacity
I (2015)	6 MGD (1 train @ 6 MGD)	6 MGD (1 train @ 6 MGD)
II (2020)	6 MGD (1 train @ 6 MGD)	12 MGD (2 trains @ 6 MGD)
III (2030)	18 MGD (3 trains @ 6 MGD)	30 MGD (5 trains @ 6 MGD)
IV (2040)	18 MGD (3 trains @ 6 MGD)	48 MGD (8 trains @ 6 MGD)

Table 5 Dual Plant Treatment Capacity by Phase – South Plant

Phase	Added Capacity per Phase	Total Plant Capacity
I (2015)	18 MGD (3 trains @ 6 MGD)	18 MGD (3 trains @ 6 MGD)
II (2025)	12 MGD (2 trains @ 6 MGD)	30 MGD (5 trains @ 6 MGD)
III (2035)	6 MGD (1 train @ 6 MGD)	36 MGD (6 trains @ 6 MGD)
IV (2045)	6 MGD (1 train @ 6 MGD)	42 MGD (7 trains @ 6 MGD)

Table 6 Dual Plant Treatment Capacity by Phase – Both Plants Combined

Phase	Added Capacity per Phase	Combined Plant Capacity
I (2015)	24 MGD (4 trains @ 6 MGD)	24 MGD (4 trains @ 6 MGD)
II (2025)	18 MGD (3 trains @ 6 MGD)	42 MGD (7 trains @ 6 MGD)
III (2035)	24 MGD (4 train @ 6 MGD)	66 MGD (11 trains @ 6 MGD)
IV (2045)	24 MGD (4 train @ 6 MGD)	90 MGD (15 trains @ 6 MGD)

The dual-plant option does not compare favorably with the single-plant option in terms of costs, water treatment plant locations, and the opportunity to serve future development. The full alternative comparison is shown in Section 5 of the main body of the report. The dual-plant option does have the advantage in terms of the proposed alignment and environmental impacts. The higher annual costs related to the operation of the dual-plant system reflects many of the disadvantages of the dual-plant alternative, hence it is the overriding consideration. *Table 7* -- *Table 11* show the cost comparisons between the two alternatives.

Table 7 Alternative Comparison – Probable Construction Costs

Phase (Year)	**I (2015)** *(Million $)*	**II (2025)** *(Million $)*	**III (2035)** *(Million $)*	**IV (2045)** *(Million $)*
Single Plant Alternative	$290	$62	$127	$118
Dual Plant Alternative	$268	$65	$149	$133
[1] *Values as of January 2008.*				

Table 8 Alternative Comparison – Probable Capital Costs in 2008 Dollars

Phase (Year)	**I (2015)** *(Million $)*	**II (2025)** *(Million $)*	**III (2035)** *(Million $)*	**IV (2045)** *(Million $)*
Single Plant Alternative	$385	$81	$171	$159
Dual Plant Alternative	$360	$85	$200	$178
[1] *Values as of January 2008.*				

Table 9 Alternative Comparison – Probable Capital Costs in Future Dollars

Phase (Year)	**I (2015)** *(Million $)*	**II (2025)** *(Million $)*	**III (2035)** *(Million $)*	**IV (2045)** *(Million $)*
Single Plant Alternative	$542	$185	$637	$964
Dual Plant Alternative	$507	$194	$744	$1,082
[1] *Values as of the year cost will incur computed at a 5% annual inflation rate.*				

Table 10 Alternative Comparison – Operation & Maintenance Costs

Phase (Year)	**I (2015)** *(Million $)*	**II (2025)** *(Million $)*	**III (2035)** *(Million $)*	**IV (2045)** *(Million $)*
Single Plant Alternative	$7.3	$11.4	$15.7	$20.7
Dual Plant Alternative	$7.9	$11.4	$16.5	$21.5
[1] *Values as of January 2008.*				

Table 11 Alternative Comparison – Annual Costs

Phase (Year)	**I (2015)** *(Million $)*	**II (2025)** *(Million $)*	**III (2035)** *(Million $)*	**IV (2045)** *(Million $)*
Single Plant Alternative	$44.4	$59.0	$48.0	$63.2
Dual Plant Alternative	$42.8	$57.2	$51.7	$68.2
[1] *Values as of January 2008.*				

The preferred alternative is the single-plant alternative as discussed in Section 6 of the main body of the report. The probable capital costs of the single-plant option are given in *Table 12*.

Table 12 Single Plant Option – Probable Capital Costs

Phase (Year) **Capital Improvements**	**I (2015)** *(Million $)*	**II (2025)** *(Million $)*	**III (2035)** *(Million $)*	**IV (2045)** *(Million $)*
Construction (Capital) Costs	$290	$62	$127	$118
Engineering, Financial, & Legal [2]	$87	$19	$38	$36
Land & Easements	$8	$0	$6	$5
TOTAL	**$385**	**$81**	**$171**	**$159**

[1] Values as of January 2008.
[2] Engineering, Financial, & Legal Services (30% of probable construction costs which include the following: Engineering 10%, Program Management 3%, Environmental Studies and Mitigation 5%, Surveying 1%, Construction Management 6%, Financial 3% and Legal 2%.).

The single-plant alternative produces the most advantageous rate structure when financed through a combination of Water Infrastructure Fund (WIF) loans and State Participation loans available through the TWDB. The rates for the combination WIF/State Participation funding alternative are summarized in *Table 13* below.

Table 13 Single Plant System Rates for Initial WIF Financing And State Participation

Year	**Groundwater**		**Surface Water**	
	Demand (mgd)	**Anticipated Rate ($/1,000 gal)**	**Demand (mgd)**	**Anticipated Rate ($/1,000 gal)**
2009	59.6	0.51		
2015	49.3	1.65	21.0	2.05
2020	59.7	1.93	21.0	2.33
2025	48.6	2.64	41.0	3.04
2030	58.5	3.95	41.0	4.35
2035	48.0	4.50	61.0	4.90
2040	58.6	5.23	61.0	5.63
2045	46.7	6.77	86.0	7.17
2050	60.8	7.95	86.0	8.35
2055	76.1	9.15	86.0	9.55

Rates are in future dollars at a 5% annual inflation Rate

While funding for both the WIF and State participation loans may be limited on availability during any year, obtaining these funds would provide the lowest overall rates as well as a significant initial rate reduction over conventional funding through municipal bond sales. The combination of below market interest rates for the WIF and the deferred up front costs available under both the WIF and State Participation fund make this combination the preferred funding and rate alternative. An additional benefit of utilizing these deferral options would be found if county wide pumping fees could not be utilized in the initial states. The reduction in up front revenue stream requirements would make this funding option preferable should only a subset of the groundwater users be charged a groundwater pumping fee or some other revenue limitation occur.

Section 1 Introduction

1.1 Purpose

The Lone Star Groundwater Conservation District (District), in their Phase I District Regulatory Plan (Phase I DRP), is requiring countywide groundwater consumption to be at or below 64,000 ac-ft/yr by the year 2015. This can be achieved by reducing groundwater consumption through conservation and by replacing groundwater use by one or more alternative supplies. While there are a number of options available to the Public Water Systems (PWSs) in Montgomery County to achieve the goals of the Phase I DRP, it is recognized that the large projected groundwater shortages will require a large-scale conversion to surface water to be the predominant solution.

In March 2006, the TWDB in association with the San Jacinto River Authority (SJRA) and the District entered into a joint planning activity under the State Regional Facility Planning Grant Program to conduct a follow-on study to the June 2006 Regulatory Study and Facilities Implementation Plan (discussed in Section 1.2 below). The primary objectives of this study are to:

- Select the most cost-effective surface water pipeline alignment;
- Size pipelines;
- Determine treatment plant location(s) and layout(s);
- Perform cost and rate analyses.

1.2 Previous Studies

In June 2004, the TWDB in association with the SJRA and the LSGCD entered into a joint planning activity under the State Regional Facility Planning Grant Program to develop a Conjunctive Use of Groundwater and Surface Water Study and Facilities Implementation Plan for meeting the long-term water supply needs of Montgomery County. The investigation includes a study of options for groundwater regulation (GR study) and a Conceptual Facilities Plan. The GR study provides the science and engineering underpinnings for the establishment of groundwater management zones by the LSGCD. It also analyzes the need for reduction in groundwater usage to meet the goals in each zone option identified. The Facilities Implementation Plan is the technical mechanism for implementing the GR study. It sets the timetable for implementation of surface water (or other alternatives) based on goals established in the GR study.

The major tasks accomplished in this planning effort included:

- Data collection and analysis
- Development of regulatory options and evaluation of management zones for regulation
- Conceptual planning of a wholesale surface water supply system to facilitate the reduction in dependency on groundwater
- Considerations of financial and management options for implementing a wholesale surface water supply system

- Communication with the stakeholder interests in the planning activity and in soliciting support for its implementation

The final report for this study was released in June 2006 and is entitled *Regulatory Study and Facilities Implementation Plan for Lone Star Groundwater Conservation District and San Jacinto River Authority*. This report, referred to as the "Phase I Study", assumed an initial conversion date of 2013 and developed planning level facilities costs for 2013, 2020, 2030, and 2040.

Since the publication of the Phase I Study, the District adopted its Phase I District Regulatory Plan (DRP) which accomplished two things: established a date of January 1, 2015 by which the countywide groundwater consumption must be at or below 64,000 ac-ft/yr; and established a single countywide management zone.

1.3 Planning Horizon

The planning horizon for this report is from 2015 to 2045. The District's statutory deadline for initial conversion, as established in the Phase I DRP, is 2015. While the District does not currently have regulations regarding long-term management of the groundwater resources, this study anticipates that the surface water system will be expanded in the years 2025, 2035, and 2045. The 2045 date is predicated on the assumption that all of the water in Lake Conroe (100,000 acre-feet/year) will be available for use in Montgomery County, and that the entire supply of the lake will be necessary to meet the conversion requirements in 2045. It is also assumed that conversion beyond 2045, given today's demand projections, will need to be met by sources other than Lake Conroe (e.g. advanced conservation, wastewater reuse, Lake Houston supply, etc.) It is very important for the reader to note that the project's cost, design, and implementation schedule would be substantially impacted if one or more of the assumptions in this report fail to come to fruition.

Section 2 Existing Conditions

This section discusses the existing conditions in Montgomery County that will affect the implementation of a surface water system. Existing conditions were summarized for water production facilities, water demands, environmental conditions, and raw water quality.

2.1 Existing Facilities

The focus of this report is on PWSs -- those systems that provide water for human consumption and "have at least 15 service connections or serve at least 25 individuals at least 60 days out of the year" (30 TAC §290.38).

There are over 300 active PWSs in Montgomery County (TCEQ Water Utility Database, 2006), each with groundwater from the Gulf Coast Aquifer as their source. For the most part, each PWS operates independently of all the others; they have their own wells that are in close proximity to their entry points, and they operate their own distribution system. There is currently no regional system that supplies a group of PWSs.

The Phase I Study identified the most cost-effective solution to the problem of converting the existing groundwater supply to an alternative source: a transmission system supplying Lake Conroe water to the densely populated areas along the I-45 corridor. This system will minimize the amount of pipeline that needs to be constructed and hence the rate charged for the use of that water. For that reason the data collection phase of this project focused on the PWSs with the highest demand; those that would likely be provided wholesale water in the first conversion phase in 2015.

The city limits and currently available utility district (Municipal Utility Districts, Utility Districts, Water Control and Improvement Districts) boundaries in the areas targeted for conversion are shown in *Exhibits 1 – 4*. Not all utility district boundaries are shown in these exhibits; only those available from either TCEQ or Montgomery County Appraisal District (MCAD).

2.1.1 Wells

Well data was collected from various sources: the District permitting database, the TCEQ water utility database, and from individual PWSs as appropriate. PWS wells from the TCEQ water utility database, SJRA, The City of Conroe, and Southern Montgomery County MUD are shown in *Exhibits 1 – 4*.

2.1.2 Distribution

Maps of distribution systems are useful in locating or verifying ground storage tank locations. The assumption in this study is that wholesale treated water will be delivered through an air gap to each ground storage tank (GST) location agreed to by the receiving water system and SJRA. It is the responsibility of each individual PWS receiving wholesale surface water to ensure that their distribution system is capable of operating correctly with the addition of surface water. If surface water is introduced at each GST, there would likely be no physical delivery issues (as opposed to chemical issues) since surface water would replace groundwater with essentially the same volumes and rates. In larger distribution systems, if surface water is introduced in only one or two locations, the PWS will need to ensure, through hydraulic modeling, that there is sufficient high service pump and distribution line capacity to deliver the water throughout the system.

Electronic maps of distribution systems in either GIS or AutoCAD/Microstation formats were provided by The Woodlands, City of Conroe, Southern Montgomery County MUD, Rayford Road MUD, and City of Shenandoah. These were used to verify well and tank locations, but are not included as part of this report.

2.2 Existing Water Demand

All of the municipal, manufacturing, and mining water demand in Montgomery County is currently supplied by groundwater from the Gulf Coast aquifer. The two primary sources for evaluating the current water demand in Montgomery County are the 2006 Region H Regional Water Plan (RWP) and the District's permitting system.

2.2.1 Regional Planning Demands

The Region H RWP developed population and water demand projections by use type through the year 2060. Each county in the 13-county region, including Montgomery County, is subdivided into Water User Groups (WUGs) per regional planning criteria that consider population and year 2000 municipal water use. Generally speaking, Municipal WUGs represent cities with year 2000 populations greater than 500, water utilities or groups of utilities with year 2000 water usage of more than 280 acre-feet per year or which were designated a WUG by the TWDB Planning Group, and a special WUG called "County-Other" that represents the area of the county left over after individual WUGs have been designated. The Region H RWP subdivides Montgomery County into 35 Municipal WUGs, and single county-wide WUGs for Irrigation, Livestock, Manufacturing, Mining, and Steam Electric use categories. *Table 14* provides a summary of the Region H WUGs and their projected water demands through 2060.

Table 14 Montgomery County Region H Water Demand Projections: 2000-2060

Use Category	Water Demand (ac-ft/yr)						
	2000	2010	2020	2030	2040	2050	2060
Irrigation	66	66	66	66	66	66	66
Livestock	510	510	510	510	510	510	510
Manufacturing	1,587	2,045	2,332	2,608	2,883	3,126	3,392
Mining	414	480	509	526	543	559	573
Municipal	51,193	68,638	90,346	111,441	133,994	164,466	200,243
Steam Electric	2,507	5,046	8,537	9,981	11,741	13,886	16,502
TOTALS:	**56,277**	**76,785**	**102,300**	**125,132**	**149,737**	**182,613**	**221,286**

Assuming a straight line in demands between decades, the 2008 overall water demand in Montgomery County is 72,683 ac-ft. The 2008 municipal demand, which is supplied 100% by groundwater, is 65,149 ac-ft; 90% of the total demand.

As mentioned above, there are 35 municipal WUGs in Montgomery County. *Table 15* lists the municipal WUGs and their demand projections.

Table 15 Montgomery County Region H Municipal WUG Water Demand Projections: 2000-2060

WUG Name	Demand (ac-ft/yr)						
	2000	2010	2020	2030	2040	2050	2060
Conroe	7,175	9,334	10,611	13,190	16,310	20,406	25,281
Consumers Water Inc	164	210	237	299	366	464	578
County-Other	14,307	21,619	26,954	38,344	51,726	70,827	93,011
Crystal Springs Water Company	368	564	681	914	1,189	1,568	2,008
Cut And Shoot	169	210	235	285	348	430	529
East Plantation UD	284	439	533	719	937	1,230	1,570
H M W SUD	1,268	1,625	1,825	2,249	2,737	3,403	4,176
Houston	82	190	253	375	516	704	926
Magnolia	233	275	300	351	412	495	593
Montgomery County MUD #18	720	1,685	2,276	3,431	4,784	6,569	8,642
Montgomery County MUD #19	477	459	452	448	444	444	444
Montgomery County MUD #8	651	920	1,085	1,411	1,785	2,297	2,893
Montgomery County MUD #9	522	856	1,058	1,455	1,917	2,536	3,254
Montgomery County UD #2	369	526	520	513	507	507	507
Montgomery County UD #3	425	472	497	554	624	722	844
Montgomery County UD #4	645	924	913	903	892	892	892
Montgomery County WCID #1	435	486	512	571	645	750	879
New Caney MUD	965	1,371	1,600	2,116	2,670	3,470	4,398
Oak Ridge North	563	683	748	897	1,067	1,297	1,573
Panorama Village	605	768	864	1,056	1,153	1,148	1,148
Patton Village	76	87	88	101	115	136	165
Point Aquarius MUD	334	669	873	1,272	1,732	2,348	3,063
Porter WSC	1,391	1,847	2,104	2,653	3,305	3,274	3,274
Rayford Road MUD	999	2,096	2,077	2,059	2,059	2,059	2,059
River Plantation MUD	811	828	817	806	795	791	791
Roman Forest	168	202	222	266	317	387	471
Shenandoah	517	512	507	502	497	493	493
Southern Montgomery County MUD	1,163	1,776	2,149	2,121	2,107	2,107	2,107
Southwest Utilities	181	241	274	345	426	536	669
Splendora	126	188	224	297	383	502	640
Spring Creek UD	339	503	593	784	1,010	1,320	1,681
Stanley Lake MUD	367	682	871	865	859	859	859
The Woodlands (CRU/CDP)	13,714	14,671	26,596	28,330	28,197	28,063	28,063
Willis	424	568	649	816	1,024	1,296	1,626
Woodbranch	156	152	148	143	139	136	136
Totals:	**51,193**	**68,638**	**90,346**	**111,441**	**133,994**	**164,466**	**200,243**

2.2.2 District Permitting System

The District's permitting system contains records of the amount of groundwater each non-exempt user may pump throughout the year. This allocation of groundwater for each user is specified in either a Historic Use Permit (HUP), Operating Permit (OP), or both. Enforcement of this allocated amount is achieved by requiring each user to meter their wells and to report their annual pumpage every year.

In December 2007 there were 714 permittees holding either a HUP, OP, or both. The total permitted amount at that time was 79,800 ac-ft/year. The average permit allocation was 112 ac-ft/year and the median was 11 ac-ft/yr.

Each permit is assigned one of six major use types. The permit allocations for each use type are shown in *Table 16*. Total Public Supply use accounts for 88% of the total permitted volume which is consistent with the percentage of municipal demand in *Table 14* (90% of total demand in 2008).

Table 16 Permit Amount by Use Type

Use Category	Permitted Amount (ac-ft/yr)	% of Total
Commercial	885	1%
Industrial	2,287	3%
Irrigation	5,189	7%
Irrigation(Agriculture)	1,533	2%
Public Supply	5,421	7%
Public Supply (PWS)	64,500	81%
TOTALS:	**79,817**	**100%**

2.2.2.1 Reported Pumpage

Permittees are required to report annual metered pumpage and are penalized for pumping more than their permit allocation. A large percentage of the total permitted pumpage is represented by a relatively small number of permits: permitted allocations above the 95th percentile account for approximately 70% of the total permitted volume. *Table 17* lists permittees at or above the 95th percentile, their permitted allocation, and their historic use from 2005-2007.

Table 17 Permit Allocation and Reported Pumpage for Major Groundwater Users

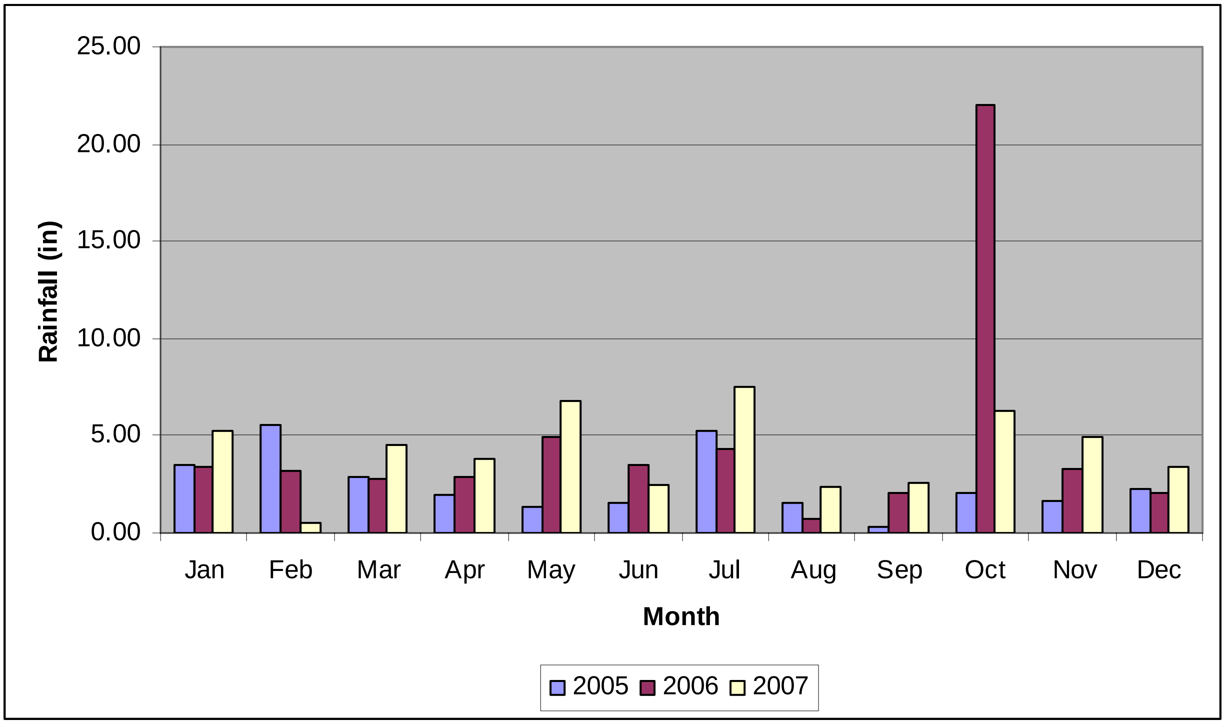
Permittee	Permit Number(s)	Use Type	Permit Allocation (ac-ft/yr)	Metered Pumpage (ac-ft/yr)		
				2005	2006	2007
San Jacinto River Authority	HUP193/OP03-0050	PWS	16,404	18,473	18,172	16,043
City of Conroe	HUP038/OP02-0001	PWS	9,121	8,956	9,304	8,414
City of Houston	HUP1300001	PWS	2,964	3,029	2,812	2,458
Montgomery County MUD #18	HUP138/OP-05060201	PWS	1,768	1,127	1,131	1,092
Porter Special Utility District	HUP177/OP03-0006	PWS	1,720	1,558	1,571	1,444
Rayford Road MUD	HUP184/OP-05101901	PWS	1,412	1,329	1,312	1,119
Southern Montgomery County MUD	HUP199/OP-06032301	PWS	1,350	1,220	1,293	1,199
New Caney MUD	HUP154/OP03-0073	PWS	1,181	975	945	988
Montgomery County MUD #8	HUP145/OP-05112102	PWS	1,019	943	640	634
Huntsman Petrochemical Corp.	HUP099	Ind	972	601	626	502
City of Willis	HUP045/OP-07062601	PWS	918	59	656	680
Montgomery County MUD #89 (Also MUD 88)	OP03-0043	PWS	902	345	540	703
Montgomery County MUD #9	HUP147/OP-06081401	PWS	837	563	779	543
City of Shenandoah	HUP043/OP-04113002	PWS	813	742	821	768
City of Splendora	HUP044/OP-04062801	PWS	792	745	738	805
Montgomery County UD #4	HUP143/OP-05112101	PWS	773	730	649	460
Entergy Gulf States / Lewis Creek Plant	HUP072	Ind	768	369	727	657
Stanley Lake MUD	HUP213/OP-04031003	PWS	705	512	497	446
River Plantation MUD	HUP187	PWS	693	519	518	427
Montgomery County MUD #19	HUP140/OP03-0021	PWS	675	588	625	599
Green Valley Growers	HUPAG1500020/OP03-0002	Irr	659	85	246	296
City of Magnolia	HUP039/OP-04041601	PWS	654	494	393	422
Kings Manor MUD	HUP107/OP03-0058	PWS	644	390	373	336
Spring Creek Utility District	HUP210/OP03-0075	PWS	640	468	454	338
Montgomery County MUD #83	HUP146/OP-04042802	PWS	615	151	287	298
Quadvest, LP. 1 (Lake Windcrest WS)	HUP178/OP03-0025	PWS	615	826	796	473

Table 17 (cont'd) Permit Allocation and Reported Pumpage for Major Groundwater Users

Permittee	Permit Number(s)	Use Type	Permit Allocation (ac-ft/yr)	Metered Pumpage (ac-ft/yr)		
				2005	2006	2007
City of Panorama Village	HUP042	PWS	612	538	477	423
T & W Water Services (Riverwalk)	HUP218/OP03-0012	PWS	602	714	783	Not Avail.
Montgomery County UD #3	HUP148/OP-05112104	PWS	583	544	481	474
The Woodlands Land Development Company, LP	HUP248	Irr	574	712	410	272
City of Oak Ridge North	HUP041/OP-06060701	PWS	552	541	510	414
Point Aquarius MUD	HUP175/OP03-0071	PWS	552	455	434	306
MSEC Enterprises (Montgomery Trace WS/Crown Oaks)	HUP151/OP02-0011	PWS	492	439	468	408
Montgomery County UD #2	HUP141/OP-04113001	PWS	491	434	327	337
Quadvest, LP. (Benders Landing)	HUP180/OP-04030801	PWS	461	261	325	317
Montgomery County WC & ID #1	HUP149	PWS	448	354	332	239
TOTALS (Excluding T&W Water Services (River Walk)):			**54,380**	**50,075**	**50,667**	**45,333**

As can be seen in *Table 17*, the reported pumpage varies; it is primarily influenced by climatic conditions, changes in population, and significant changes in commercial demands. In the years shown, 2005 was a relatively dry year, while 2006 and 2007 were relatively wet years. Total rainfall amounts in the Conroe area for the years 2005-2007 are 29.73 in, 55.11 in, and 50.52 inches respectively. *Figure 2* shows the monthly rainfall amounts for 2005 – 2007.

Figure 2 Monthly Rainfall Amounts for the Conroe Area: 2005 - 2007



For many of the permittees in *Table 17*, pumpage in the last three years was lowest in 2007: this can primarily be explained by the fact that 2007 was a wet year, and rainfall was relatively higher in the high demand months of July and August. While 2006 had more total rainfall than 2007, most of it (40%) occurred in October. San Jacinto River Authority, the largest groundwater user in the County, experienced increased population from 2005 to 2007, but used 13% less groundwater in 2007 compared to 2005. The City of Conroe, the second largest groundwater user, used 6% less groundwater in 2007 than in 2005 despite population increasing roughly 3% per year. Overall for the users listed, 2007 pumpage was 9.5% lower than 2005 pumpage.

2.2.2.2 Comparison of Reported Pumpage to Regional Planning Demands

Many of the large groundwater users in *Table 17* are also WUGs in the Region H 2006 RWP. *Table 18* shows a comparison, where applicable, of the Region H water demand for 2005 to the 2005 reported pumpage for large water users. For the entities listed, the total 2005 reported pumpage is 12.9% higher than the total projected demand in the Region H RWP. Three possible reasons for large differences between the Region H projections and actual usage are: a different rate of population growth than projected based on growth in the 1990's, changes in per capita usage rates, and an unexpected arrival or departure of a major commercial interest (particularly applicable in smaller PWSs). Where there are large differences, it can be difficult to determine whether the rate of demand change will continue in the future, or whether the change is due to short-term effects.

Table 18 Comparison of Region H Demands to 2005 Reported Pumpage for Large Users

Permittee	2005 Region H Demand (ac-ft/yr)	2005 Reported Pumpage (ac-ft/yr)	% Difference
San Jacinto River Authority	14,193	18,473	30.2%
City of Conroe	8,255	8,956	8.5%
Montgomery County MUD #18	1,203	1,127	-6.3%
Porter Special Utility District	1,619	1,558	-3.8%
Rayford Road MUD	1,548	1,329	-14.2%
Southern Montgomery County MUD	1,470	1,220	-17.0%
New Caney MUD	1,168	975	-16.5%
Montgomery County MUD #8	786	943	19.9%
City of Willis	496	692	39.5%
Montgomery County MUD #9	689	563	-18.3%
City of Shenandoah	515	742	44.0%
City of Splendora	157	745	374.5%
Montgomery County UD #4	785	730	-7.0%
Stanley Lake MUD	525	512	-2.5%
River Plantation MUD	820	519	-36.7%
Montgomery County MUD #19	468	588	25.6%
City of Magnolia	254	494	94.5%
Spring Creek Utility District	421	468	11.1%
City of Panorama Village	687	538	-21.7%
Montgomery County UD #3	449	544	21.2%
City of Oak Ridge North	623	541	-13.1%
Point Aquarius MUD	502	455	-9.5%
Montgomery County UD #2	448	434	-3.2%
Montgomery County WC & ID #1	461	354	-23.1%
TOTALS:	**38,542**	**43,499**	**12.9%**

2.3 Existing Environmental Conditions

The proposed project is located in Montgomery County in the Piney Woods Natural Region of Texas. The topography is generally rolling and primarily timbered. The project area is crossed by many creeks and includes two lakes. Soils consist of loam, sand and alluvium. The entire project is located within the San Jacinto River Basin. Lake Conroe will provide the surface water for the proposed project with the potential for a Dual Plant Alternative to provide water from the West Fork of the San Jacinto River (WFSJR) near its convergence with Lake Creek. For a map of existing environmental conditions please refer to *Appendix J* for the Environmental Constraints Map.

2.3.1 Land Use and Population

Based on the 2006 aerial photographs, the project area is approximately 65% urban and 35% wooded. According to the Texas State Data Center and Office of the State Demographer (2007), the current population estimate for Montgomery County is 412,665 and the estimate for the City of Conroe is 53,424. This represents a population increase of 40.5% in Montgomery County and 45.1% in the City of Conroe between the year 2000 and 2007. Population projections for Montgomery County represent additional growth as follows; 483,105 by 2020, 596,820 by 2030, and 717,590 by 2040.

2.3.2 Vegetation

The Piney Woods Natural Region of Texas includes three vegetation types: “Pine Hardwood Forest”, “Young Forest/Grassland” and “Other Native or Introduced Grasses” as defined by *The Vegetation Types of Texas* (TPWD 1984).

The following plants are commonly associated with “Pine Hardwood Forest”, “Young Forest/Grassland” and “Other Native or Introduced Grasses”: shortleaf pine, loblolly pine, water oak, white oak, southern red oak, winged elm, beech, blackgum, magnolia, American beautyberry, American hornbeam, flowering dogwood, yaupon, hawthorn, supplejack, Virginia creeper, wax myrtle, red bay, sassafras, southern arrowwood, poison oak, greenbriar, blackberry, sweetgum, post oak, black hickory, elm, hackberry, sumac, holly, blueberry, beaked panicum, bitter sneezeweed, blackjack oak, broomsedge bluestem, brownseed paspalum, bushclover, cedar, common persimmon, eastern redcedar, elbowbush, gay feather, Indiangrass, little bluestem, purpletop, sand post oak, sand lovegrass, sandjack oak, slender bluestem, spranglegrass, three-awn, tickclover, velvet bundleflower, yellow jessamine, yellow neptunia, red bay and mixed native or introduced grasses and forbs (TPWD 1984)..

<u>Bottomland Hardwood Forests</u>

Another vegetation type common to the Piney Woods is bottomland hardwood forest systems. They are the most diverse Texas ecosystems and are considered a high priority conservation effort for the TPWD. Bottomland wetlands are plant communities that have been created as a result of the actions of creeks, rivers and floodplains and are generally part of a system that begins at a river’s headwaters and ends in an estuary at the ocean. They play a vital role in maintaining water quality by serving as a depository for sediments, wastes and pollutants from runoff.

Historically, oak, ash, hickory, gum, and cottonwood species were common in the Piney Woods along the major river drainages such as the Trinity, Red River, Sulphur, Sabine, Angelina, Neches, and Attoyac. These hardwood trees grew very large in the rich bottomland soil. Early accounts described oaks, ashes, and hickories up to diameters of 6, 4, and 3 feet, respectively. Much of this timber was being harvested and rafted out along the rivers. Local factories were being constructed to utilize the hardwood material.

In addition to the commercial harvest of the bottomland forest, settlers were clearing the forests for settlement and agricultural production in the nutrient rich soils. Much of the area previously occupied by bottomland hardwood forests has been converted to other uses. Many thousands of acres of bottomland hardwood forest have been lost due to reservoir construction. The construction of dams along major river drainages has resulted in the upstream flooding and loss of bottomland hardwood forests. As mentioned previously, these bottomland areas contain highly productive soils. Therefore, thousands of acres of bottomland hardwood forests have been lost due to conversion to agricultural production.

2.3.3 Threatened and Endangered Species

The Endangered Species Act (ESA) provides for the protection of all listed threatened and endangered species from "take", defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct." "Harm" is further defined by U.S. Fish and Wildlife Service (USFWS) to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering. "Harass" is defined by USFWS as "actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering" (50 CFR §17.3).

Two species listed as threatened or endangered in Montgomery County with potential habitat in the project area are the bald eagle and the red-cockaded woodpecker. Potential habitat for these species has been mapped on the Environmental Constraints Map in *Appendix J*.

Table 19 Threatened and Endangered Species for Montgomery County, Texas

Species	USFWS*	TPWD*	Known Occurrence in Project Area
American Peregrine Falcon	DL	E	No
Arctic Peregrine Falcon	DL	T	No
Bald Eagle	DL	T	Yes
Piping Plover	T	T	No
Red-cockaded Woodpecker	E	E	Yes
White-faced Ibis	-	T	No
Wood Stork	-	T	No
Creek Chubsucker	-	T	No
Paddlefish	-	T	No
Louisiana Black Bear	T	T	No
Rafinesque's Big-eared Bat	-	T	No
Red Wolf	E	E	No
Alligator Snapping Turtle	-	T	No
Louisiana Pine Snake	-	T	No
Texas Horned Lizard	-	T	No
Timber/Canebrake Rattlesnake	-	T	No
E=endangered, T=threatened, DL=delisted			

Source: TPWD, 2007.

<u>Bald Eagle</u>

The bald eagle (*Haliaeetus leucocephalus*) has staged a remarkable rebound and has recovered to the point that they no longer need protection under the ESA. Effective August 8, 2007, the bald eagle was delisted from the USFWS list of threatened and endangered species. The bird will still be protected by the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act. Both laws prohibit killing, selling or otherwise harming eagles, their nests, or eggs. Bald eagles are found primarily near seacoasts, rivers, and large lakes where food resources such as fish and waterfowl are readily available. Eagles usually build their nests in 40- to 120-foot tall trees or on cliffs.

Red-cockaded Woodpecker

The red-cockaded woodpecker (*Picoides borealis*) sleeps and nests in the cavities of live, large, mature pine trees in east Texas and the southeastern United States. The nesting season is usually from April through July. In Texas, these cavities have been found in longleaf, loblolly, shortleaf, and slash pines approximately 60 to 70 years of age or older. The woodpecker prefers a cluster of trees containing and surrounding the cavity trees where they roost and nest. The preferred cluster sites are mature, park-like pine stands with 50 to 80 square feet of basal area per acre. The decline of the red-cockeded woodpecker is attributed to the decrease in the quality and quantity of old growth pine forest nesting habitat, primarily due to short rotation timber management and to a lesser extent fire suppression.

When alignments are finalized a field study of the entire project area should be completed by a qualified biologist to determine if the project would impact the bald eagle or red-cockaded woodpecker. Additional permitting may be required for construction. Potential impacts to threatened and endangered species should be evaluated and best management practices for construction as well as mitigation opportunities should be documented. Coordination may be required through the county or local municipalities as well as the USFWS and/or TPWD.

2.3.4 Cultural Resources

The Antiquities Code of Texas was passed in 1969 and requires that the Texas Historical Commission (THC) review any action that has the potential to disturb historic and archeological sites on public land. In 1995 the Texas Antiquities Committee, which was created in 1969, was abolished and the THC became the legal custodian of the Antiquities Code, and therefore, all cultural resources, historic and prehistoric, within public domain of the State of Texas.

According to the THC there are 59 historic markers, 2 national register properties and 64 cemeteries located in Montgomery County. Of these resources there is only one cemetery adjacent to the project.

Archeological site records are maintained by the Texas Archeological Research Laboratory (TARL) in Austin, Texas. Research was conducted by a qualified environmental specialist at TARL to locate archeological resources in the proposed project vicinity and digitize them into an electronic file. Resources that were identified by TARL are indicated in orange on the Environmental Constraints Map in Appendix J. Based on an initial research and a desktop survey, one archeological site, Record #100, may be impacted by the proposed project. However, it is possible that new archeological evidence could be discovered along utility corridors or creek crossings during excavation. If resources are discovered during excavation, construction work would cease until the proper THC authorities were notified.

2.3.5 Oil and Gas Pipelines

A review of available oil and gas information from the Railroad Commission of Texas was conducted. Water transmission lines for the proposed project cross over oil and gas pipelines. Pipelines are identified on the Environmental Constraints Map in *Appendix J*. The pipelines crossed are owned by fourteen various entities and are crossed more than once in some cases.

2.3.6 Public Lands

The TPWD regulates activities which require the acquisition of any public land “designated and used prior to the arrangement of the program or project as a park, recreation area, scientific area, wildlife refuge, or historic site” under Chapter 26 of the Texas Parks and Wildlife Code.

While there are multiple parks in Montgomery County and the City of Conroe located within one mile of the proposed alignments, there are no impacts expected to parks due to encroachment because none are directly adjacent to the project. Refer to the Environmental Constraints Map in *Appendix J* for the location of parks in the project area.

While several schools are near the project area, only six campuses are directly adjacent to the proposed alternatives. A field survey is recommended to confirm any potential encroachment on public lands. Further coordination with the Conroe ISD, Magnolia ISD, and the school campuses where construction impacts may occur is recommended.

2.3.7 Waters of the United States

The U.S. Army Corps of Engineers (USACE) is the regulatory agency for activities that may impact waters of the U.S. Under Section 404 of the Clean Water Act, a permit is required from the USACE for any activity involving the discharge of dredged or fill material into waters of the U.S., including wetlands. Dependent on the scope and type of impacts to waters of the U.S., authorizations may be in one of three primary forms: general permit, a letter of permission, or a standard individual permit.

A study of the surface water resources for the proposed project included a review of the USGS topographic maps and aerial photographs. The project area will require additional field surveys to determine the extent of waters of the U.S. as defined by the USACE. The survey will identify the ordinary high water mark on drainage features and identification of potential wetlands.

There are several drainage crossings within the project limits. Depending on the proposed method of construction the water transmission lines may tunnel around the various segments of the water bodies and therefore impacts may be avoided. Potential impacts can be assessed when the alignments are finalized and the construction method for the water transmission lines is determined.

2.3.8 Wetlands

Wetlands are defined as lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. An area shall be classified as a wetland if it meets the USACE three parameter technical criteria as outlined in the USACE 1987 Wetlands Delineation Manual. Three parameters for wetland determination include prevalence of hydrophytic vegetation, hydric soil formation, and presence of adequate hydrology.

As mentioned above, the USACE regulates activities that may impact waters of the U.S. Under Section 404 of the Clean Water Act, a permit is required from the USACE for any activity involving the discharge of dredged or fill material into waters of the U.S., including wetlands.

The National Wetland Inventory (NWI) Quad Maps (USFWS, 1992) produced by the USFWS have been used to identify potential wetlands mapped in the project area. The NWI maps indicate the presence of wetlands in the project area and those areas are shown on the Environmental Constraints Map in *Appendix J*.

When alignments are finalized a field study and wetland mapping should be completed for the entire project area by a qualified wetland scientist. Additional permitting may be required for construction. Potential impacts to wetlands should be evaluated and best management practices for construction as well as mitigation opportunities should be documented. Coordination may be required through the county or local municipalities as well as the USFWS. If wetlands are disturbed during the construction of the water treatment facility, an intake site, or the water transmission lines additional permitting and mitigation may be required.

2.3.9 Water Quality

The Texas Commission on Environmental Quality (TCEQ) is required under Section 303(d) of the Clean Water Act to identify water bodies for which effluent limitations are not stringent enough to implement water quality standards and for which the associated pollutants are suitable for measurement by maximum daily load. The TCEQ develops a schedule identifying Total Maximum Daily Loads (TMDLs) that will be initiated in the next two years (from June 27, 2007) for priority impaired waters.

According to TCEQ's Draft 2006 303(d) List, the project is located near three impaired stream segments or tributaries to impaired segments which are described in detail below. Category 5 water bodies comprise the 303(d) List. A Category 5 water body does not meet applicable water quality standards or is threatened for one or more designated uses by one or more pollutants. Being classified as Category 5a means a TMDL is underway, scheduled, or will be scheduled. Being classified as Category 5b means a review of the water quality standards for the water body will be conducted before a TMDL is scheduled. Being classified as Category 5c means that additional data and information will be collected before a TMDL is scheduled.

The WFSJR is a freshwater stream that begins at the confluence of Spring Creek in Harris/Montgomery County and travels to the Conroe Dam in Montgomery County. This portion of the San Jacinto River is defined as Segment 1004 and is in the San Jacinto River Basin. In 2004, only the area from IH 45 to the Spring Creek confluence was identified as Category 5c and was impaired for bacteria on the TCEQ's 303(d) List. The updated Draft 2006 303(d) List identifies the area from IH 45 to the Spring Creek confluence as Category 5a and still impaired for bacteria. Additionally, in 2006 the WFSJR from Lake Conroe Dam to IH 45 is identified as Category 5c and as impaired for macrobenthic community.

Upper Panther Branch is an unclassified water body and freshwater stream in the San Jacinto River Basin. This stream is defined as Segment 1008B and is an intermittent stream with perennial pools from the normal pool elevation of 125 feet of Lake Woodlands upstream to Old Conroe Road. The segment is identified as Category 5a and was first listed in 2006. The impaired area of the segment is from Old Conroe Road to the confluence with Bear Branch for bacteria.

Spring creek is a freshwater stream that begins at the confluence with the WFSJR in Harris/Montgomery County and extends to the most upstream crossing of FM 1736 in Waller County. This creek is defined as Segment 1008 and is in the San Jacinto River Basin. This freshwater stream is impaired for bacteria from SH 249 to IH 45 and IH 45 to confluence with Lake Houston.

Issuance of permits to discharge into 303(d)-listed water bodies is described in the TCEQ regulatory guidance document *Procedures to Implement the Texas Surface Water Quality Standards* (August 2002, RG-194). Further coordination with the TCEQ is recommended once final alignments are determined and construction methods are known.

Compliance with the TCEQ's Texas Pollutant Discharge Elimination System (TPDES) General Permit for Construction Activities is required if a project disturbs one or more acres. The project described in this document would disturb more than one acre and would be required to adhere to the conditions of the

TPDES General Permit. A Storm Water Pollution Prevention Plan must be prepared and incorporated in to the construction plans.

2.3.10 Floodplains

The National Flood Insurance Program (NFIP) was established to reduce future flood losses through local floodplain management. NFIP requires participating cities, counties, or states, to adopt floodplain management ordinances containing certain minimum requirements intended to reduce future flood losses. The local jurisdiction is responsible for coordinating with the Federal Emergency Management Agency (FEMA) any alterations or relocation of a waterway and proposals for amendments to NFIP maps should it be necessary.

The proposed water treatment facilities, intake facility, and many portions of the transmission lines are located in existing floodplains mapped as Zone A or AE by FEMA on the Flood Insurance Rate Maps (FIRM). Refer to the Environmental Constraints Map in *Appendix J* for the locations of the 100-year and 500-year floodplain areas.

Zone A is defined as an area with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Because detailed analyses are not performed for such areas; no depths or base flood elevations are shown within these zones.

Zone AE is defined as an area with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. In most instances, base flood elevations derived from detailed analyses are shown at selected intervals within these zones. Mandatory flood insurance purchase requirements apply to all of these zones. An initial environmental survey of floodplain maps associated with the project area has identified that these creeks and tributaries have been modeled.

Construction and modification of these floodplains may require coordination with the local Montgomery County Floodplain Administrator. The Engineering Division of the City of Conroe is charged with the maintenance and enforcement of the City's floodplain and floodway ordinances as mandated by the NFIP. The City Engineer operates in the capacity of the Certified Floodplain Administrator (CFM). While only a portion of the proposed water transmission lines are located within the City Limits of Conroe it will be necessary to request a Floodplain Letter from the City to aide in identifying if a parcel in the proposed construction area is affected by the 100-year Floodplain. The purpose of a FIRM is to show the areas in our community that have a 1% or greater chance of flooding in any given year, known as Special Flood Hazard Areas (SFHAs). Further, the project may require FEMA to make an official determination regarding the location of the project relative to the SFHA, and may trigger the need for a Letter of Map Amendment (LOMA) or a Letter of Map Revision Based on Fill (LOMR-F). LOMAs and LOMR-Fs are documents issued by FEMA that officially remove a property and/or structure from the SFHA. To obtain a LOMA or LOMR-F, the applicant must submit mapping and survey data for the property. In most cases, the applicant will need to hire a land surveyor to prepare an Elevation Certificate for the property. The issuance of a LOMA or LOMR-F eliminates the federal flood insurance purchase requirement as a condition of federal or federally backed financing.

2.3.11 Groundwater

Montgomery County is located over the Gulf Coast aquifer which forms a wide swath along the Gulf of Mexico from Florida to Mexico. In Texas, this aquifer provides water for municipal and irrigation uses to all or parts of 54 counties and extends from the Rio Grande to the Louisiana-Texas border. The Greater Houston metropolitan area is the largest municipal user of water from this aquifer in Texas.

There are no known water wells located within the proposed right-of-way. No reservoir, aquifer, well, or any other actively used source of public water would be impacted by the proposed project, either during or following construction.

2.3.12 Hazardous Materials

The Resource Conservation and Recovery Act (RCRA) of 1976 governs the management of non-hazardous solid waste, hazardous waste, and underground storage tanks (USTs). Specifically, the RCRA program regulates: solid waste recycling and disposal; federal procurement of products containing recycled materials; waste minimization; hazardous waste generators and transporters; hazardous waste treatment; and storage and disposal facilities.

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) approved in 1980, is best known for its "Superfund," program and provides EPA with the authority to respond to releases or threatened releases of hazardous substances, pollutants, or contaminants that may endanger human health or the environment. Superfund was primarily designed to remedy the mistakes in hazardous waste management made in the past at sites that have been abandoned or where a sole responsible party cannot be identified. CERCLA requires reporting of releases, establishes the liability of persons responsible for releases of hazardous substances, and established a trust fund to provide cleanup when no responsible party can be identified.

A review of selected regulatory environmental databases published by federal and state agencies was conducted via the internet to determine the potential for environmental degradation in the project limits.

The environmental databases provide information on regulated facilities that are listed as having a past or present record of actual or potential environmental impact. The listings are limited and include only those sites that are known to the regulatory agencies at the time of publication to be contaminated or in the process of evaluation for potential contamination. The following is a list of the federal and state databases that were reviewed;

- TCEQ State Superfund List
- TCEQ Municipal Solid Waste Sites/Landfills
- TCEQ Permitted Industrial and Hazardous Waste Sites
- TCEQ Radioactive Waste Sites
- EPA Toxic Release Inventory (TRI)

Based on the regulatory database review of the project limits, few regulated or other suspect hazardous material facilities were identified in the project area.

One superfund site, United Creosoting, is located directly adjacent to the proposed water transmission lines for both the Single Plant and Dual Plant Alternative. Refer to the Environmental Constraints Map in *Appendix J* for the location of this site. A summary of the site's description, status, and detailed location map can be found in *Appendix K*.

A visual reconnaissance of the project limits is recommended to confirm the location of the listed regulatory facilities; look for evidence of underground or aboveground storage tanks; and look for ground stains or other indications that contaminated soils occur within the project.

2.3.13 Air Quality

The Clean Air Act (CAA) was passed in 1963 which established permanent federal support for air pollution research and provided federal assistance to states for development of pollution control agencies. The CAA has been amended several times; beginning in 1970 the Clean Air Act Amendment (CAAA) established National Ambient Air Quality Standards (NAAQS) for six air pollutants (Ozone, Carbon Monoxide, Particulate Matter, Nitrogen Dioxide, Sulfur Dioxide and Lead). The CAA was amended again in 1977 which strengthened the CAA by establishing deadlines for reaching air quality attainment status, requiring the development and implementation of the State Implementation Plans (SIPs) to bring air quality non-attainment areas into compliance with NAAQS. The original Texas SIP was approved by EPA in May 1972 and has been revised several times thereafter. The CAA's most recent amendment was in 1990 which established specific criteria that must be met for air quality in non-attainment areas.

Montgomery County along with Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty and Waller counties, collectively referred to as the Houston-Galveston-Brazoria (HGB), hold non-attainment status for ground level ozone under the eight-hour standard. The region was classified as being in "moderate" non-attainment of the eight-hour standard and was given a maximum attainment deadline of June 15, 2010.

All activities associated with the construction of the proposed project would be required to comply with the current Texas SIP.

2.4 Existing Raw Water Quality

The proposed alternatives would potentially draw water from one or more surface water locations. The first potential site is Lake Conroe, near the San Jacinto River Authority (SJRA) Lake Conroe Dam. The second potential source water site is the West Fork of the San Jacinto River, 6.9 miles south of the dam.

Raw water quality data from Lake Conroe is very limited. Previously recommended sampling and testing of the water quality is still needed to finalize treatment process selection. Limited water quality data is obtained from USGS website "National Water Information System", where the water quality of Lake Conroe (USGS 08067600) is continuously monitored. The assessment of the "Overall Public Water Supply Use" is "FULLY SUPPORTING", which means that there are no major chemical or biological contaminates of concern. Conventional treatment methods should be capable of treating the water for drinking purposes.

There is no raw water quality data for the West Fork San Jacinto River that would be applicable to the Woodlands Area Plant Site. However, the source water is 6.9 miles north at Lake Conroe. There are no heavy industrial or agricultural activities along the river between Lake Conroe and the proposed river intake. The water quality at this site should be similar to, but slightly worse than and more variable than the water quality in Lake Conroe. An additional suspended solids sediment load due to movement of the water in the river is expected. This additional sediment load could still be treated with conventional treatment systems.

At either plant site location, the water quality is anticipated to fully support public water supply use, but specific water quality parameters need to be verified by sampling and testing.

Water quality data collected from Lake Conroe at the Intake Structure East Gate is provided in *Appendix B* and summarized in *Table 20* and *Table 21* below.

The monthly testing summary for Lake Conroe water quality, as collected at the Intake Structure East Gate, is summarized below for October through December 2007.

Table 20 Lake Conroe Water Quality - Monthly Testing Summary

Analyte	Units	10/01/07	10/24/07	11/28/07	12/19/07
Alkalinity, bicarbonate	mg/L as Ca CO_3	65.5	68.0	66.6	*Note 1*
Alkalinity, carbonate	mg/L as Ca CO_3	< 1.0	< 1.0	< 1.0	*Note 1*
Alkalinity, total	mg/L as Ca CO_3	65.5	68.0	66.6	*Note 1*
Hardness, calcium	mg/L as Ca CO_3	55	60	63	*Note 1*
Hardness, magnesium	mg/L as Ca CO_3	7.9	8.6	8.8	*Note 1*
Hardness, total	mg/L as Ca CO_3	63	69	72	*Note 1*
Color	Pt/CO units	40	40	30	*Note 1*
Odor	TON	< 1.00	< 1.00	< 1.00	*Note 1*
Sodium	mg/L	12	13	14	*Note 1*
Turbidity	NTU	4.1	4.5	3.6	*Note 1*
Total dissolved solids	mg/L	130	130	120	*Note 1*
Total suspended solids	mg/L	< 10	< 10	< 10	*Note 1*
Total organic carbon	mg/L	7.48	7.23	7.83	*Note 1*
Dissolved oxygen	mg/L	Not given	6.61	8.25	8.83
Air temperature	F	Not given	58	56	68
Temperature	C	Not given	22.3	16.14	15.13
Conductivity	umho/cm	Not given	209.4	212.2	205.1
pH	s.u.	Not given	8.13	8.32	7.68
Secci Depth	inches	Not given	42	40	42

SJRA Results Summary, Monthly Testing, Intake Structure East Gate. This report is a Results Summary of tests previously performed and reported. Test results were reported by Nova Biologicals, Inc., U/L Laboratories, and LCRA Environmental Laboratory Services.
[1] No results were reported for this test date.

The quarterly testing summary for Lake Conroe water quality, as collected at the Intake Structure East Gate, is summarized below for the late November 2007 testing.

Table 21 Lake Conroe Water Quality - Quarterly Testing Summary

Analyte	Units	11/28/07
Aluminum	ug/L	37
Ammonia-nitrogen	mg/L	< 0.1
Bromide	mg/L	0.08
Calcium	mg/L	25
Chloride	mg/L	21
Fluoride	mg/L	2.2
Iron	mg/L	0.068
Manganese	ug/L	97
Magnesium	mg/L	2.1
Orthophosphate-phosphorus	mg P/L	< 0.05
Potassium	mg/L	3.4
Silicon	mg/L	9.6
Sulfate (as SO_4)	mg/L	< 5.0
Total kjeldhal kitrogen (TKN)	mg/L	0.6
Total Nitrate (as N)	mg/L	0.22
Total Nitrite (as N)	mg/L	0.05
Total Phosphorus (as P)	mg P/L	0.09
UV 254 absorbance	cm^{-1}	0.136
Carbonaceous BOD	mg/L	< 3.0
Chemical oxygen demand	ug/L	16
Chlorophyll-A	mg/L	18.4
E.coli / fecal coliform	mpn/100ml	1.0
Total coliform	mpn/100ml	547.5

SJRA Results Summary, Quarterly Testing, Intake Structure East Gate. This report is a Results Summary of tests previously performed and reported. Test results were reported by Nova Biologicals, Inc., U/L Laboratories, and LCRA Environmental Laboratory Services.

Section 3 Future Conditions & Needs

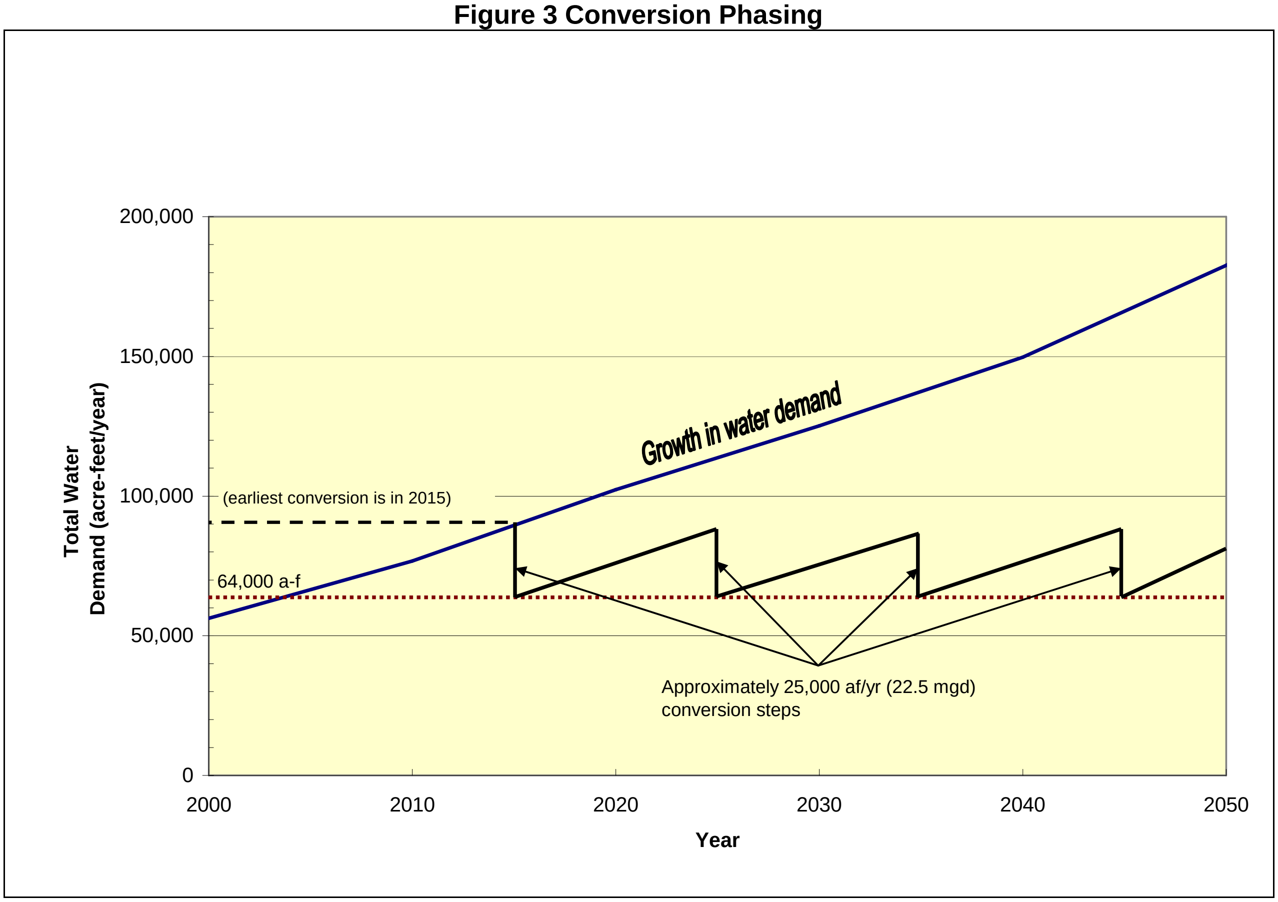
3.1 Desired Conversion

The levels of future conversion are based on projected water demands and available information on the direction of the Districts' regulatory planning efforts. This section discusses the planning assumptions made in establishing conversion requirements, the development of conversion requirements for 2015, 2025, 2035, and 2045, and seasonal issues affecting plant sizing.

3.1.1 "Saw Tooth" Curve

The District's Phase I Regulatory Plan requires groundwater consumption in Montgomery County to be at or below 64,000 acre-feet/year by the year 2015. Given that the District does not have regulations covering conversions beyond 2015, an assumption had to be made regarding the requirements for future conversions. This study adopts a "minimum conversion" approach consistent with the 2006 Phase I study; groundwater consumption must be reduced to the target in 2015, 2025, 2035, and 2045, but increased demands due to growth between those conversion points can be met by groundwater. *Figure 3* illustrates this concept.

Figure 3 Conversion Phasing



This approach has important consequences: it has the benefit of minimizing the extent, size and cost of facilities, but allows groundwater withdrawals to periodically exceed the sustainable recharge rate of the aquifer system. Given the relatively short timeframe to implement a surface water system to meet the Phase I DRP requirements, this is the most expedient approach. Over time, the District will be evaluating the conditions that affect how the groundwater resources are managed: these include population growth, change in demands due to aggressive conservation and wastewater reuse, and the results of a District-funded aquifer recharge rate study currently being conducted by the United States Geological Society (USGS). District regulations on groundwater use can change periodically to reflect conditions at that point in time.

3.1.2 Phasing Requirements

As discussed in the above section, the amount of conversion in each decade, starting in 2015, is just enough to bring total groundwater consumption in the County to 64,000 ac-ft/yr at that point in time; i.e. a “minimum conversion” approach. *Table 22* gives the minimum conversion requirements by decade and is based on projected demands in the Region H RWP.

Table 22 Minimum Phasing Requirements

	2015 (I)	2025 (II)	2035 (III)	2045 (IV)
Total Demand (ac-ft/yr) from 2006 RWP[1]	89,543	113,716	137,435	166,175
Demand Met By Surface Water (ac-ft/yr)[2]	7,840	7,840	7,840	7,840
Demand Met By Groundwater (ac-ft/yr)	81,703	105,876	129,595	158,335
Minimum Conversion Amount (ac-ft/yr)	17,703	41,876	65,595	94,335
Minimum Conversion Amount (mgd)	15.8	37.4	58.6	84.2

1. Demands prorated from published decadal values (e.g. 2015 demands are an average of 2010 and 2020 demands)
2. Steam-electric contract amount

The total demand is broken down into surface water and groundwater components of supply; the demand met by surface water is the volume of water provided by contract from Lake Conroe to the steam-electric WUG. The demand met by groundwater is the basis for conversion: that number minus 64,000 ac-ft/yr gives the minimum conversion amount for each decade. For the purposes of this study, the minimum conversion amount is the volume of water that the surface water system must be capable of delivering on an annual basis.

These amounts are predicated on regional planning projections, and these projections are based on usage rates established in the year 2000. Climate alone can change the total demand and thus the required conversion. In a relatively dry year such as a repeat of 2000 or 2005, the surface water system may provide all the water it is capable of, but in a wet year such as a repeat of 2007 the demand on the system could be less than the total capacity of the system components.

3.1.2.1 Conservation Effects

The regional planning projections take a small amount of conservation into account through increased projected use of water saving plumbing fixtures, but do not take aggressive conservation or use of reclaimed water into account. The District and SJRA encourage conservation and the use of reclaimed water, and the District is currently evaluating conservation and reuse incentives as ways to reduce total demand and groundwater demand into the future, thereby reducing or delaying the need for expansion of surface water facilities beyond 2015.

A 2007 investigation into wastewater reuse opportunities in Montgomery County showed there is the potential for 12% of the County's total demand to be met by reclaimed water. Assuming that countywide, aggressive conservation could reduce total demands by 10%, the surface water required in 2045 would be reduced from 94,335 ac-ft/yr to 73,581 ac-ft/yr. This could significantly extend the supply in Lake Conroe and delay the need to bring in additional surface water supplies from other sources such as Lake Houston.

3.1.3 Seasonal Demand Issues

Required conversion volumes are on an annual basis, and it is assumed that the treatment plant(s) would operate such that average day demands are supplied. A PWSs' actual daily demand is typically either below or above the average daily rate throughout the year. Over the course of a year if no more than average daily flow is delivered to any PWS, the actual volume consumed is less than the yearly demand. Said another way, if no more than average daily flow is delivered, there is a limit to how much of any PWS's annual demand can be converted to surface water.

Table 23 illustrates this concept by showing the monthly demand from an actual PWS, the available supply (average day constant throughout the year), and the volume of surface water actually supplied. The surface water volume supplied is the lesser of the demand and the available supply in each month. In this example, the annual demand and available supply is 397,647 thousand gallons and the volume supplied is 357,948 thousand gallons. The conversion rate for this PWS is 90% (357,948/397,647). In this case it took 1.09 mgd of available supply to deliver 0.98 mgd on the average.

Table 23 Seasonal Supply Example

Month	Demand (x 1,000 gal)	Available Supply (x 1,000 gal)	Volume Supplied (x 1,000 gal)
Jan	24,358	33,137	24,358
Feb	22,479	33,137	22,479
Mar	25,523	33,137	25,523
Apr	30,170	33,137	30,170
May	38,785	33,137	33,137
Jun	46,822	33,137	33,137
Jul	39,688	33,137	33,137
Aug	37,311	33,137	33,137
Sep	35,971	33,137	33,137
Oct	39,946	33,137	33,137
Nov	29,715	33,137	29,715
Dec	26,879	33,137	26,879
TOTALS:	397,647	397,647	357,948

The conversion rate will vary depending on the usage pattern, but it would typically be below 90% when the supply is provided at a rate equal to the average daily rate on an annual basis.

Consideration of this issue is important when the goal is to minimize the amount of transmission pipeline by converting a smaller number of PWSs at a high rate. In those cases the water treatment plant may have to have capacity above the average day rate to handle achieving the desired conversion; i.e. the plant will require a peaking factor. If the desired level of conversion can't be met with a plant delivering water at an average day rate, the two options are to “peak the plant” or deliver water to enough PWSs so that the overall conversion rate is lowered. In the example above, the conversion rate at which no peaking to the plant would be required would be 68% (the ratio of minimum month to average month: 22,479/33,137).

The variability in daily demands versus supply is discussed in *Section 4.1.3*. The daily demands should be reviewed further during subsequent preliminary engineering efforts and the results may impact the overall plan and costs.

3.2 Pipeline Distribution System

3.2.1 Preliminary Alignment Corridor

A preliminary alignment corridor, shown in *Exhibit 5*, was identified in the *Groundwater Regulatory Plan and Facilities Implementation Plan* report (Phase I Study). This corridor was established with a desktop level routing analysis for the purpose of establishing high-level planning costs and water rates. While there was no significant Right of Way (ROW) analysis performed during the Phase I Study, there was significant communication between the District and the regulated community in terms of the general approach. This communication was in the form of public meetings and a series of presentations given to various cities and water districts throughout the County. The basic assumptions of the Phase I Study solution presented to stakeholders represents an accepted starting point for this study; the assumptions being that a treatment plant at or near Lake Conroe and a relatively compact transmission system would be used to convert the densely populated I-45 corridor initially.

The 2020, 2030, and 2040 phases in the Phase I Study were generally not adopted in the current study. For the Lake Conroe system, the Phase I Study showed Southwest Montgomery County as being served starting in 2030: this area will likely continue to develop as low-density ranch style communities, requiring an extensive network of transmission lines to deliver the required conversion volumes.

Using the Phase I Study alignment as a general starting point, the proposed alignment was established based upon stakeholder input regarding available right-of-way, proposed planning alignments, demand phasing, proposed plant locations, and constructability issues. The revised preliminary alignment corridor is discussed in more detail in Section 3.2.2 below.

3.2.2 Revised Alignment Corridor

Two proposed pipeline alignments to supply surface water in Montgomery County in the future are considered in this phase of the study:

1. Single Plant Alignment: The single plant alignment has one water treatment plant located by Lake Conroe which is the sole source of water supply for the proposed alignment.

2. Dual Plant Alignment: The dual plant alignment has two proposed water treatment plants. The first one is located by Lake Conroe (north plant) and the second one is on the West Fork of San Jacinto River (WFSJR) north of the Woodlands (south plant). In this option, water is released from Lake Conroe to the San Jacinto River and withdrawn downstream from the West Fork of San Jacinto River where the second proposed treatment plant is located.

The two alignment alternatives are shown in *Exhibit 6*. The revised alignment corridors are also shown in *Exhibit 22* through *Exhibit 28*.

Timelines (2015, 2035 and 2045) for the surface water pipelines for both the single and dual treatment plant options are presented in *Exhibit 7*. The proposed 2015 system can deliver an amount up to 21 MGD. In

2035, the proposed pipelines are extended to the west of Lake Conroe and to west and south-west areas in the County. The 2035 system can deliver up to approximately 66 MGD. The 2045 system is extended east of Lake Conroe, south of Conroe, and in the south-east area of the County and can deliver up to approximately 90 MGD. The pipeline segments for the single and dual plant options are presented in *Exhibit 8* and *Exhibit 9* respectively. A summary of pipeline lengths for the single and dual plant options are presented in *Table 24*.

Table 24 Summary of Pipeline Lengths

System Year	Single Plant		Dual Plant	
	(ft)	(miles)	(ft)	(miles)
2015	294,681	55.8	266,850	50.5
2035	232,542	44.0	253,206	48.0
2045	179,389	34.0	179,387	34.0

The feasibility and recommended construction method for these alignments were analyzed and a recommended location within the right-of-way or an adjacent easement was identified. Among the constraints that were considered as part of this recommendation are public agency input, visible or planned utilities within the right-of-way, access/room for construction, existing waterways and topography, existing and planned infrastructure, environmental considerations, and other anticipated impacts of construction.

A detailed narrative of the entire alignment, grouped by segment, is provided in *Appendix C*.

3.2.2.1 Pipeline Sizing

Surface water pipelines are sized for both single and dual treatment plant options. The pipelines are sized using the Pipe2008 (version 4.102) software program developed by KYPipe. *Table 25* provides a list of criteria used to size the pipelines.

Table 25 Criteria Used to Size Surface Water Pipelines

Pipeline Sizing
Pipelines sized for average day flow. Peaking will be done by existing groundwater facilities.
Hazen-Williams formula used to calculate head loss. C value = 120 to 140.
Maximum flow velocity allowed is 5.5 ft/sec.
Pipelines sized assuming a maximum head loss of 5 feet per 1,000 feet of pipe.
Maximum working pressure of pipe material is 150 psi.
Maintain 20 psi at the ground at the end of the alignment to enable filling of storage tanks.

Surge analysis was not conducted during this study. The operational impacts of lower demands on the water pipeline sized for larger flows should be investigated and addressed during subsequent preliminary engineering efforts. The lower demands on the water pipeline sized for larger flows may impact the overall plan and costs.

3.2.2.1.1 Model Demand

The pipelines are sized for 90% of 2045 demand amounts at each of the PWSs supplied, allowing a total flow of approximately 90 mgd. The 2045 demand amounts are developed by interpolating the 2040 and 2050 demand projections from 2006 Region H Regional Water Plan which were spatially distributed and aggregated to 'Demand Planning Areas' during the Phase I Facility Planning Study. Spatial distribution is based on the U of H Small Area Model (provided by Dr. Steven Craig).

The 'Demand Planning Areas' are developed for the purpose of planning and do not have any regulatory jurisdiction. Water demand amounts broken down by PWSs and demand planning areas are presented in *Table 26.*

Demand for the Woodlands is divided into each entry point based on the ultimate flow rate at each well as presented in *Table 27*. Demand for the City of Conroe is divided into each entry point based on the tested capacity (GPM) of the wells. Water demand at each entry point for the City of Conroe is presented in *Table 28*.

For the rest of the PWSs, the demand data is split into different entry points of each PWS based on their tested GPM or capacity listed in the TCEQ website. For any PWSs where no information was available to split the total demand into different entry points, the total demand was distributed evenly between the different entry points (Ex. City of Shenandoah). Water demand amounts at each of the PWS entry points are presented in *Exhibit 10*.

Table 26 Water Demand for Pipeline Sizing

Demand Planning Area	WUG	2040 Demand (ac-ft/yr)	2045 Demand[1] (ac-ft/yr)	2050 Demand (ac-ft/yr)	90% of 2045 Demand (ac-ft/yr)	Model Entry Point Demand	
						(ac-ft/yr)	(gpm)
105 to Lake Creek	COUNTY-OTHER	2,279	2,457	2,636	2212	1289	799
105 to Lake Creek	MANUFACTURING	84	88	91	79		
105 to Lake Creek	SOUTHWEST UTILITIES	44	51	58	46	46	28
106 to Lake Creek	CITY OF MONTGOMERY	192	216	240	194	194	120
	SUBTOTALS:	**2,599**	**2,812**	**3,025**	**2,531**	**1,529**	**947**
Conroe/Woodlands	CONROE	16,310	18,358	20,406	16522	16522	10243
Conroe/Woodlands	CONSUMERS WATER INC	210	213	216	192	192	119
Conroe/Woodlands	COUNTY-OTHER	10,591	12,881	15,172	11593	11593	7187
Conroe/Woodlands	EAST PLANTATION UD	937	1,084	1,230	975	975	605
Conroe/Woodlands	H M W SUD	263	254	246	229	229	142
Conroe/Woodlands	MANUFACTURING	383	399	416	359	359	223
Conroe/Woodlands	MONTGOMERY COUNTY MUD #19	444	444	444	400	400	248
Conroe/Woodlands	MONTGOMERY COUNTY WCID #1	645	698	750	628	628	389
Conroe/Woodlands	OAK RIDGE NORTH	1,067	1,182	1,297	1064	1064	660
Conroe/Woodlands	PANORAMA VILLAGE	1,153	1,151	1,148	1035	1035	642
Conroe/Woodlands	RAYFORD ROAD MUD	2,059	2,059	2,059	1853	1853	1149
Conroe/Woodlands	RIVER PLANTATION MUD	795	793	791	714	714	442
Conroe/Woodlands	SHENANDOAH	497	495	493	445	445	276
Conroe/Woodlands	SOUTHERN MONTGOMERY COUNTY MUD	2,107	2,107	2,107	1896	1896	1176
Conroe/Woodlands	SOUTHWEST UTILITIES	121	144	166	129	129	80
Conroe/Woodlands	SPRING CREEK UD	1,010	1,165	1,320	1049	1049	650
Conroe/Woodlands	THE WOODLANDS (CRU/CDP)	28,197	28,130	28,063	25317	25317	15696
	SUBTOTALS:	**66,790**	**71,556**	**76,323**	**64,401**	**64,401**	**39,927**
East Lake Conroe	COUNTY-OTHER	332	355	378	319	319	198

Demand Planning Area	WUG	2040 Demand (ac-ft/yr)	2045 Demand[1] (ac-ft/yr)	2050 Demand (ac-ft/yr)	90% of 2045 Demand (ac-ft/yr)	Model Entry Point Demand	
						(ac-ft/yr)	(gpm)
East Lake Conroe	MANUFACTURING	1	1	1	1		
East Lake Conroe	MONTGOMERY COUNTY UD #2	507	507	507	456	456	283
East Lake Conroe	POINT AQUARIUS MUD	1,732	2,040	2,348	1836	1836	1138
	SUBTOTALS:	**2,572**	**2,903**	**3,234**	**2,613**	**2,612**	**1,619**
Lake Creek to 1488	COUNTY-OTHER	2,049	2,474	2,899	2226		
	SUBTOTALS:	**2,049**	**2,474**	**2,899**	**2,226**	**0**	**0**
Northeast	COUNTY-OTHER	5,298	5,748	6,198	5173	3386	2099
Northeast	CUT AND SHOOT	348	389	430	350		
Northeast	MANUFACTURING	260	271	282	244		
Northeast	SOUTHWEST UTILITIES	144	191	237	172	172	106
Northeast	WILLIS	1,024	1,160	1,296	1044	1044	647
	SUBTOTALS:	**7,074**	**7,759**	**8,443**	**6,983**	**4,602**	**2,852**
Northwest	COUNTY-OTHER	2,212	2,372	2,532	2135	1657	1027
Northwest	MANUFACTURING	855	891	927	802		
Northwest	SOUTHWEST UTILITIES	93	67	41	60	60	
Northwest	STEAM ELECTRIC POWER	6,745	7,818	8,890	7036	7036	4362
	SUBTOTALS:	**9,905**	**11,148**	**12,390**	**10,033**	**8,753**	**5,389**
Southeast	CONSUMERS WATER INC	156	202	248	182		
Southeast	COUNTY-OTHER	17,961	21,390	24,819	19251	3513	2178
Southeast	CRYSTAL SPRINGS WATER COMPANY	1,189	1,379	1,568	1241		
Southeast	HOUSTON	516	610	704	549		
Southeast	MANUFACTURING	1,298	1,353	1,408	1218	1218	755
Southeast	MINING	229	211	192	189		

Demand Planning Area	WUG	2040 Demand (ac-ft/yr)	2045 Demand[1] (ac-ft/yr)	2050 Demand (ac-ft/yr)	90% of 2045 Demand (ac-ft/yr)	Model Entry Point Demand	
						(ac-ft/yr)	(gpm)
Southeast	NEW CANEY MUD	2,670	3,070	3,470	2763		
Southeast	PATTON VILLAGE	115	126	136	113		
Southeast	PORTER WSC	3,305	3,289	3,274	2961		
Southeast	ROMAN FOREST	317	352	387	317		
Southeast	SPLENDORA	383	443	502	398		
Southeast	WOODBRANCH	139	138	136	124		
	SUBTOTALS:	**28,278**	**32,561**	**36,843**	**29,305**	**4,731**	**2,933**
Southwest	COUNTY-OTHER	10,892	13,447	16,002	12103	3188	1976
Southwest	H M W SUD	2,474	2,816	3,158	2534		
Southwest	MAGNOLIA	412	454	495	408		
Southwest	MANUFACTURING	1	1	1	1		
Southwest	SOUTHWEST UTILITIES	24	29	34	26		
	SUBTOTALS:	**13,803**	**16,746**	**19,690**	**15,071**	**3,188**	**1,976**
West Lake Conroe	COUNTY-OTHER	112	125	138	112	112	70
West Lake Conroe	MONTGOMERY COUNTY MUD #18	4,784	5,677	6,569	5109	5109	3167
West Lake Conroe	MONTGOMERY COUNTY MUD #8	1,785	2,041	2,297	1837	1837	1139
West Lake Conroe	MONTGOMERY COUNTY MUD #9	1,917	2,227	2,536	2004	2004	1242
West Lake Conroe	MONTGOMERY COUNTY UD #3	624	673	722	606	606	376
West Lake Conroe	MONTGOMERY COUNTY UD #4	892	892	892	803	803	498
West Lake Conroe	STANLEY LAKE MUD	859	859	859	773	773	479
	SUBTOTALS:	**10,973**	**12,493**	**14,013**	**11,244**	**11,244**	**6,971**
	GRAND TOTALS:	**144,043**	**160,451**	**176,860**	**144,406**	**101,059**	**62,614**
	(MGD)	***(128.59)***	***(143.24)***	***(157.89)***	***(128.92)***	***(90.22)***	

1. 2045 demands are averages of 2030 and 2050 demands.

Table 27 Demand at the Woodlands Entry Points

The Woodlands	Ultimate Flow Rate	Percent by Well Flow Rate	90% of 2045 Demand			Model Entry Point Demand (gpm)
			(ac-ft/yr)	(mgd)	(gpm)	
WP 1	15763	29.62%	7500	6.70	4649	4649
WP 2	14707	27.64%	6997	6.25	4338	4338
WP 3	8921	16.76%	4244	3.79	2631	2631
WP 4	8023	15.08%	3817	3.41	2366	2366
WP 5	5799	10.90%	2759	2.46	1710	1710
Total	53213	100.00%	**25317**	**22.61**	15694	15694

Table 28 Demand at the City of Conroe Entry Points

City of Conroe	Tested Capacity (gpm)	Percent by Well Tested Capacity	90% of 2045 Demand (ac-ft/yr)	Redistributed Demand at the Wells Served			Model Entry Point Demand (gpm)
				(ac-ft/yr)	(mgd)	(gpm)	
WELL #3	0						
WELL #4	976	8.73%	1442	2103	1.88	1304	
WELL #5	837	7.48%	1237	1898	1.69	1176	1176
WELL #6	867	7.76%	1281	1942	1.73	1204	1204
WELL #7	1,122	10.03%	1658				
WELL #8	791	7.08%	1169	1830	1.63	1135	1135
WELL #12	1,073	9.60%	1586	2247	2.01	1393	
WELL #13	603	5.39%	891	1552	1.39	962	2355
WELL #14	1,107	9.90%	1636	2297	2.05	1424	1424
WELL #15	1,179	10.54%	1742				
WELL #17	1,348	12.06%	1992	2653	2.37	1645	2949
WELL #18	1,278	11.43%	1889				
Total	11,179	100.00%	16522	**16522**	**14.75**	10243	10243

3.2.2.1.2 Pipeline Sizing Results

The resulting pipeline sizes from pipeline network modeling ranges from 8 inches to 54 inches in diameter. Lengths and diameters for the proposed pipelines for the single and dual plant options are presented in *Table 29* and *Table 30* respectively. The pipeline diameters for the single and dual plant options are shown in *Exhibit 11* and *Exhibit 12* respectively. Output files from the water models for pipeline sizing are attached as *Appendix D*.

Table 29 Proposed pipeline length and diameter for single plant option

Pipe Segment	Segment Name	Year	Total Segment Length (ft)	Pipe Diameter (inches)	Sum of Pipe Length (ft)
1	Lake Conroe Plant West	2015	20,666	54	7,912
				48	12,754
2	Fish Creek Thoroughfare North	2015	28,694	48	28,694
3	Fish Creek Thoroughfare South	2015	14,459	48	9,353
				8	5,106
4	FM 2978	2015	18,655	48	1,865
				24	14,394
				18	2,396
7	Research Forest West	2015	14,007	42	14,007
8	Kuykendahl South	2015	7,100	42	4,483
				18	2,617
10	SJRA Water Plant #3	2015	2,165	18	2,165
11	Lakeland West	2015	15,404	42	15,404
13	Lakeland East	2015	16,880	36	2,091
				24	1,938
				16	12,610
				8	241
14	Research Forest East	2015	16,674	36	16,464
				8	210
15	Oak Ridge North	2015	21414	36	9,519
				30	1,816
				10	5,774
				8	4,305
16	Rayford	2015	30,517	30	16,485
				12	4,726
				10	4,876
				8	4,430
17	Sawdust	2015	18,241	30	701
				24	10,404
				10	2,127
				8	5,009
18	Lake Conroe Plant East	2015	50,462	48	9,839
				36	29,125
				16	8,957
				12	2,541
19	Conroe Well #6	2015	8,037	12	8,037

Pipe Segment	Segment Name	Year	Total Segment Length (ft)	Pipe Diameter (inches)	Sum of Pipe Length (ft)
20	UP Railroad	2015	11,306	30	5,827
				24	4,990
				16	259
				12	230
21	FM2854 West	2035	71,205	12	46,833
				8	24,372
22	Lake North West	2035	106,723	24	26,872
				18	65,559
				12	8,303
				10	5,989
23	Millers Crossing	2035	3,259	12	3,259
24	South West Extension	2035	51,355	16	5,205
				12	28,800
				10	3,356
				8	13,994
25	FM2854 Loop	2045	42,281	12	42,281
26	Lake North East	2045	80,387	30	27,878
				24	15,985
				16	7,493
				12	23,569
				8	5,462
27	Crighton Ridge River Plantation	2045	36,539	24	17,659
				16	3,561
				10	10,488
				8	4,831
28	Oak Ridge 2045 Extension	2045	9,924	8	9,924
29	Spring Creek UD	2045	10,258	10	10,258

Table 30 Proposed pipeline length and diameter for dual plant option

Pipe Segment	Segment Name	Year	Total Segment Length (ft)	Pipe Diameter (inches)	Sum of Pipe Length (ft)
1	Lake Conroe Plant West	2035	20,667	30	7,912
				12	12,755
3	Fish Creek Thoroughfare South	2015	14,460	24	9,353
				8	5,107
4	FM 2978	2015	18,655	24	16,259
				18	2,396
5	Sendera-Conroe	2015	15,028	24	15,028
6	Woodlands Plant	2015	27,666	48	23,290
				36	4,376
9	Kuykendahl North	2015	6,964	18	6,964

Pipe Segment	Segment Name	Year	Total Segment Length (ft)	Pipe Diameter (inches)	Sum of Pipe Length (ft)
10	SJRA Water Plant #3	2015	2,164	18	2,164
12	Research Forest Central	2015	8,382	42	8,382
13	Lakeland East	2015	16,880	36	2,091
				24	1,938
				16	12,610
				8	241
14	Research Forest East	2015	16,675	36	16,465
				8	210
15	Oak Ridge North	2015	21414	36	9,519
				30	1,816
				10	5,775
				8	4,304
16	Rayford	2015	30,516	30	16,484
				12	4,726
				10	4,877
				8	4,429
17	Sawdust	2015	18,242	30	702
				24	10,404
				10	2,128
				8	5,008
18	Lake Conroe Plant East	2015	50,461	48	9,839
				36	29,124
				16	8,956
				12	2,542
19	Conroe Well #6	2015	8,037	12	8,037
20	UP Railroad	2015	11,306	30	5,826
				24	4,991
				16	259
				12	230
21	FM2854 West	2035	71,205	12	46,833
				8	24,372
22	Lake North West	2035	106,722	24	26,872
				18	65,559
				12	8,302
				10	5,989
23	Millers Crossing	2035	3,259	8	3,259
24	South West Extension	2035	51,353	16	5,205
				12	17,859
				10	6,077
				8	22,212
25	FM2854 Loop	2045	42,281	12	42,281
26	Lake North East	2045	80,387	30	27,877
				24	15,985
				16	7,493

Pipe Segment	Segment Name	Year	Total Segment Length (ft)	Pipe Diameter (inches)	Sum of Pipe Length (ft)
				12	23,570
				8	5,462
27	Crighton Ridge River Plantation	2045	36,538	24	17,658
				16	3,561
				10	10,488
				8	4,831
28	Oak Ridge 2045 Extension	2045	9,924	8	9,924
29	Spring Creek UD	2045	10,257	10	10,257

3.2.2.2 Right of Way

The revised alignment corridor consists of nearly sixty miles of potential alignment corridor. Due to the widespread nature of the existing wells, storage tanks, pumps, and service area distribution systems to be served, use of a large number of various types of right-of-ways must be considered to provide service to this growing and heavily-developed area.

The proposed right-of-way is shown in *Exhibit 6* and *Exhibit 22* through *Exhibit 28*. A summary of the major right-of-ways that are under consideration is provided in *Table 31* below.

Table 31 Summary of Major ROW by Segment

Preliminary Corridor Segment		Right-of-Way Description
1	Lake West	SJRA Property, Private, McCaleb Road
2	Fish Creek Throughfare North	Fish Creek Thoroughfare, Private, Sendera Ranch Drive (North)
3	Fish Creek Throughfare South	Fish Creek Thoroughfare, Sendera Ranch Drive (South), Honea Egypt Road/FM 2978, Private
4	FM 2978	FM 2978, Private
5	Sendera–Conroe	Private, Overhead Power Easement
6	Woodlands Plant	Private, Overhead Transmission Easement
7	Bear Branch Reservoir	Drainage Easement
7	Research Forest West	Research Forest Drive
8	Kuykendahl	Kuykendahl Road
9	SJRA Water Plant #3	Drainage Easement
10	Lakeland West	Drainage Easement
11	Research Forest Central	Drainage Easement
12	Lakeland East	Drainage Easement, Vision Park Boulevard, Private
13	Research Forest East	Overhead Transmission Easement, Pipeline Easement, Private
14	Oak Ridge North	David Memorial Drive, Oak Ridge School Road, Drainage District No. 6 Ditches, Private
15	Rayford	Drainage District No. 6 Ditches, Private, Robinson Road, Pipeline Easement, Rayford Road
16	Sawdust	Southern Montgomery MUD Drainage Ditches, Gas Easement, Overhead Transmission Easement, Private
17	Lake East	SJRA Property, Overhead Power Easement, Private, Longmire Road, FM 3083, N. Frazier Street, N. Loop 336 E, Ditch
18	Conroe Well No. 6	Conroe Sanitary Sewer (Gravity) Easement, Private, Westview Boulevard
19	Downtown Conroe	N. 1st Street, Union Pacific Railroad, N. Pacific Street

As shown in *Table 32*, the only major existing property that can be used as a significant waterline right-of-way is the property owned by the San Jacinto River Authority (SJRA) along the Lake Conroe Dam. This property runs a significant distance in an east-west direction and could be used for both the proposed water treatment plant or the pipeline alignment across the site. A significant number of other properties would potentially be crossed by the proposed alignment and require a waterline easement, but discussion of all private properties potentially requiring an easement is beyond the scope of this report.

Table 32 Summary of Major Property Right-of-Ways

Right-of-Way	Proposed Side	Primary Issues
SJRA Property	South	Geotechnical, dam, spillways, property width.

Table 33 lists the major streets and roadways with right-of-way that the proposed alignment could potentially run parallel to or within. These roadways are typically either Montgomery County roadways

(Commissioner Precincts 1, 2, or 3), City of Conroe roadways, or The Woodlands Development Company (TWDC) roadways that are owned by the developer.

Table 33 Summary of Major Roadway Right-of-Ways

Right-of-Way	Proposed Side	Primary Issues
David Memorial Drive	East	Utilities, Limited ROW
Honea Egypt Road	West	Limited ROW; Winding, dangerous road; development both sides
Kuykendahl Road	East	West 2/4 lanes built; buried elect, water, sewer, tree buffer reserved.
Longmire Road	East	Limited ROW, houses close to ROW
McCaleb Road	East	Limited ROW, houses both sides, utilities, mature trees in ROW
N. 1st Street	West	Homes/businesses very close to south ROW, RR/utilities to north, homes immediately north of RR
N. Pacific Street	West	Downtown buildings to east, railroad to west. Crosses many busy roads.
Oak Ridge School Road	South/West	Between school & shallow ditches
Rayford Road	South	Limited ROW, utilities, creek crossing
Research Forest Drive	South	Alden Bridge – Kuykendahl (4 lanes), remainder 2/4 north lanes or undeveloped right-of-way.
Robinson Road	South	Limited ROW, utilities, homes and businesses very close to ROW.
Sendera Ranch Drive	West	Limited ROW, utilities, deep lots.
Vision Park Boulevard	North	New road, professional buildings, deep lots, many lots empty, utilities.
Westview Boulevard	East	Developed, limited ROW, utilities.

The Houston-Galveston Area Council (www.h-gac.com) prepares a 2035 Houston-Galveston Regional Transportation Plan that summarizes and prioritizes all regional transportation projects that are to be implemented by Montgomery County, the City of Conroe, or the TxDOT Houston District. Widening and extensions to many of these area roads are planned prior to 2035, as shown in the plan at the website http://2035plan.org/index.htm.

The Texas Department of Transportation (TxDOT) Houston District is responsible for the maintenance and modifications to state highways. While a number of state highways are proposed to be crossed by the proposed alignment, only right-of-way of the following four state highways is proposed to be paralleled or utilized.

Table 34 Summary of Major State Highway Right-of-Ways

Right-of-Way	Proposed Side	Primary Issues
Fish Creek Thoroughfare (proposed extension of FM 2978)	East	West 2 lanes built. ROW cleared. Lake creek low-lying flooded area, utilities.
FM 2978	East	Scattered businesses along west side. Gas station, school, Woodlands Pkwy crossing on east side.
FM 3083	South	Bottleneck east of IH-45 (cemetery north side, retail development to south with retaining wall).
SH 75 (N. Frazier Street)	East	Industrial complexes both sides, deep lots. Heavy fencing/security to west.
SH Loop 336 (N Loop 336 E)	Varies	Businesses very close either side, almost no ROW in places. RR bridge.

Existing utility rights-of-way are required to be used in a number of locations due to the high level of development that is already in place. Oftentimes, the level of residential development is so high that there is no place to run a proposed waterline easement without utilizing an existing utility right-of way, such as a ditch, or being forced to open cut an existing roadway which would likely be highly disruptive and expensive. *Table 35* summarizes the major utility rights-of-way that the proposed alignment corridor follows.

Table 35 Summary of Major Utility Right-of-Ways

Right-of-Way	Proposed Side	Primary Issues
Bear Branch Reservoir	North	Upstream of dam, standing water, subject to major flooding, heavy trees.
Conroe Sanitary Sewer Easement	East	Existing gravity sewer on back of undeveloped land, crosses creek.
Drainage District #6 Ditches	Varies (wider side)	Limited space between ditch and berm or residential back fence line.
Drainage Easement	Varies (wider side)	Wide and flat, few utilities, narrow creek pilot channel, minimal trees.
Gas Easement	South	Mostly undeveloped either side.
Overhead Power Easement	North	Stay north of, Residential to south.
Overhead Transmission	West	Wide easement, more room available to west.
LP/Petroleum Pipeline Easement	South	Wide easements, typically multiple lines. Crossings no problem, likely need own esmt to run parallel.
Southern Montgomery MUD Ditches	Varies (wider side)	Limited ROW, some difficult bridge/roadway crossings. May have to take buffer trees to install.
Union Pacific Railroad	East	Crossings acceptable. Locate waterline outside ROW.

3.2.2.2.1 Planned Right-of-Way Modifications

Montgomery County is growing so quickly, particularly in the Woodlands and Conroe areas, that a number of roadways and highways are planned to receive modifications, including widenings, grade separations at intersections, and extensions. Many of these proposed improvements will likely have a significant impact on the available right-of-way that can be used for proposed pipeline alignments. Many of these projects are not planned to be designed and constructed for many years, making it difficult to determine the feasibility of installing the future pipeline within the future right-of-way at this conceptual level. *Table 36* summarizes the planned roadway modifications as stated in the *Houston-Galveston Area Council 2035 Regional Transportation Plan*.

Table 36 Planned Roadway Modifications through 2035

Roadway	**Planned Modification Description**	**Sponsor / Bid Award Date**
Kuykendahl Road	Kuykendahl Road – construct 2 lane roadway (missing sections) FM 1488 to N Villa Oaks, Alden Bridge to Crown Ridge	Montgomery County 05/01/2009
Kuykendahl Road	Kuykendahl Road widening from 2 to 4 lanes (in sections) FM 1488 to Woodlands Parkway	Montgomery County 09/01/2011
Robinson Road	Robinson Road widening to 4 lane undivided IH-45 to Hardy	Montgomery County 01/01/2018
Research Forest Drive	Research Forest Drive construct new two lane divided road FM 2978 to Branch Crossing	Montgomery County 01/01/2018
Research Forest Drive	Research Forest Drive widen to 4 lane divided road FM 2978 to Alden Bridge	Montgomery County 01/01/2018
Longmire Road	Longmire Road widening from 2 to 4 lanes FM 3083 north to League Line Road	City of Conroe 01/01/2023
McCaleb Road	McCaleb Road (FM 2978) widening from 2 to 4 lanes SH 105 to Fish Creek Thoroughfare (FM 2854)	Unsponsored 01/01/2023

Table 37 summarizes the planned state highway modifications as stated in the *Houston-Galveston Area Council 2035 Regional Transportation Plan*.

Table 37 Planned State Highway Modifications through 2035

Roadway	Planned Modification Description	Sponsor / Bid Award Date
IH 45	IH 45 widen to 8 main lanes, reconstruct 2-lane frontage roads Loop 336 north to 0.435 miles south of FM 830	TxDOT Houston District 09/01/2008
IH 45	14' Noise Abatement Wall Woodlands Parkway to Tract 7 Drainage Ditch	TxDOT Houston District 05/01/2009
Fish Creek Thoroughfare	Grade Separation over FM 2854 and BNSF Railroad	Montgomery County 09/01/2009
Fish Creek Thoroughfare	Construct 2 lane asphalt road (in sections) FM 1488 to FM 2854	Montgomery County 09/01/2011
FM 3083	FM 3083 construct new 4 lane divided roadway, new location IH-45 southwest to SH 105	TxDOT Houston District 07/01/2012
FM 3083	FM 3083 widen to 4 lanes divided rural with raised median IH-45 east to N Loop 336E	TxDOT Houston District 09/01/2012
Loop 336	Loop 336 widening from 4 lanes to 6 lanes divided 0.06 miles east of IH-45 to 0.47 miles east of MPRR	TxDOT Houston District 09/01/2012
FM 2978	FM 2978 widening from 2 to 4 lanes FM 1488 south to Harris County line	Montgomery County 01/01/2013
Loop 336 (North)	North Loop 336 widening to 6 lanes (in sections) SH 105 to IH-45	TxDOT Houston District 01/01/2023

3.2.2.3 Existing Utilities

The primary existing utilities that were encountered along the proposed alignment corridor are summarized in *Table 38* below. Utility coordination information gathered during the course of this study is attached in *Appendix E*.

Field location of all utilities should be completed during subsequent preliminary engineering efforts. It is recommended that the alignment is staked by all utilities and the Texas One Call system locator to identify the location of utilities that may not be properly documented. This effort and the resulting findings may impact the overall plan and costs.

Table 38 Summary of Major Utilities in Project Area

Right-of-Way	Utility Companies
Water	SJRA; City of Conroe; Woodlands Joint Powers Agency (Woodlands MUDs); Sendera Ranch; Woodland Oaks Subdivision; Lakeland; Shenandoah; Montgomery County MUD 19, Southern Montgomery County MUD; Rayford Road MUD; Chateau Woods MUD; City of Oak Ridge North
Sanitary Sewer	City of Conroe; Woodlands Joint Powers Agency (Woodlands MUDs); Sendera Ranch; Woodland Oaks Subdivision; Lakeland; Shenandoah; Montgomery County MUD 19, Southern Montgomery County MUD; Rayford Road MUD; Chateau Woods MUD; City of Oak Ridge North
Buried Cable	Consolidated Communications (formerly Lufkin-Conroe Telephone Exchange); Conroe Telephone; TXU; Cox Communications; SBC; ICTX/Wave Media
Buried Electric	Mid-South Synergy; Entergy; Centerpoint Energy; TXU; Reliant
Overhead Cable or Power	Mid-South Synergy; Entergy; Centerpoint Energy; TXU; Reliant
Overhead Transmission	Mid-South Synergy; Entergy; Centerpoint Energy; TXU; Reliant
Signalized Intersection	TxDOT; Railroad
Natural Gas	Centerpoint Energy; LDC, Inc.; Devon Energy; Mid South Synergy; Tennessee Gas Pipeline (El Paso Corp)
High Pressure Products / Petroleum / LPG	Conoco/Phillips; Magellan; Koch; Energy Transfer d.b.a. Houston Pipeline; Gulf South Pipeline Co.
Railroad	Atchinson Topeka & Santa Fe; Union Pacific; Burlington Northern Santa Fe
Drainage Ditch	Drainage District No. 6, Southern Montgomery MUD
Drainage Culverts/ Conduit/Box Culvert	Woodland Oaks Subdivision; TxDOT

Most of these utilities affect the alignment only as crossings or as small utilities at the edge of the existing right-of way. Since the distribution line is pressurized, the typical utility crossing requirements require that the waterline be installed deeper than the existing utility in order to maintain the required cover over the line and maintain the required clearance. Such a crossing is typically feasible and not very costly as long as the installation depths are not excessive. Existing products and overhead easements should normally be paralleled rather than trying to install the line in the existing easement. Land for additional easements is often available near these types of easements as developers will often leave a ditch or other buffer between residential development and these types of “unsightly” or “undesirable” easements.

3.2.2.4 Environmental Considerations

Environmental considerations associated with the proposed pipeline alignments would be those resource areas expected to be most impacted by the proposed project and likely to require coordination and/or permitting through regulatory agencies at the state and federal level. These resource areas have been identified as being water resources, cultural resources, threatened and endangered species, and hazardous materials. Water resources that have potential to be impacted are jurisdictional Waters of the U.S., wetlands, and floodplains. Depending on the nature and extent of the impacts a permit may be required from the USACE. Cultural resources may be an issue since areas near water bodies are known to have higher probabilities of containing archaeological artifacts. Additionally there may be cemeteries located within the proposed pipeline alignments and may require coordination with THC. Since some of the area along the proposed pipeline alignments is currently undeveloped it could potentially provide habitat for threatened and endangered species that have the potential to occur in the area. Evaluations would have to be made by qualified biologists to determine what actions will be required with regard to these undeveloped areas. Hazardous materials will be a constraint as well since a superfund site has already been identified to be adjacent to a portion of the project area. Prior to acquiring additional ROW, Phase I Environmental Site Assessments will be required to identify potential sources of contamination prior to acquisition.

3.3 Surface Water Treatment

3.3.1 Water Quality Standards Forecast

In January 2006, the EPA enacted two new rules under the authority of the Safe Drinking Water Act. These rules are the Long Term Phase 2 Enhanced Surface Water Treatment Rule (LT2), and Stage 2 of the Disinfectant / Disinfection Byproduct Rule (D/DPR2). These new rules potentially impact the proposed water treatment plant(s) that are proposed to meet the conversion requirements of the District. The new rules require extensive raw water quality monitoring and treatability studies before the full impact of these rules is determinable. In developing the site plan to meet the requirements of the SJRA water treatment plants, several assumptions based on anticipated raw water quality and treatment performance have been made and areas for future additional treatment processes have been identified. A brief overview of the Rules and the potential impact to the water treatment plant planning process is presented in the following paragraphs.

3.3.1.1 Long Term Phase 2 Enhanced Surface Water Treatment Rule (LT2).

The LT2 is a long awaited rule to address cryptosporidium (crypto) in drinking water. In March and April 1993, an outbreak of cryptosporidiosis occurred in Milwaukee, Wisconsin that was traced to the drinking water supply. Dozens of deaths (69) and an estimated 403,000 illnesses were attributed to this outbreak. This outbreak was the first attributed to cryptosporidium, which was a relatively unknown pathogen at the time.

The Milwaukee cryptosporidiosis outbreak occurred 2 months prior to the June 30, 1993 compliance date for the Surface Water Treatment Rule (SWTR). An analysis of the facilities and operations of the Milwaukee water system indicated that the utility was already in compliance with the then proposed SWTR, but the outbreak still occurred. The Milwaukee outbreak sent a near panic through the regulators because it was now obvious that the proposed rules were not capable of adequately protecting our drinking water supplies from pathogens. Since that time, the EPA has promulgated several rules (Interim Enhanced Surface Water Treatment Rule, Enhanced Surface Water Treatment Rule, Long Term Phase 1 Enhanced Surface Water Treatment Rule, etc), has been gathering information on the occurrence of cryptosporidium in surface water sources, and has been identifying treatment technologies to remove or inactivate cryptosporidium in drinking water supplies and protect consumers. LT2 is the result of these investigations and regulatory actions and is expected to be the final word on cryptosporidium control in drinking water supplies.

In the years following the Milwaukee outbreak, the EPA has analyzed watersheds and raw water sources through out the United States for the occurrence of cryptosporidium. The EPA analyses have determined that cryptosporidium is an elusive pathogen, but environmental conditions required to support cryptosporidium occur in every watershed used for drinking water purposes. Cryptosporidium is difficult to detect because it occurs infrequently and intermittently. Many large utilities have been monitoring for cryptosporidium for many years and have never detected it. Cryptosporidium has also proven to be very difficult to inactivate and is resistant to commonly used disinfection technologies.

EPA regulations must demonstrate cost effectiveness. In other words, EPA can not promulgate arbitrary regulations and must justify the financial impact of the regulations or provide funding to the utilities for implementation. The EPA is prevented from promulgating an unfunded mandate. Therefore prior to issuing new rules, the EPA must estimate the cost for implementing the new rules and compare it to the costs for not implementing the new rules. Typically the costs of lost productivity and illnesses, including medical costs are used in this analysis. Because of the infrequent occurrence of cryptosporidium, and the high cost associated with removing or inactivating cryptosporidium, cryptosporidium based regulations have been difficult to justify economically. The Center for Disease Control (CDC) estimated the costs of the cryptosporidiosis outbreak in Milwaukee to be between $75 million and $118 million. Even though in the Milwaukee case, cryptosporidium treatment requirements could have been justified, the infrequency of outbreaks throughout the country could not economically justify a nationwide uniform treatment mandate.

The new LT2 regulation takes a measured approach to addressing the cryptosporidium enigma. LT2 only addresses systems using surface water as the supply source. The initial steps, which began in November 2006, require large systems to perform 2 years of source water monitoring for cryptosporidium. Smaller systems also have monitoring requirements on a slightly delayed scheduled compared to the large systems. This monitoring is considered to be an initial monitoring phase and must be completed by 2010. Based on the initial monitoring results, bin classification and treatment requirements will be established for all systems, and implementation schedule requirements are established. The entire process is repeated for a second round beginning in 2015. *Table 39* presents a synopsis of the monitoring and implementation schedule for various utility sizes.

Table 39 Monitoring / Implementation Schedule by System Size

ACTION ITEM	SYSTEM SIZE (Population Served)				
	>99,999	50,000 to 99,000	10,000 to 49,999	<10,000 (E. coli [2])	<10,000 (Crypto [3])
	Schedule 1	Schedule 2	Schedule 3	Schedule 4	
Begin Monitoring	10/01/06	04/01/07	04/01/08	10/01/08	04/01/10
Complete Initial Monitoring	10/01/08	04/01/09	04/01/10	10/01/09	04/01/12
Report Initial Bin Classifications	04/01/09	10/01/09	10/01/10	N/A	10/01/12
Compliance/ Implementation[(1)]	04/01/12	10/01/12	10/01/13	10/01/13	10/01/14
Begin Round 2 Monitoring	04/01/15	10/01/15	10/01/16	10/01/17	04/01/19
Complete Round 2 Monitoring	04/01/17	10/01/17	10/01/18	10/01/18	04/01/21
Report Second Bin Classifications	10/01/17	04/01/18	04/01/19	N/A	10/01/21
Round 2 Compliance	TBD by TCEQ	TBD by TCEQ	TBD by TCEQ	TBD by TCEQ	TBD by TCEQ

1. *A 2 year extension for Compliance/Implementation can be granted if capital improvements are required.*
2. *Small filtered systems that provide E. coli monitoring or other indicator.*
3. *Small filtered systems that monitor for cryptosporidium and unfiltered systems.*

New systems also have to comply with the monitoring and treatment requirements, though the schedule is not as clear cut as it is for existing systems. The EPA has allowed the individual States to establish monitoring and implementation schedules for new systems. States may require the two year source water monitoring to occur prior to construction of the facilities or may allow the monitoring period to extend into the operational period. Guidance on this issue is not clear cut in the Federal regulations, and because it will be decided at the State level on a case by case basis, early discussions with the TCEQ are recommended to avoid project delays and to optimize process selections.

The Bin classifications that will result from the 2 year source water quality monitoring program are critical to establishing treatment requirements for existing and new treatment systems. Under the Bin classification system, a baseline treatment technique is established for the current in-place treatment technologies, and then additional treatment requirements are established for the respective Bin classifications. For instance, if conventional treatment is the basis, then 3-log (99.9%) removal inactivation credit for cryptosporidium is granted, contingent on compliance with conventional treatment requirements. The treatment requirements for each Bin classification are then over and above the baseline treatment that exists. The EPA has provided a "Toolbox" of treatment techniques that can be used to meet the Bin classification treatment requirements. The additional treatment requirements required under the LT2 Bin classifications are presented in *Table 40*. From review of *Table 40*, any Bin classification above Bin 1 will impact treatment processes at surface water treatment facilities.

To achieve the required performance for Bin classification 2, 3, and 4, the LT2 identifies several processes that can be used in addition to conventional treatment. For full credit, the conventional treatment is assumed to be fully capable of meeting all of the requirements of the Surface Water Treatment Rule (SWTR), the Interim Enhanced surface Water Treatment Rule (IESWTR), and the Long Term Phase 1 Enhanced Surface Water Treatment Rule (LT1ESWTR). The available Toolbox processes are divided into 5 categories of processes; 1) source Protection and Management Options, 2) Pre-filtration Options, 3) Treatment Performance Options, 4) Additional Filtration Options, and 5) Inactivation Options

Table 40 Treatment Requirements for Bin Classifications

Bin	**ADDITIONAL TREATMENT REQUIRED**	**APPLICABLE TOOLBOX PROCESSES**
Bin 1	No Additional Treatment Required 3-log Total Crypto Removal (99.9%)	Conventional Treatment is Adequate
Bin 2	1-log Additional Treatment Req'd; 4-log Total Crypto Treatment (99.99%)	All Toolbox Processes
Bin 3	2-log Additional Treatment Req'd; 5-Log Total Crypto Treatment (99.999%)	Ozone, Chlorine Dioxide, UV, Membranes, Bag Filtration, Cartridge Filtration, Bank Filtration
Bin 4	2.5-log Additional Treatment Req'd; 5.5-log Total Crypto Treatment (99.9997%)	Ozone, Chlorine Dioxide, UV, Membranes, Bag Filtration, Cartridge Filtration, Bank Filtration

A brief description of the processes identified in the LT2 Toolbox for meeting the Bin classification treatment requirements is provided in the following *Table 41*.

Table 41 The EPA Microbial Toolbox for Compliance with LT2

SOURCE PROTECTION AND MANAGEMENT OPTIONS		
Watershed Control Program	0.5-log credit	Comprehensive program and ongoing monitoring requirements to be established by States
Source/Intake Management	TBD	No prescribed credit. Requires simultaneous monitoring of alternate source locations to determine applicability.
PREFILTRATION OPTIONS		
Pre-Sedimentation with Coagulation	0.5-log credit	Continuous operation of pre-sedimentation system with coagulation. At least 0.5 log turbidity reduction required
Two-Stage Lime Softening	0.5-log credit	Chemical addition and hardness removal required in two stages
Bank Filtration	0.5 to 1.0 log credit	Credit depends on setback. Aquifer must contain <10% fines, turbidity from wells must be < 1NTU. No additional credit for existing systems.
TREATMENT PERFORMANCE OPTIONS		
Combined Filter Performance	0.5-log credit	Combined filter effluent must be < 0.15 NTU in 95% of samples.
Individual Filter Performance	0.5-log credit	Individual filters must be < 0.15 NTU in 95% of samples & never exceed 0.3 NTU. This credit is in addition to combined filter performance.
Performance Demonstration	TBD	Only available after challenge test using State approved protocol.
ADDITIONAL FILTRATIONS OPTIONS		
Bag and Cartridge Filters	<= 2.5-log credit	Challenge test required
Membranes	TBD	Challenge test required
Second Stage Filtration	0.5-log credit	Coagulant applied to first stage filters and second stage filters required.
Slow Sand Filters	2.5 to 3.0 log credit	2.5 log credit for secondary filtration step, 3 log credit available for primary filtration step.
INACTIVATION OPTIONS		
Chlorine Dioxide	CT Tables	Based on published CT tables
Ozone	CT Tables	Based on published CT tables
UV	CT Tables	Based on UV dose tables. Reactor validation testing required.

Based on the above information, conventional treatment will be adequate for Bin 1 classification. Bin 2 Classification will require some modifications to the conventional treatment processes, but is likely to be achievable with a conservative filter design. Bin 3 and Bin 4 classifications will require significant advance treatment techniques and will also likely require validation or performance challenge testing through pilot plant or full scale testing of the proposed processes. It is currently anticipated that Lake Conroe and the San Jacinto River immediately downstream of Lake Conroe will be assigned a Bin 1 or Bin 2 Classification, which should be achievable by a well-designed and operated conventional treatment system. For this reason, cost estimates are based on conventional treatment at this time.

A second round of source water sampling for cryptosporidium is required but will not be completed for more than 10 years. It is not known at this time if cryptosporidium requirements will be further tightened at that time or if new treatment technologies will become available. Therefore, the site plan has identified space for advance treatment, but no associated costs are identified at this time.

To further refine the anticipated Bin classification and to identify appropriate treatment processes and resultant costs, a raw water sampling protocol should be identified as quickly as possible and discussions with the TCEQ should begin soon. As with any long term planning efforts, significant contingencies should be established to account for future regulatory changes and unanticipated conditions.

3.3.1.2 Disinfectants/Disinfection Byproducts Rule Stage 2 (D/DBP2)

The second major rule that was enacted in early 2006 is the Disinfectants / Disinfection Byproducts Rule Stage 2 (D/DBP2). Whereas the previously described LT2 focuses on removing or inactivating pathogens in drinking water, D/DBP2 limits the amount and types of disinfectants that can be applied to accomplish the disinfection requirements and also places limits on the formation of disinfection byproducts. The relationship between LT2 and D/DBP2 is a balancing act to ensure adequate disinfection is achieved without introducing other constituents that could compromise water quality.

The D/DBP2 Rule establishes numeric limits on disinfection dosages and on the disinfection byproducts that are created with each disinfectant. Limits were originally established under D/DBP1 in the mid 1990s. Although the numerical limits do not change under D/DBP2, the method of calculation for compliance is significantly stricter than previous regulations and will impact the disinfection processes used at many surface water treatment plants. The numeric limits for the most common disinfection byproducts are 0.080 mg/l total trihalomethanes and 0.060 mg/l haloacetic acids.

To ensure that the water is adequately disinfected, a disinfectant residual must be maintained in all portions of the distribution system. This can lead to long detention times in the distribution system. Because treated water exhibits a disinfection demand, in general the disinfection residual will deteriorate with time. The longer the retention time in the distribution system, the residual leaving the treatment plant will have to be higher to maintain the minimum residual at the consumer’s tap. Disinfection byproduct formation is directly related to the detention time and the concentration of disinfectant in the system. The result is that systems must select an appropriate disinfection protocol that allows the system to be in compliance with both the minimum disinfection residual and the byproduct formation requirements.

Under the previous D/DBP1 Rule, disinfectant and byproduct concentrations were measured at several locations in the distribution system. Rule compliance was measured by a running annual average of quarterly sampling of all samples taken in the distribution system. Under this calculation methodology, if certain locations in the distribution system received consistently high level of byproducts, compliance could be achieved through offsetting readings at other locations in the system. Under the proposed rule, each sampling location must achieve compliance based solely on the samples from that location.

Because the dilution effect of averaging is eliminated, the byproducts in the water leaving the surface water treatment plants must be generally lower while still maintaining adequate disinfection. DBP formation is generally caused by the chemical reaction between the disinfectant and organic matter or other constituents in the water. The D/DBP2 Rule will require systems with medium or high levels of organics in the water to further reduce the level of organics prior to applying the disinfectant. This could result in no disinfectant credit being available until after treatment for organics has been accomplished, or a primary disinfectant be chosen that does not form objectionable byproduct levels.

To understand the impacts of this rule, extended distribution system modeling and field sampling are required to determine the longest system residence times and then to further determine if objectionable levels of byproducts would be formed at these locations. For existing systems, a sampling program could be performed to directly measure the byproduct formation throughout the system. For a planned system (not yet constructed), system hydraulic modeling is required to determine the maximum detention times, and then extended distribution system DBP formation studies performed to estimate the amount of byproducts that would be formed. An Initial Distribution System Evaluation (IDSE) plan is required. The IDSE will identify sampling locations. Consecutive systems (such as systems receiving water from a wholesale supplier) are also required to comply with all monitoring and sampling requirements and the numerical limits. Therefore, in a wholesale-retail consecutive system, the entire network must be considered in the planning and treatability testing efforts.

With the new locational running annual average techniques to be employed, lower disinfection byproducts levels will be required leaving the plant site. The disinfectant demand of the water will also have to be lowered. Treatment techniques that could be employed to lower disinfection byproducts and disinfectant demand of the water would generally focus on removing organic matter during the treatment processes, such as enhanced coagulation, activated carbon, or nano-filtration membranes. Enhanced coagulation is not capable of removing a substantial portion of organics and often will not allow the application of a strong disinfectant. Activated carbon is effective at removing organic material but requires costly periodic regeneration and/or disposal of spent carbon. Nano-filtration membranes require high quality water applied to the membrane to avoid fouling, and therefore are typically used as an add-on process using either a conventional or a high rate conventional plant for pretreatment. The nano-filtration process is relatively expensive process with high operational and maintenance costs, although membrane costs have become more economical in recent years.

Alternatively, a disinfectant that does not form appreciable byproducts in the presence of organics could also be employed, such as UV radiation or chloramines. Currently, neither of these disinfectants is without significant drawbacks for use as a primary disinfectant. UV radiation requires a substantial field validation testing program and is currently not approvable in Texas. Chloramine is a very weak disinfectant and requires very large basins to achieve the required contact time for adequate disinfection. To select the appropriate disinfection protocol, the selection of disinfectant must be coordinated with the process selection. A comprehensive sampling and testing program on the source water is recommended to fine-tune these selections.

The schedule for DBP2 is staggered based on system size, but generally requires an IDSE to be submitted for approval approximately 1 year ahead of system monitoring. IDSE monitoring will occur for approximately one year and the results of the monitoring reported to the State within 4 months of completion. Compliance with the DBP2 is required to coincide with the LT2 compliance dates, which occurs approximately 3 years after the submission of the IDSE report. A two-year extension is possible if extensive capital improvements are necessary to establish compliance. The DBP2 compliance schedule is presented in *Table 42*.

Table 42 DBP2 Compliance Schedule

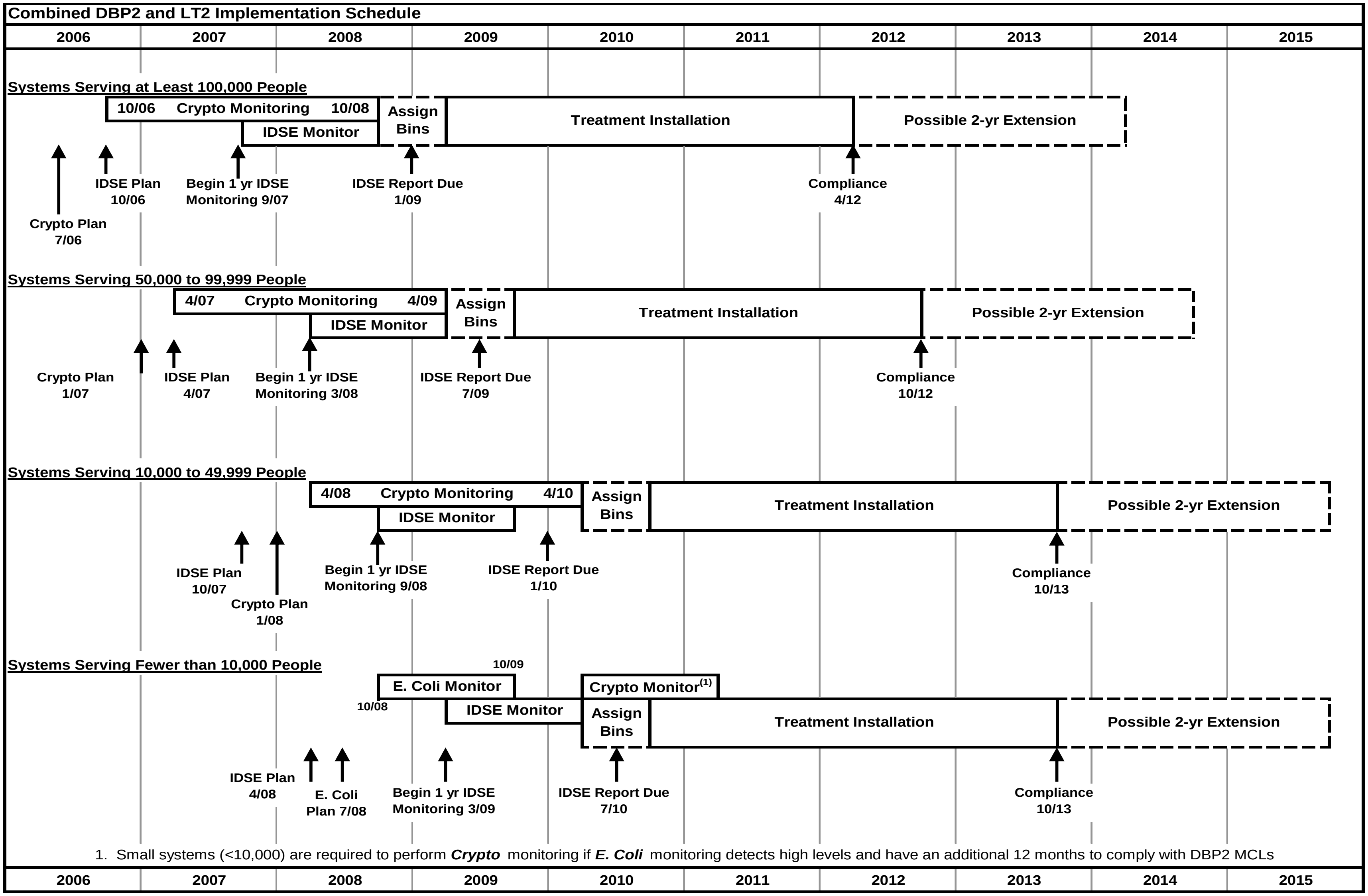
ACTION ITEM	SYSTEM SIZE (Population Served)			
	>99,999	**50,000 to 99,999**	**10,000 to 49,999**	**<10,000**
Submit IDSE Monitoring Plan	10/01/06	04/01/07	10/01/07	04/01/08
Complete Monitoring	09/30/08	03/31/09	09/30/09	03/31/10
Submit IDSE Report	01/01/09	07/01/09	01/01/10	07/01/10
Compliance Date(1)	04/01/12	10/01/12	10/01/13	10/01/13

1. A 2 year extension for Compliance/Implementation can be granted if capital improvements are required.

The LT2 and DBP2 regulations are integrally related from a process selection and compliance schedule perspective. These rules can not be addressed individually. Both LT2 and DBP2 require the treatment and disinfection processes to be compatible if simultaneous compliance of both Rules is to be achieved. *Figure 4* presents a combined compliance schedule for LT2 and DBP2.

New systems also have to comply with the monitoring and treatment requirements of the LT2 and DBP2, though the schedule is not as clear cut as it is for existing systems. The EPA has allowed the individual States to establish monitoring and implementation schedules for new systems. States may require the two year source water monitoring to occur prior to construction of the facilities or may allow the monitoring period to extend into the operational period. Guidance on this issue is not clear cut in the Federal regulations, and because it will be decided at the State level on a case by case basis, early discussions with the TCEQ are recommended to avoid project delays and to optimize process selections. A likely scenario is that if existing monitoring of the surface water has already been performed on this watershed and near the proposed intake locations, an initial Bin assignment might be available and would provide a direction for final treatability analyses and process selections. However, this could result in a conservative Bin assignment and costly plant construction and operations. With initial plant operations scheduled for 2015, the initial two year sampling program should begin soon to allow sufficient time for Bin classifications, treatability studies, preliminary engineering, design, and construction activities.

Figure 4 Combined DBP2 and LT2 Implementation Schedule



3.3.2 Proposed Treatment Process Selection

There are several issues described in previous sections that make process selection and optimization a difficult task at this time. Several studies need to be performed before process selections and facilities sizing can be finalized. The most significant unknowns at this point are the LT2 Bin classifications that won't be available until at least 2010, and the disinfection byproduct formation potential correlation between the water source and the various disinfectants.

3.3.2.1 Ultraviolet Radiation Technology

From a technology perspective, ultraviolet radiation disinfection holds significant promise as a primary disinfectant that does not contribute to disinfection byproducts. This technology has been approved for use at the federal level, but TCEQ is still resistant to allowing disinfection credit for UV. Because UV radiation is accomplished by applying a light source through the water, there is no disinfection residual that can be measured to verify that adequate disinfection has been accomplished. The inability to have positive verification of disinfection is the primary concern of the TCEQ. At the nearby Northeast Water Purification Plant, a UV radiation disinfection system was installed in anticipation of approval, but currently sits idle in favor of conventional chlorine based disinfection techniques. With the significantly more stringent rules concerning disinfection and disinfection byproducts, UV radiation technology should be considered in all future water treatment applications.

3.3.2.2 Membrane Technology

Membrane technology is also viable for new treatment plants. Membranes have evolved significantly in the last 15 years in terms of both advancing the technology and reducing cost. In large plants greater than 10 mgd, membranes are still more expensive than conventional treatment, but provide a positive barrier to suspended solids and pathogens when working properly. Relatively high operating and membrane replacement costs can impact the overall cost effectiveness of membranes. High turbidity water or highly variable raw water quality could require significant pretreatment prior to application on to the membranes. The selection of membranes requires a site specific pilot test to validate membrane performance. This site specific test must use the specific water to be treated and the specific membrane to be used. Pilot testing requirements are specific to each membrane manufacturer, and therefore to maintain a competitive bidding environment, several pilot studies are typically conducted. These pilot studies can add significant cost and schedule to the membrane procurement process.

3.3.2.3 Conventional Processes

Without further studies on the quality and treatability of the raw water, conventional treatment processes are selected at this phase of the project. Conventional treatment processes represent proven technology and are indicated as the bases for the LT2 Bin classifications. The success of conventional treatment is based on decades of experience and the multiple barriers that are inherent to the process. The proposed process block diagram identifies an area for advanced treatment processes that can be added on in the future once the Bin classifications are known and treatability studies are conducted. Alternatively, if this information is obtained in advance of the design phase of the project, the process selection and site plan can be modified at that time if appropriate. This methodology offers a conservative, reliable, yet flexible approach to the water treatment planning process.

A conventional plant results in the largest potential plant site for planning purposes. Conventional circular clarifiers are shown in the plant layouts, but the actual sediment removal method will be determined during preliminary design.

3.3.3 Proposed Treatment Process Description

The treatment processes described herein are limited to the facilities that will be located within the treatment plant boundaries. Offsite facilities such as the raw water intake and pumping, and offsite storage and transmission facilities are included elsewhere.

3.3.3.1 Pre-sedimentation

Because of the proximity to Lake Conroe, a forebay has not been included for the Lake Conroe Dam plant site location. For the plant site near The Woodlands, additional sediment and variable water quality is anticipated due to the river velocities in the source water. Some additional treatment is required at this location. Two options are readily available: 1) construct a forebay to act as a pre-sedimentation basin, or 2) remove the additional sediment load through the conventional treatment process. Using a three-day storage volume in the forebay, the forebay option will require an additional 39 acres of water surface area plus areas for berm construction and buffer zones. Treating the additional sediment load in the conventional treatment process would require additional chemical treatment and greater sludge processing capacity at the plant site. The forebay option is considered to be the most conservative approach at this time for the plant site near The Woodlands and is included in the cost estimates for this site.

3.3.3.2 Rapid Mix and Flocculation

Raw water entering the plant will be injected with a coagulant and polymer. This water will then enter a rapid mix chamber to thoroughly mix the chemicals with the raw water. The water will then proceed to a flocculation zone. In the flocculation zone, the water is gently mixed to facilitate chemical precipitation, flocculation, and coagulation of particles. The purpose of this process is to remove suspended solids and to precipitate some of the dissolve material that might be present in the raw water. The coagulant dosage will be applied in sufficient quantities to achieve enhanced coagulation, which is designed to also precipitate a significant portion of organic material that might be present in the raw water. The removal of organic material is important to minimize the disinfection byproduct formation potential in the disinfection process.

3.3.3.3 Disinfection

A disinfectant can also be injected at this phase of the project to begin the primary disinfection process. At this stage of the process, organic material has not been removed and therefore the selected disinfectant at this stage must not form significant disinfectant byproducts in the presence of organic material. Chloramine is a very weak disinfectant that does not form appreciable byproducts, but because of its weak nature will probably not be able to fully disinfect the water. Chlorine is a relatively strong disinfectant but freely forms objectionable levels of disinfection byproducts in the presence of organic material. Chlorine dioxide is a strong disinfectant that could be used in this application. The disinfectant byproduct formation is more closely related to the manufacture and application of the disinfectant than it is to the presence of organics. Chlorine dioxide is a volatile chemical with a short shelf life and must be generated onsite. If chlorine dioxide is used in the sedimentation process, a high rate, low volume sedimentation process will be selected.

3.3.3.4 Sedimentation

Following the flocculation zone, the water is sent to large, quiescent basins wherein the flocculated particles are allowed to settle out of the process stream. Both standard rate and high rate sedimentation systems are available. The standard rate systems are larger basins that rely on gravitational forces to remove the flocculated material. High rate sedimentation processes use physical or mechanical devices to assist in the solids removal process. The high rate processes use smaller tanks, but the savings in tank volume is typically offset by the additional mechanical equipment used in the process. For the site plans presented in this study, the more conservative conventional clarification basins are used.

Two process streams leave the sedimentation process. The solid material that settles to the bottom of the basins is removed in a dilute slurry with a concentration of 0.5% to 1% solids and sent to a solids processing area. The clarified water is sent to additional treatment processes for further purification.

The settled water stream must have a very low turbidity to meet state design requirements and to prevent overloading downstream processes with excess solids. The TCEQ design criteria requires a maximum of 2 NTU coming off the sedimentation basins, though a well designed sedimentation tank can provide water that is typically less than 1 NTU.

3.3.3.5 Filtration

After sedimentation, the water is filtered through a granular media filtration process. An additional or alternative disinfection application point will be included in the process between the sedimentation basins and the filters. Typically filters are loaded at up to 5 gpm/square foot of filter surface area. Higher loading rates have been achieved, and approved through the TCEQ. However, in anticipation of the LT2 Bin classifications and the expectation that filter performance will be the backbone of LT2 compliance, a conservative filter design was chosen for this plant configuration. Extra deep filters with a filter loading rate of 4 gpm per square foot is chosen with a goal filtered turbidity of less than 0.10 NTU in each individual filter. With this conservative design philosophy, the plant can be in compliance with LT2 requirements for either Bin 1 or Bin 2, which are the most likely Bin classification assignments at this location.

The effluent from the filters is collected in a filter clearwell. The clearwell will be baffled to enhance the effective detention time of the filtered water and improve the disinfection process.

3.3.3.6 Advanced Treatment

Space will be allotted in the site plan and process flow diagram to accommodate the addition of advanced treatment in the future if warranted by the impacts of LT2 and DBP2 regulations. Advanced treatment may include additional solids removal through the use of membranes, or alternative or additional disinfection processes such as ultraviolet radiation or ozone. Although it is anticipated that full treatment meeting the anticipated regulatory requirements will be achieved with the conventional treatment processes described above, prudence dictates that regulations will continue to require more stringent water quality standards and that some additional treatment will be required in the future.

3.3.3.7 Storage & Residual Disinfection

Depending on the plant site topography, a transfer pumping station will probably be required to deliver the water to onsite ground storage tanks. Chlorine and ammonia will be added to the transfer line to form chloramine as the residual disinfectant.

Onsite ground storage tanks will provide 6 to 8 hours of detention time for the finished water and function as equalization basins between plant production and system demands. Again, depending on topography and demand locations relative to the ground storage tanks, a high service pump station will be provided to deliver treated water to the distribution systems and consumers.

3.3.3.8 Solids Processing

The residual streams that are removed from the sedimentation and filtration systems will be diverted to a solids processing area. The solids processing will consists of a thickener, a sludge storage facility, and a centrifuge or belt press sludge dewatering facility. The solids removed in this process will be in a sludge cake form that is easily handled by conveyors and hauled in trucks to landfill. The material will be relatively inert and poses no special disposal problems. The liquid that is separated from the solids will be pumped back to the head of the plant and recycled through the treatment process.

3.3.3.9 Support Facilities

In addition to the process units, support facilities will also be provided. An Administration/Laboratory building will house administrative offices, locker and restroom facilities, and a water laboratory to run routine tests required to run the plant and generate reports. Maintenance facilities will be provided to store spare parts and to provide tools and working space to perform routine maintenance on the plant equipment. It is also anticipated that a separate instrumentation storage and workspace area will also be provided in the maintenance facility.

3.3.4 Proposed Treatment Plant Capacity

The treatment plant(s) will be sized to handle the shortage in groundwater supply in 2045. Based on the Region H RWP demand projections and current District regulations, the deficit will be nearly 90 mgd at that time. Details of treatment plant capacities and phasing are discussed in Section 4.1. The estimated system demands by decade are shown in *Table 43*.

Table 43 Estimated Conroe System Demand through 2045

Phase (Year)	Estimated Demand
I (2015)	18 MGD
II (2025)	40 MGD
III (2035)	61 MGD
IV (2045)	86 MGD

The installed treatment plant capacity at the time of each phase should be planned to provide at least as much treatment capacity as these projected demands. The 2045 demands were used to set the ultimate plant treatment capacity at 90 mgd, to include 3 to 5 percent loss through the plant. The ultimate plant capacity is important from a planning standpoint to help identify a large enough site for the treatment plant to allow for future planned growth.

The nominal plant capacity of 90 mgd is used for the plant siting requirements, transmission line sizing, and the development of anticipated costs. Considering seasonal demand fluctuation, current demand projections, and the desire to minimize the footprint of the transmission system, the plant would likely need to have a capacity greater than 90 mgd to actually provide an average of 90 mgd on a daily basis; i.e. the plant would require a seasonal peaking factor (seasonal demand issues and plant peaking are discussed in Section 3.1.3). If potential wastewater reuse and aggressive water conservation is taken into account, the projected conversion requirement could be reduced significantly from 86 mgd. In that event a 90 mgd plant would have a built-in peaking factor and the capacity would be sufficient to deliver the required volume on an annual basis.

3.3.5 Treatment Plant Layout Assumptions

The following assumptions were made for the layout of the water treatment plant:

3.3.5.1 Treatment Type

As discussed in Section 3.3.2, a conventional type plant was assumed to develop the layout. The actual process will be selected based on additional collection of raw water quality data and the completion of treatability studies. The selection of a conventional plant layout at this point results in the largest potential plant site for planning purposes. The proposed layouts show conventional circular clarifiers. The actual sediment removal method will be determined during preliminary design.

3.3.5.2 Additional Treatment

The advanced treatment area was provided to allow the capability of providing additional treatment beyond conventional treatment to provide maximum flexibility for future regulations and to provide an area for additional process units that may be required based on the future sampling and treatability studies. The current location of the additional treatment was provided to simply allow space for future facilities. The exact location is dependent upon what type of additional treatment is planned. The processes that will be planned for will be determined from the treatability study.

3.3.5.3 Storage Volume

Ground storage tank (GST) volume requirements that are based on typical water demand parameters resulted in a GST volume representing approximately 8 hours of daily pumping. This volume assumes a 35 feet water depth in the GSTs. The height of the GSTs could be increased in height to 40+ feet side wall depth to obtain additional volume in the GSTs or could be decreased to be more neighbor friendly. The actual required GST volume may be less depending on the peak pumping capacity required. The actual number of the GST will depend upon storage requirements and tank diameter and height.

3.3.5.4 Stormwater Detention

Based on input from the San Jacinto River Authority (SJRA), no stormwater detention pond was provided.

3.3.5.5 Site Restrictions

The plants were laid out on the proposed sites without information regarding geotechnical, structural, or other development restrictions.

3.3.5.6 Topographic Survey

The exact property lines and existing utilities were not surveyed and parcel sizes were estimated based on information provided by SJRA and the Montgomery County Appraisal District. A survey of the property corners, dam, creek, and all surrounding access roads and topographical features is recommended to determine the actual size and useable limit parameters of each site. Building setbacks or other area development requirements should be investigated and taken into consideration as part of the future layout.

3.3.5.7 Environmental Assessment

No environmental assessments were performed on the proposed sites or alignments. It is assumed that no environmental impacts exist on the sites which would limit the useable area of the site or require cleanup/mitigation prior to construction of improvements. An environmental assessment should be made as required.

3.3.5.8 Site Access

Access to and from each plant site varies considerably based upon the site and is discussed in greater detail in the planning alternatives discussion. Access is not only for plant operations personnel, but also heavy delivery truck traffic to and from the plant for chemicals, sludge removal, maintenance activities, and construction activities. Generally it was assumed that access to the site could be provided along at least one major access road to the plant site.

It was assumed that access to the site could be provided along Dam Site Road from the east (Longmire Way) by securing a short access easement for a driveway across adjoining property. Access to the water treatment plant located on the northeast end of the dam from Highway 105 would require access/traffic over the dam and gate structure leading to security and facility maintenance issues. Therefore access to the water treatment plant would only be from Longmire Way. It appears that White Oak Ranch Drive has limited access (key-access gate) which could limit the ability to use this east entry as a general access point.

3.3.5.9 Phasing

Construction of the plant to the ultimate capacity is assumed to occur in four phases. Space is left between each phase to allow access and prevent disruptions to existing operations during construction of future phases.

3.3.5.10 Extra Treatment Train

Consideration was given to including an extra treatment train to provide firm treatment capacity. However, given that the initial stages of the plant are only providing a small portion of the water for the area and that well capacity is available to meet the majority of peak day capacity, the additional cost associated with an extra train appears to be overly conservative. TCEQ does requires parallel treatment trains but does not require redundant sedimentation basins when a public water supply has interconnections or wells that can meet the system's average daily demand. Whether an extra treatment train is required appears to be an Owner preference but this should be confirmed during the preliminary engineering phase of plant design.

3.4 Operational Issues with Introduction of Surface Water

There are a number of issues that must be addressed in introducing surface water into a typical Montgomery County PWS. The mechanics of introducing the surface water into one tank, or into multiple tanks in a system should be addressed with hydraulic modeling. This section discusses a number of other issues that must be addressed in order to provide a water of consistent quality to the PWS's customers. These issues are related to the manner in which the surface water is introduced.

First and foremost, all of the PWSs use free chlorine as the disinfectant of choice and they will have to change their disinfection practices. Most surface water in this area is treated with chloramines, a combination of chlorine and ammonia, instead of free chlorine. Use of chloramines provides a longer lasting disinfectant residual, and reduces the formation of disinfection byproducts (DBPs). DBPs are formed as a result of the interaction of free chlorine and organic acids present in surface water from the decomposition of leaves, grass, algae, and other materials common to surface waters in Texas. In order to be compatible with the chloraminated surface water, each PWS will need to provide ammonia feed equipment at all of their current disinfection locations. If this is not done, the combination of the free chlorine from the groundwater with the organic acids in the surface water will result in accelerated DBP formation and likely exceedances of the standard. One other issue is that chloramines are a less powerful disinfectant than free chlorine. As a result, the PWS may have to revert to free chlorine in the distribution system for short periods of time each year to "burn out" unwanted bacterial slime growths commonly referred to as biofilm.

A second water quality issue that needs to be addressed is the blending of surface and groundwater in the system. The ideal method of blending surface and groundwater is at the storage tanks. Groundwater is generally at a lower temperature than surface water, usually has a higher hardness, and oftentimes contains dissolved gasses that are temperature dependent for their saturation concentrations. Mixing groundwater with generally higher temperature surface water, with typically lower hardness, can produce interactions which cause gases to be driven off, and can result in the precipitation of calcium carbonate and iron, if there is dissolved iron in the system. Blending at the tanks allows this process to take place, precipitates to form and drop out of solution, and gases to leave via the tank vents. The end result of this process is the production of a more stable water quality in the distribution system.

Although introduction of the surface water and blending it with the groundwater in the storage tanks is the preferred method, there are circumstances where this is not feasible. One of these is where elevated storage tanks are served primarily by a well which pumps into the top of the tank. It will probably not be feasible to provide sufficient pressure to lift the surface water into an elevated tank. Also, some of the tanks may be far from the likely connection point with the surface water and the cost of lines through densely populated areas may make this option cost prohibitive. For these situations, a careful analysis of the surface and groundwater compatibilities is needed. The chemical equilibrium for calcium carbonate (the whitish precipitate that forms in most moderately hard waters) can be calculated for various blending ratios and parameters and adjustments made to minimize this occurrence. Similarly, the wells may need some type of splash plate aeration to reduce the occurrence of dissolved gases in the system. If either iron or manganese is present, a sequestering agent can be fed into the system to prevent the iron or manganese from being oxidized and forming a precipitate.

All of the issues in the above paragraph are primarily for aesthetic purposes. However, the chemical equilibrium of the water is important in determining compliance with the Lead Copper Rule as well. The Lead Copper rule requires that water in the distribution system be stabilized so that it will not tend to dissolve copper or lead pipes in the distribution system. While a particular water system is not likely to have significant quantities of lead pipe in their service lines or in the plumbing of the houses they serve, copper is a common plumbing material inside houses and there will be a concern to balance the water so that it will not tend to dissolve the copper pipes. This is especially true for systems which have previously had well water with some moderate hardness in it. Again, sequestering agents can be used to provide a thin protective coating on the pipes to prevent this occurrence.

Finally, there is a need to prepare the city and water district customers for the change to softer surface water. Those customers who have water softeners will need to adjust their softeners for the new hardness levels in the blended water. The zeolite softeners in common use today are capable of softening to zero hardness, and if that occurs the water produced will be very aggressive. Houses in other areas that have changed from groundwater to surface water have experienced pinhole leaks in copper plumbing within two to three years. Bypassing a portion of the incoming water around the softener effectively remedies this problem, but people will have to be informed of the need to do so. The softer water also requires less frequent regenerations. Water softeners will need to be adjusted to regenerate on alternate time or flow schedules depending on the current basis for regeneration.

All of the issues noted above can be effectively managed if they are known prior to the initiation of surface water into the system. At the same time, if they are neglected they can become a source of friction between the surface water supplier and its customers and a negative perception of the surface water supply can be created.

3.5 Unit Cost Development

Capital costs for construction of pipelines, pumps, storage, and treatment facilities were compiled from a variety of reliable sources and analyzed for trends that could be used for estimating purposes. The prior

Regulatory Study and Facilities Implementation Plan utilized Appendix F*(Cost Estimating Procedure) of the TWDB 2006 Region H Regional Water Plan*, which is based on second quarter 2002 dollars. For this *Surface Water Supply Plan*, the Engineering News Record Construction Cost Index (ENR CCI) was used to adjust the Region H cost data to January 2008 dollars.

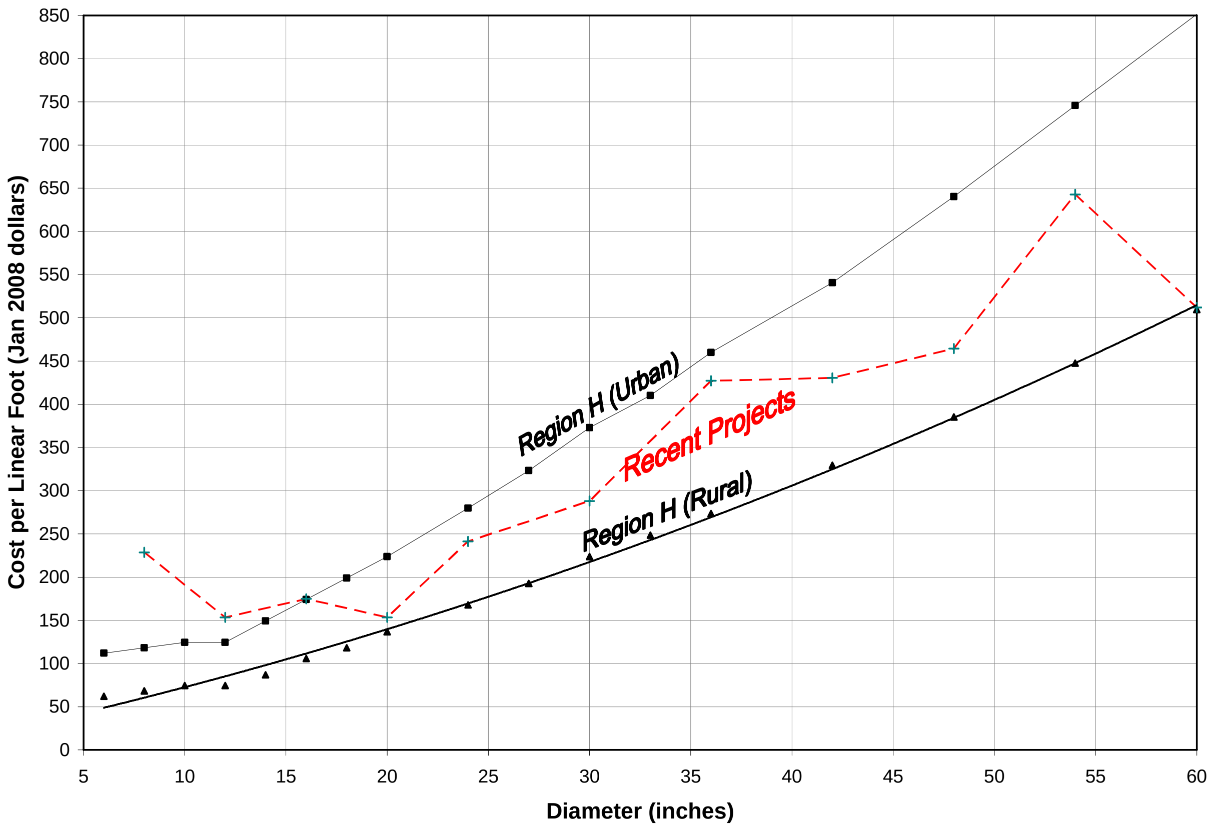
See *Appendix F* for additional detail on unit cost development.

3.5.1 Waterline Unit Costs

The bid tabs for 24 recent waterline construction projects that were bid between 2004 and 2007 were analyzed to help identify any recent cost trends in the last 5-10 years. The ENR CCI was used to adjust the bid tab data for each project to January 2008 dollars, based on when the project was bid.

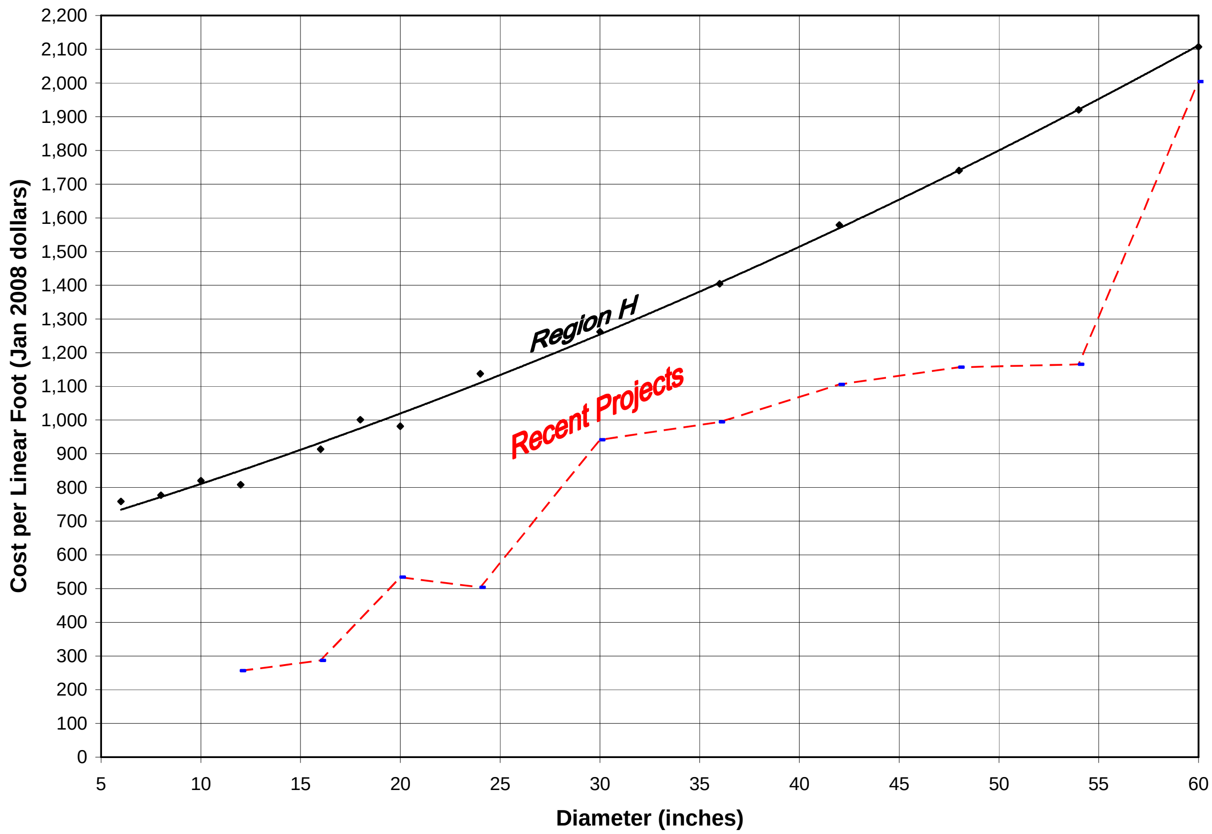
A comparison of the Region H cost data and the recent waterline project cost data is shown in *Figure 5*. The open cut unit costs for the recent waterline data tended to be less than the Region H urban costs and more than the Region H rural costs. This is likely due to a varying level of urbanization at the 24 different recent waterline project sites.

Figure 5 Open Cut Waterline Unit Cost Development



A comparison of the Region H cost data and the recent waterline project cost data for trenchless waterlines is shown in *Figure 6*. The Region H trenchless cost data tended to be somewhat more conservative than the recent project data that was collected. Because of the small amount of trenchless installation, the more conservative trenchless costs were used. Since only approximately 2 percent of the total installed 2015 pipeline length is anticipated to be installed by trenchless methods, the overall trenchless construction cost is not anticipated to have a significant impact on the overall project cost.

Figure 6 Trenchless Waterline Unit Cost Development



As a result of all the cost input gathered from recent projects and Region H, the conclusion was drawn that the Region H unit cost data, as adjusted to January 2008 dollars, formed a representative basis for estimating proposed pipeline construction in the local area. However, the recommended alignment passes through downtown Conroe, The Woodlands, the IH-45 corridor, and the surrounding growing areas. These areas are expected to result in a higher level of pipeline installation complexity than would be expected in other parts of Region H.

The additional project complexity is generally due to the disruptions in these heavily developed areas and requirements that would be needed to protect or restore the area. Pipeline construction generally requires an open cut trench to install pipe or open cut access pits from which the pipe is constructed underground. Both of these open cut areas have the potential to disrupt traffic, buried utilities, landscaped or forested areas, or other surface improvements.

In addition to traffic and utilities throughout these areas, The Woodlands has a number of waterways, parks, and heavily forested areas and downtown Conroe has the adjacent railroad and historic buildings that will need to be protected.

The resulting additional utility adjustments/crossings, traffic control, protective measures, and surface restoration in these areas are expected to add approximately 10 percent to the pipeline construction cost. Both open cut and trenchless unit costs were adjusted to account for the additional complexity of working in these areas.

Table 44 below summarizes the unit costs that were used for estimating pipeline construction costs on this project.

Table 44 Unit Costs for Waterline Construction

Pipe Diameter *(inches)*	**Open Cut (Rural)** *($/LF)*	**Open Cut (Urban)** *($/LF)*	**Trenchless** *($/LF)*
6	70	125	835
8	75	130	855
10	80	135	900
12	85	140	890
14	95	165	
16	115	190	1,005
18	130	220	1,100
20	150	245	1,080
24	185	310	1,250
27	210	355	
30	245	410	1,390
33	275	450	
36	300	505	1,545
42	360	595	1,735
48	425	705	1,915
54	490	820	2,115
60	560	935	2,320

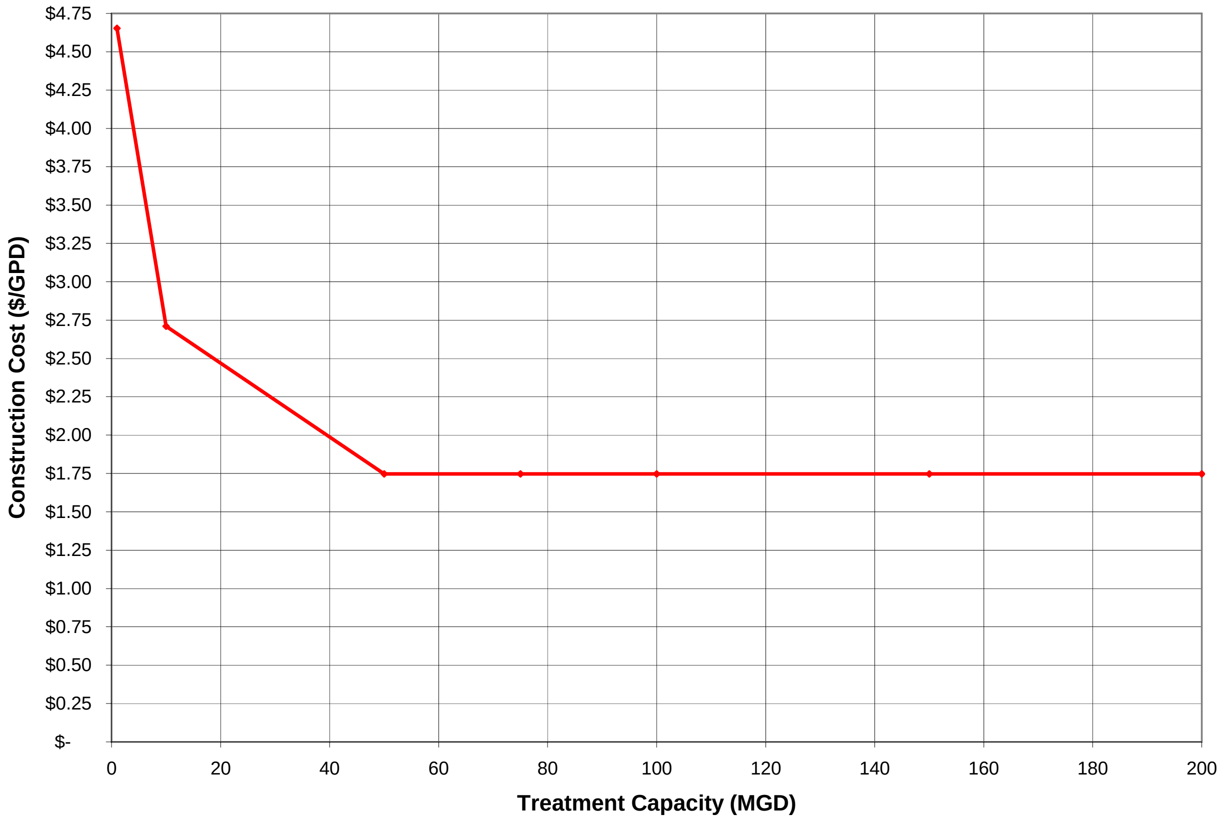
[1] *Values as of January 2008.*

3.5.2 Water Treatment Plant Unit Costs

The Region H conventional treatment plant unit cost curve, after adjustment to January 2008 dollars, varies from $4.65 to $2.71 per gallon per day (gpd) of treated water for a plant between 1 and 10 mgd and varies from $2.71 to $1.75 per gpd of treated water for a plant between 10 mgd and 50 mgd. For a plant larger than 50 mgd, the construction cost is approximately $1.75 per gpd of treated water. The reason for this variation is due to economy of scale.

The Region H water treatment plant costs, after adjustment to January 2008 dollars and without contingencies, are illustrated below in *Figure 7*.

Figure 7 Region H Water Treatment Plant Cost per GPD



Construction costs are typically higher during the initial construction phase than during subsequent expansion phases. This factor is not reflected in the Region H estimating values which only reflect new construction and not expansion phases. Obviously, how much variation exists between the initial construction phase and subsequent expansion phases will vary from plant to plant and phase to phase, depending on how much infrastructure is put in with the initial phase that decreases the cost of subsequent phases. Generally, facilities such as administrative and maintenance facilities, site development, intakes, and pump stations are mostly constructed during the initial phase, resulting in a higher initial phase cost and substantial reduction in the cost per MGD in subsequent phases. The actual cost for the different phases of construction will be much better defined during the preliminary engineering phase of design when the facilities that will be constructed in each phase will be defined.

A contingency of 35 percent was added to the Region H costs after adjustment to January 2008 cost basis due to the lack of water quality data, the substantially higher cost of membrane technology which may be used, and the conceptual level of the study.

Table 45 below summarizes the unit costs that were used for estimating conventional water treatment plant construction costs on this project.

Table 45 Unit Costs for Conventional Water Treatment Plant Phased Construction

Treatment Plant Capacity *(MGD)*	Conventional Treatment [2] *($)*
1	6,281,000
6	23,122,000
8	29,858,000
10	36,594,000
12	40,662,000
18	52,868,000
22.5	62,022,000
50	117,965,000
75	176,945,000
100	235,926,000

[1] Values as of January 2008. [2] Includes 35 percent contingency due to unknowns associated with lack of water quality data, potential inclusion of membrane technology, and conceptual study level.

Section 4 Planning Alternatives

This section identifies where wholesale treated water is planned to be delivered by conversion phase, the conversion percentages by phase, and the proposed treatment plant and transmission pipeline alternatives. The capital costs, annual cost, and annual water rates are presented for each alternative. Finally, the major elements of a standard SJRA water supply contract are discussed.

4.1 Delivery of Wholesale Water

The most beneficial and efficient wholesale water system will result from delivering water to the largest areas of demand. The top two Montgomery County groundwater producers, and six of the top twenty groundwater producers are geographically situated on the I-45 corridor from the City of Conroe in central County to Southern Montgomery County MUD in southern County.

As a result of the relatively large populations and demands along the I-45 corridor, this area is also experiencing by far the largest declines in aquifer water levels anywhere in the County. A 2008 District study titled *Montgomery County Surface Water Conversion Aquifer Study* showed that surface water conversion along the I-45 corridor would halt water level declines.

4.1.1 Areas of Conversion Through 2025

The I-45 corridor is targeted for the initial conversion because it addresses the aquifer water level declines and it allows delivery of the largest amount of water using the least amount of transmission pipeline. There is enough demand in the corridor to meet the initial conversion in 2015 and the following conversion in 2025.

Table 46 lists the PWSs targeted for conversion in 2015 and 2025, along with their projected demands. There are currently no official contracts in place to serve these entities; this is a potential list only. There are a number of small PWSs nearby that could also receive wholesale water, but the systems listed here are sufficient to handle the first two conversion phases. Adding more PWSs will increase the pipeline costs, but will reduce the amount each entity will be required to convert.

Table 46 Conversion Area Water Demands: 2015 - 2025

PWS	Projected Demand (ac-ft/yr)	
	2015	**2025**
The Woodlands	25,270	28,330
City of Conroe	10,400	13,510
Rayford Road MUD	2,090	2,070
Southern Montgomery County MUD	1,970	2,140
City of Oak Ridge North	720	830
City of Shenandoah	510	510
Montgomery County MUD #19	460	460
Chateau Woods MUD	280	370
Woodlands Oaks Subdivision	320	320
TOTALS:	**42,020**	**48,540**

The minimum conversion amounts from *Table 22* are 19,970 ac-ft/yr and 44,140 ac-ft/yr for 2015 and 2025 respectively.

4.1.1.1 Conversion Amounts in 2015 and 2025

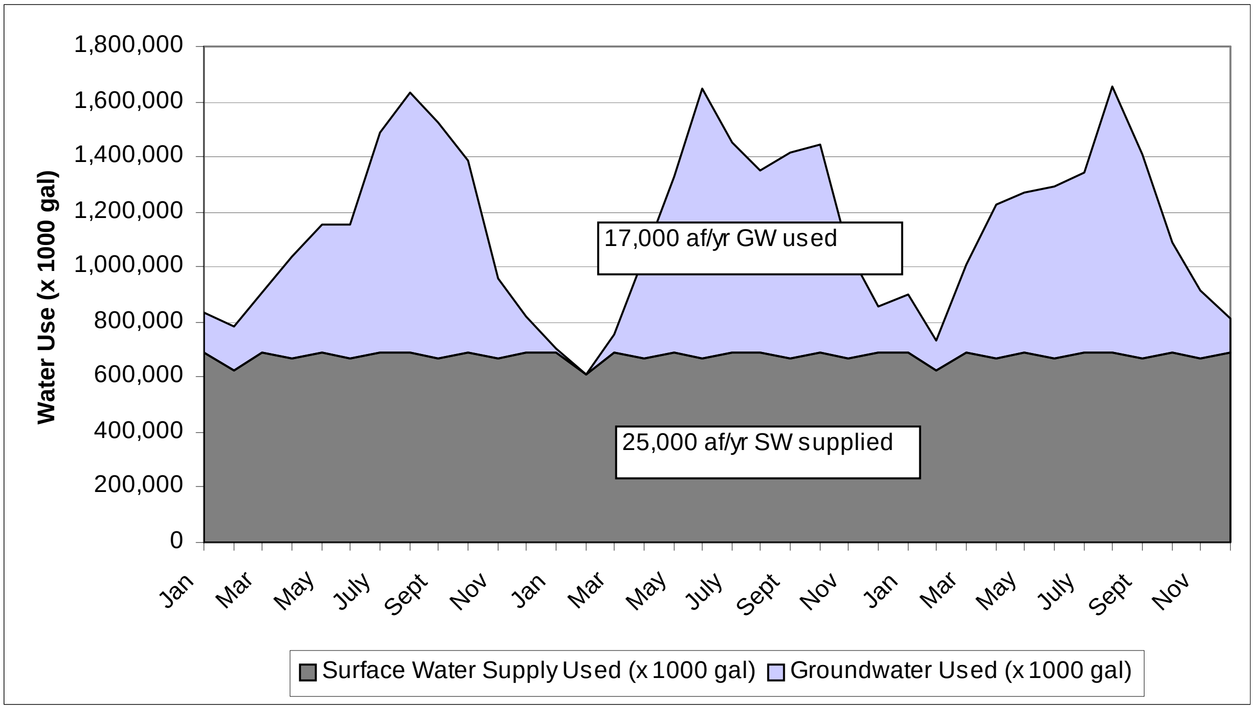
To determine conversion amounts, monthly groundwater production data was compiled for the PWSs in *Table 47* for the years 2004 to 2006. These three years represent a mix of wet years (2004, 2006) and one dry year (2005). The projected water demands for 2015 were distributed based on the monthly distribution of pumpage and compared to the volume of surface water available to determine, on a monthly basis, the relative volumes of surface water and groundwater projected to be consumed in aggregate. *Table 47* shows, based on historical trends from 2004 to 2006, projected monthly demands, available surface water, surface water usage, and groundwater usage for the 2015 conversion.

Table 47 Projected Monthly Conversion in 2015 Based on Historical Trends

Month	Projected Demand (x 1,000 gal)	Available Surface Water Supply (x 1,000 gal)	Surface Water Used (x 1,000 gal)	Groundwater Used (x 1,000 gal)	Percentage of Demand Met By Surface Water
Jan	832,169	691,852	691,852	140,317	83%
Feb	781,142	624,899	624,899	156,243	80%
Mar	906,067	691,852	691,852	214,215	76%
Apr	1,036,758	669,534	669,534	367,224	65%
May	1,155,346	691,852	691,852	463,494	60%
Jun	1,153,656	669,534	669,534	484,122	58%
Jul	1,486,358	691,852	691,852	794,506	47%
Aug	1,632,516	691,852	691,852	940,664	42%
Sep	1,520,624	669,534	669,534	851,090	44%
Oct	1,385,316	691,852	691,852	693,464	50%
Nov	955,040	669,534	669,534	285,506	70%
Dec	818,008	691,852	691,852	126,156	85%
Jan	704,334	691,852	691,852	12,481	98%
Feb	608,914	624,899	608,914	0	100%
Mar	751,817	691,852	691,852	59,965	92%
Apr	1,040,839	669,534	669,534	371,305	64%
May	1,328,799	691,852	691,852	636,946	52%
Jun	1,648,668	669,534	669,534	979,134	41%
Jul	1,451,811	691,852	691,852	759,959	48%
Aug	1,348,065	691,852	691,852	656,213	51%
Sep	1,418,903	669,534	669,534	749,369	47%
Oct	1,443,954	691,852	691,852	752,102	48%
Nov	1,060,652	669,534	669,534	391,117	63%
Dec	856,245	691,852	691,852	164,393	81%
Jan	902,147	691,852	691,852	210,295	77%
Feb	733,470	624,899	624,899	108,572	85%
Mar	1,007,244	691,852	691,852	315,392	69%
Apr	1,225,419	669,534	669,534	555,885	55%
May	1,270,283	691,852	691,852	578,431	54%
Jun	1,294,248	669,534	669,534	624,714	52%
Jul	1,344,357	691,852	691,852	652,505	51%
Aug	1,653,692	691,852	691,852	961,840	42%
Sep	1,410,475	669,534	669,534	740,941	47%
Oct	1,091,842	691,852	691,852	399,990	63%
Nov	917,814	669,534	669,534	248,280	73%
Dec	812,008	691,852	691,852	120,156	85%
TOTALS:	**40,989,000**	**24,438,000**	**24,422,015**	**16,566,985**	**60%**

The results of the above table are shown graphically in *Figure 8*.

Figure 8 Projected Monthly Conversion in 2015 Based on Historical Trends



The available monthly surface water supply is below the minimum month in 35 of 36 months. Almost 100% of the surface water supply is projected to be used, resulting in a conversion of 60% for supplied PWSs as shown in *Table 47*. This scenario will allow the water treatment plant to be operated at nearly steady-state throughout the year, which will help to reduce operating costs compared to a plant with large seasonal variations in production.

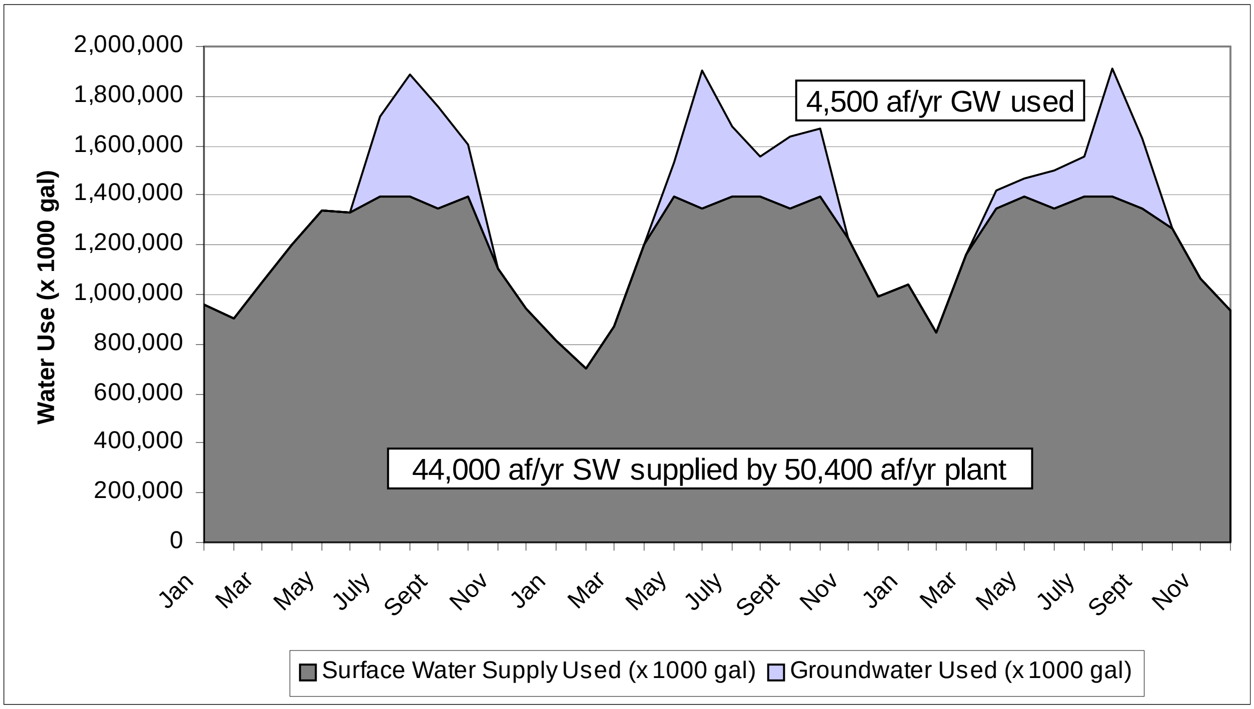
Table 48 shows, based on historical trends from 2004 to 2006, projected monthly demands, available surface water, surface water usage, and groundwater usage for the 2025 conversion.

Table 48 Projected Monthly Conversion in 2025 Based on Historical Trends

Month	Projected Demand (x 1,000 gal)	Available Surface Water Supply (x 1,000 gal)	Surface Water Used (x 1,000 gal)	Groundwater Used (x 1,000 gal)	Percentage of Demand Met By Surface Water
Jan	961,961	1,394,830	961,961	0	100%
Feb	902,976	1,259,847	902,976	0	100%
Mar	1,047,385	1,394,830	1,047,385	0	100%
Apr	1,198,460	1,349,836	1,198,460	0	100%
May	1,335,544	1,394,830	1,335,544	0	100%
Jun	1,333,590	1,349,836	1,333,590	0	100%
Jul	1,718,183	1,394,830	1,394,830	323,353	81%
Aug	1,887,137	1,394,830	1,394,830	492,307	74%
Sep	1,757,793	1,349,836	1,349,836	407,958	77%
Oct	1,601,382	1,394,830	1,394,830	206,552	87%
Nov	1,103,997	1,349,836	1,103,997	0	100%
Dec	945,592	1,394,830	945,592	0	100%
Jan	814,187	1,394,830	814,187	0	100%
Feb	703,886	1,259,847	703,886	0	100%
Mar	869,076	1,394,830	869,076	0	100%
Apr	1,203,177	1,349,836	1,203,177	0	100%
May	1,536,049	1,394,830	1,394,830	141,219	91%
Jun	1,905,808	1,349,836	1,349,836	555,973	71%
Jul	1,678,248	1,394,830	1,394,830	283,418	83%
Aug	1,558,321	1,394,830	1,394,830	163,491	90%
Sep	1,640,207	1,349,836	1,349,836	290,372	82%
Oct	1,669,166	1,394,830	1,394,830	274,335	84%
Nov	1,226,080	1,349,836	1,226,080	0	100%
Dec	989,793	1,394,830	989,793	0	100%
Jan	1,042,854	1,394,830	1,042,854	0	100%
Feb	847,869	1,259,847	847,869	0	100%
Mar	1,164,343	1,394,830	1,164,343	0	100%
Apr	1,416,546	1,349,836	1,349,836	66,710	95%
May	1,468,407	1,394,830	1,394,830	73,577	95%
Jun	1,496,110	1,349,836	1,349,836	146,274	90%
Jul	1,554,035	1,394,830	1,394,830	159,205	90%
Aug	1,911,616	1,394,830	1,394,830	516,786	73%
Sep	1,630,465	1,349,836	1,349,836	280,630	83%
Oct	1,262,135	1,394,830	1,262,135	0	100%
Nov	1,060,964	1,349,836	1,060,964	0	100%
Dec	938,656	1,394,830	938,656	0	100%
TOTALS:	**47,382,000**	**49,269,000**	**42,999,840**	**4,382,160**	**91%**

The results of the above table are shown graphically in *Figure 9*.

Figure 9 Projected Monthly Conversion in 2025 Based on Historical Trends



The overall conversion in 2025 is projected to be 91% as shown in *Table 48*. The surface water supply generally meets total demands in the months January through April and November through December, and groundwater is needed to augment supplies in the high demand months of May through October.

The above analysis for 2025 shows that, on average, there are seven months of the year where total monthly demand is below the available surface water supply. Since the full capacity of the plant cannot be used every month, a 50,400 ac-ft/yr plant can only supply 44,000 ac-ft/yr. The seasonal fluctuation in the operating level of the plant results in less efficient operation compared to a plant that operates near steady-state.

In order to operate the plant at steady-state, the transmission pipeline system would have to be expanded to serve enough demand such that the minimum month demand was above the monthly capacity of the plant (as is the case in the 2015 system). As the required conversion volumes increase, this is increasingly more difficult to accomplish since the high demand areas of the County are already being served by wholesale surface water.

4.1.2 Areas of Conversion in 2035 and 2045

As mentioned in Section 4.1.1, the I-45 corridor is converted initially due to its high population density. By 2045, the conversion requirement doubles over the 2025 amount, but all the high demand areas have been converted nearly 100%; i.e. there are no centralized high-demand areas of potential conversion using today's water demand projections.

There are three major considerations in meeting the 2035/2045 conversion requirements with a system served by Lake Conroe water:

1. The demand available for conversion, while significant, is spread over a large area with no large concentrations of demand near Lake Conroe;
2. The Southeast portion of the County is considered impractical to serve with water from Lake Conroe due to the length of transmission line required to serve a relatively low demand, eliminating a large portion of the County from consideration;
3. The spatial distribution of the 2006 Region H RWP demand projections (see details of the spatial distribution in the Phase I Study) do not reflect the presence of a surface water transmission system. The distribution of demand will likely change significantly as surface water becomes available.

Items 1 and 3 above are related: the demands are low in concentration and spread over a large area because of the assumptions in the distribution. Serving enough demand to meet the Phase III and Phase IV conversion requirements using the current demand distribution would result in extensive transmission systems to reach small far-flung pockets of demand. The approach for the Phases III and IV line expansions is to limit the extent of pipeline on the assumption that development will be drawn to the areas where transmission pipelines exist or are planned. Also, it is assumed that the total demand in these areas will be predominantly served by surface water; areas that require conversion are assumed to convert at a 90% rate. The usage patterns and relative volumes of surface water and groundwater supply will be similar to that shown in *Figure 9*.

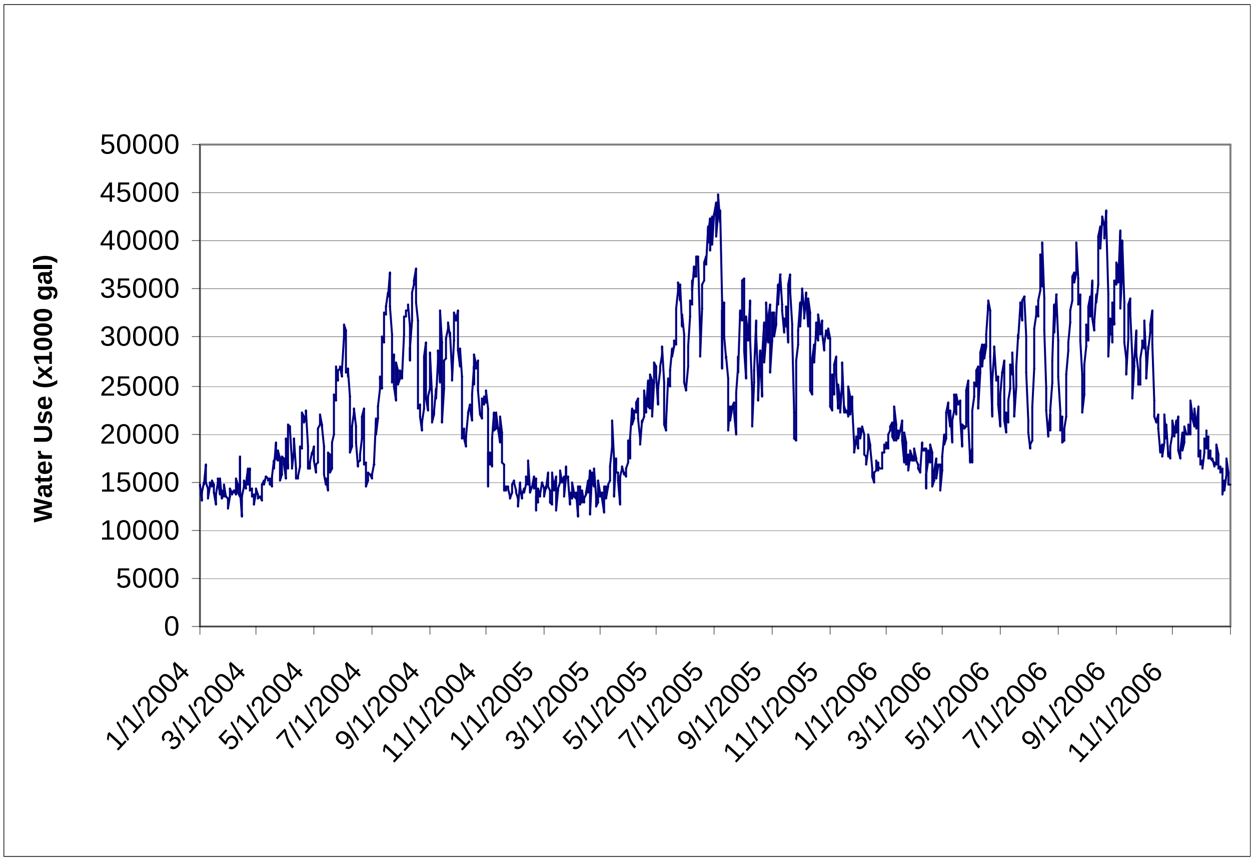
4.1.3 Post-Conversion Peak Day Well Capacity Requirements

It is important for PWSs to have an understanding of how much water their wells will be required to produce after the initial conversion so they can determine if wells can be taken out of production, and if so, how many. As mentioned previously, the initial phase of conversion will require that, as a group, participating systems convert 60% of their demand from surface water to groundwater. *Table 47* shows that the percentage of required groundwater production volume could be as high as 59% of the total demand in high-demand months.

It is necessary to look at the daily variation in demand to determine the peak day production required from groundwater wells. Since the combined water demand from The Woodlands and City of Conroe represents 85% of the total demand for the initial conversion, this analysis focuses on these two entities.

Figure 10 shows historic daily well production volumes for The Woodlands and City of Conroe for the years 2004 to 2006. The combined peak day during that period was July 5, 2005 in the amount of 44,729,000 gal.

Figure 10 2004-2006 Daily Metered Well Production for The Woodlands and City of Conroe



This daily production pattern was applied to 2015 projected demands and compared to the volume of surface water available assuming The Woodlands and City of Conroe would both convert at a rate of 60%. *Figure 11* shows the projected volumes of surface water and groundwater required.

Figure 11 Projected 2015 Daily Conversion for The Woodlands and City of Conroe

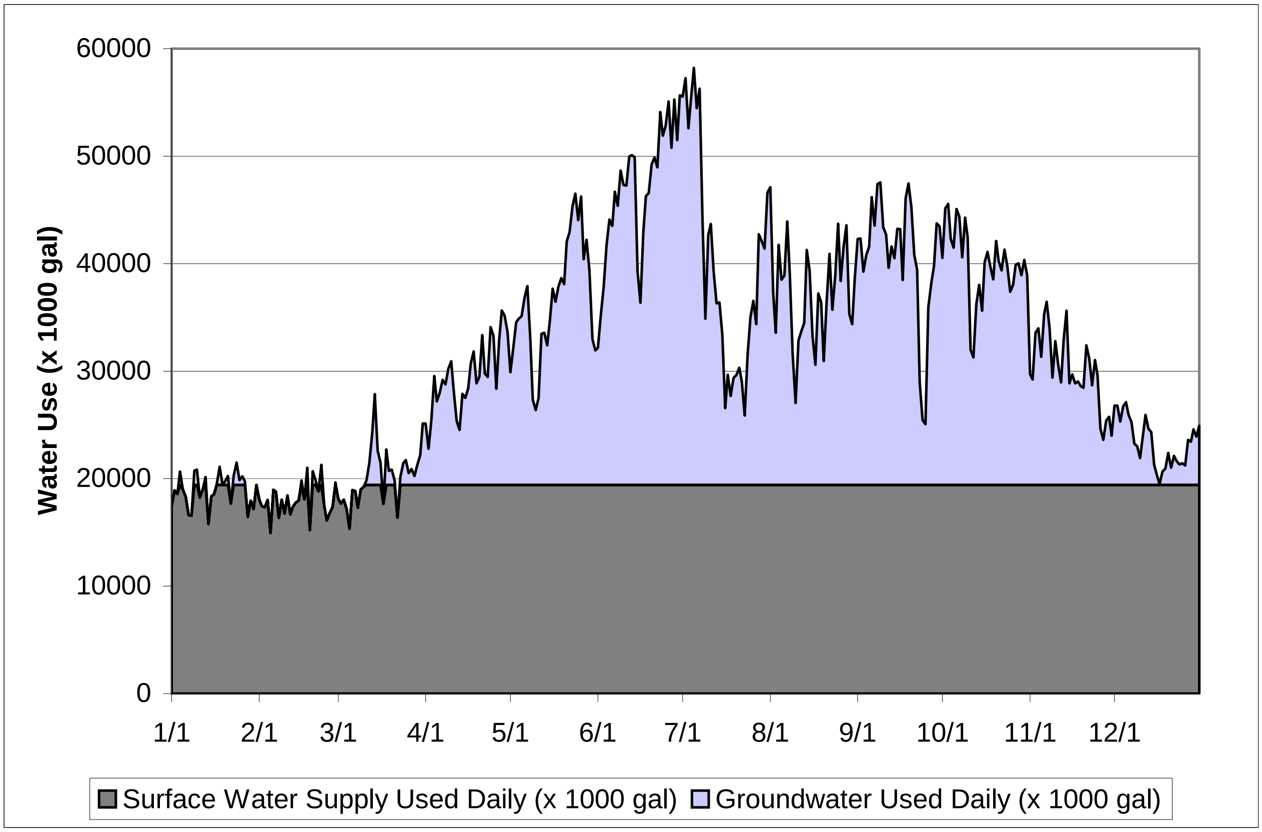


Table 49 shows, for the peak day, total demand, surface water supply, and groundwater supply requirements. It also shows the available daily well production capacity if all wells were left in service, and the percentage of total capacity required for peak day.

Table 49 Conroe and Woodlands 2015 Peak Day Well Production Requirements

PWS	Projected Peak Day Demand (x1000 gal)	Projected Daily Surface Water Supply (x1000 gal)	Peak Day Groundwater Supply Required (x1000 gal)	Projected Daily Well Production Capacity * (x1000 gal)	Well Capacity Required on Peak Day (%)
City of Conroe	17,000	5,630	11,370	20,390	56%
SJRA (The Woodlands)	41,200	13,790	27,410	47,693	57%
TOTALS:	58,200	19,420	38,780	68,083	57%

* The total daily production capacity of the wells is based on an 80% duty cycle.

The well production capacities are based on current values; they do not take into account loss in efficiency as aquifer water levels decline. Both Conroe and Woodlands would need to keep, at an absolute minimum, roughly 60% of their total well capacity after the surface water conversion.

The variability in daily demands versus supply should be reviewed further during subsequent preliminary engineering efforts and the results may impact the overall plan and costs.

4.2 Single Plant Alternative

Two planning alternatives were considered. The first alternative, known as the "Single Plant Alternative", consists of a single proposed water treatment plant to be installed at a location near the Lake Conroe Dam in order to provide water to the entire Conroe System. A second alternative, known as the "Dual Plant Alternative" and discussed in later sections, would utilize two separate proposed water treatment plants instead of one plant.

4.2.1 Water Treatment Plant

4.2.1.1 Proposed Capacity and Phasing

As previously discussed, an ultimate plant treatment capacity of 90 mgd is required. Phasing is planned to provide a minimum number of trains that allows operational flexibility, redundancy, and constructability.

Based upon the anticipated Conroe System demands, four phases that each provide 22.5 mgd of treatment capacity would satisfy the required demands. *Table 50* below shows how four 22.5 mgd phases would meet the anticipated demands.

Table 50 Single Plant Treatment Capacity versus Demand by Phase

Phase (Year)	Anticipated System Demand (including losses [1])	Total Plant Capacity [1]
I (2015)	18.3 MGD	22.5 MGD
II (2025)	40.6 MGD	45 MGD
III (2035)	62.4 MGD	67.5 MGD
IV (2045)	88.8 MGD	90 MGD

[1] *Assumes a water loss in the plant of 3 percent.*

Use of paired trains in each phase would facilitate operational redundancy. Each train would be capable of independent operation. Eight equal 11.25 mgd trains are recommended, as shown in *Table 51* below.

Table 51 Single Plant Treatment Capacity by Phase

Phase (Year)	Added Capacity per Phase	Total Plant Capacity
I (2015)	22.5 MGD (2 train @ 11.25 MGD)	22.5 MGD (2 train @ 11.25 MGD)
II (2025)	22.5 MGD (2 train @ 11.25 MGD)	45 MGD (4 trains @ 11.25 MGD)
III (2035)	22.5 MGD (2 train @ 11.25 MGD)	67.5 MGD (6 trains @ 11.25 MGD)
IV (2045)	22.5 MGD (2 train @ 11.25 MGD)	90 MGD (8 trains @ 11.25 MGD)

4.2.1.2 Site Assessment

Based upon previous water plant construction and initial site layouts, a minimum of 40-acres of useable property is recommended for construction of a conventional water treatment plant with an ultimate treatment and pumping capacity of 90 mgd. Some of the main design criteria and assumptions that this plant site layout is based on were previously described in Section 3.3.5. The 40 acres does not include any property for a forebay or buffer zones.

A conceptual analysis into the feasibility of constructing a 90-mgd water treatment plant at two alternative sites near the San Jacinto River Authority (SJRA) dam on Lake Conroe was conducted. The two sites were identified by SJRA for consideration and are hereafter referred to as the East Site and West Site.

The East Site is better suited to accommodate a 90-mgd plant of the two sites that SJRA identified. Further investigation, including geotechnical and floodplain analysis, is recommended to insure that all constraints are known prior to providing a more detailed layout. As the layout progresses, consideration of alternate raw water intake sites to avoid crossing through the dam needs to be considered. Purchasing of additional property adjacent to the site is recommended to allow additional flexibility for the project.

4.2.1.2.1 West Site

The West Site, shown in *Exhibit 22*, consists of approximately 34 acres. The approximate site boundaries were provided by SJRA. A large ditch, located along the southeast edge of the site, passes large volumes of flow coming from across Highway 105 during high rainfall periods, according to SJRA. Conversion of this ditch to a subsurface culvert is possible to allow facility development above-grade, but the facilities that could be constructed over this culvert would be limited. The useable area without this ditch is approximately 28 acres. The useable area is limited by the property lines (or the ditch) to the south, west, and east, and by the access road along the toe of the dam to the north. Highway 105 West and Dam Site Road are directly adjacent to the site along most of the perimeter. Much of the site is covered with storage buildings. Trees cover approximately 30 percent of the site.

The West Site (28-acre useable) is not considered to have enough useable land to accommodate a 90-mgd plant (40-acre minimum). Therefore, additional detailed consideration of this site was not provided.

4.2.1.2.2 East Site

The East Site, shown in *Exhibits 14, 15, and 22*, consists of approximately 79 acres of land. Of this, approximately 40 acres is useable area that is either not in the floodplain or part of the dam itself. The useable area is bounded to the north by the access road at the toe of the dam, by the 100-year floodplain to the west, and the existing property (and tree) line to the south and east. Minimal trees exist on the site itself.

Exhibits 13, 14, and 15 illustrate a possible layout of the 90-mgd ultimate plant across the site.

4.2.1.3 Site Specific Design Considerations

The following issues are recommended for further consideration as the site investigation proceeds:

4.2.1.3.1 Floodplain

The FEMA floodplain (as delineated on the FIRM panel maps) covers a significant portion of the site on the downstream side of the dam. Comparison of the base flood elevation (BFE) data to a recent topographic map suggests that the floodplain might actually cover less of the site than Zone A of the FIRM map shows.

This is an issue that needs to be investigated during future work. A detailed floodplain analysis may be needed.

4.2.1.3.2 Geotechnical & Structural Analysis

The plant was laid out with no geotechnical information and without consideration of potentially significant site restrictions which could result from the plant being located behind the Lake Conroe Dam.

A detailed geotechnical investigation of the recommended site is considered to be critical prior to doing a more detailed layout. Recommended investigations include groundwater level monitoring, slope stability analysis for any high retaining walls or sloping excavations, evaluation of excavation behind the dam, and other detailed geotechnical investigations appropriate for a plant below a dam where significant excavation may be required.

Future geotechnical work could have a significant impact on the depth of excavation behind the dam and on the ability to use significant retaining walls to allow placement of ground storage tanks. It was assumed that these factors will have no impact on the plant layout, but the extent of the actual impact will not be known until significant geotechnical work has been performed behind the dam and detailed geotechnical and structural analysis is completed. The lack of information in these areas (geotechnical, structural and other development restrictions) is a major consideration in recommending that additional adjacent property be obtained to allow layout flexibility, envisioning design restrictions that are likely to occur once detailed geotechnical and structural engineering analysis are completed.

4.2.1.3.3 Raw Water Pump Station

As shown, the raw water lift station would require another intake to be constructed in the lake. That intake pipe would be constructed either under or through the dam. Following the completion of geotechnical investigation and additional layout studies or a preliminary engineering report (PER), alternative layouts for the raw water pump station and the resulting intake piping are recommended for further consideration. One possible alternative includes a lift station near the top of the dam, close to the existing turnaround, which would enable the intake line to be constructed without crossing through the dam.

The raw water pump station was located assuming that an additional intake and pipeline through the dam would be provided. The actual location of the raw water pump station will depend upon whether an additional line through the dam is practical. It is assumed that a raw water pump station will be required to feed the plant only during periods of low lake level.

4.2.1.3.4 Additional Property

All property from the existing dam access road (at the toe) to the fence line was assumed as useable.

There are a number of reasons to consider purchasing extra property adjacent to the current site. The existing property narrows on the east (highest) side, with approximately 600 feet of width available at the westernmost (lowest) useable portion. As a minimum the property could be “squared-off”, but ideally acquisition of additional adjoining property would allow greater flexibility in the design layout, room to allow plant buffers, ability to mitigate the impact on the dam of deeper filter structures at the lower end of the property, ability to mitigate the sharp drop-off in the middle of the site (drops 10 feet in a 160-feet reach and 20 feet in a 600-feet reach), and allowing additional space for potential future use.

Additionally, no buffer zone (for lighting, access, security, noise, etc.) was used in the conceptual layout for the Lake Conroe Dam site due to the shape of the property and the limited amount of property. It is recommended that additional property be considered to provide some buffer zone for the land located immediately south and east of the plant.

4.2.2 Proposed Alignments

4.2.2.1 Right of Way Issues

The right-of-way issues that the revised alignment corridor faces were discussed in Section 3.2.2.2. The Single Plant alternative utilizes all of the proposed alignment corridor except for the Sendera-Conroe (5) segment, the Woodlands Plant (6) segment, and the Research Forest Central (11) segment.

4.2.2.2 Conflict Identification

Table 52 below summarizes the major potential conflicts for the Single Plant pipeline alignment. Additional detail on the potential conflicts is found after *Table 52*. Each potential conflict is marked in bold letters to facilitate identifying the discussion.

Table 52 Single Plant Option – Potential Conflicts

Potential Conflicts	Description	Affected Planning Alternative
Lake Conroe Dam	Geotechnical investigation may restrict pipeline alignment near dam. Bottleneck at SJRA property and residential homes to south. Fultz Road offers an alternate alignment if needed.	Single Plant
Bear Branch Reservoir	Long dam/spillway at west side of Kuykendahl Rd. forms large reservoir. Low-lying, boggy conditions, with standing water far upstream. Very heavy trees. Subject to flooding.	Single Plant
Lake Creek	Lake Creek is a relatively small creek with a flat, wide floodplain that does not drain well, resulting in a wide area of boggy land that could present constructability issues.	Both Alternatives
Robinson Road	Robinson Road is a narrow roadway with utilities through a residential area with homes and businesses on either side. This road is planned to be widened to 4 lanes in 2018.	Both Alternatives
Southern Montgomery County MUD Drainage Ditches	The drainage ditches near Grogan's Mill and Sawmill Road often have narrow top banks and varying sections. Ditches have many curves and bridge/roadway crossings.	Both Alternatives
South IH-45 Crossing (Sawdust/Rayford)	Required IH-45 crossing location is heavily built out and congested with many utilities and limited ROW. This will likely be the most difficult segment to construct.	Both Alternatives
Longmire Road	Narrow 2 lane road has residential and businesses at edge of right-of-way line and includes utilities. Road is planned for widening to 4 lanes in 2023.	Both Alternatives
FM 3083 Bottleneck (east of IH-45 feeder)	East of the IH-45 frontage road, a cemetery is located north of FM3083 ROW and a gas station located south. Retaining wall on south ROW line. Limited room available outside ROW.	Both Alternatives
N. 1st Street N. Pacific Street	This north-south route to downtown Conroe is directly adjacent to the Union Pacific Railroad. Homes and businesses are on ROW lines both sides of RR/street ROW.	Both Alternatives
Kuykendahl Road	Kuykendahl Road is currently only constructed with 2 lanes on the west side, making construction along the east side of ROW relatively easy. Widening to 4 lanes is planned for 09/2011.	Both Alternatives

Geotechnical investigation is recommended to provide guidance on the feasibility of routing a major pipeline along the downstream side at the foot of the **Lake Conroe Dam**. Realignment along Fultz Road offers a potential resolution if a conflict occurs.

Bear Branch Reservoir is a significant waterway with a long dam/spillway at Kuykendahl Road that backs up Bear Branch flows almost to FM 2978. This upstream area has very dense trees and vegetation and standing water. While the pipeline could feasibly be routed through this area, the construction costs to install the waterline and construct reliable access would likely be very high. An alternate alignment along Research Forest Drive is recommended. The majority of this roadway is not built or is only two lanes on one side of the right-of-way which would facilitate waterline installation with minimal disruptions. Installation of the missing sections of Research Forest Drive 2 lane road and widening to 4 lanes are planned for 2018, which would allow the pipeline to be installed prior to the remainder of the roadway being constructed.

Lake Creek is a relatively small creek, but it has a very wide floodplain due to the flat area on either side of the creek. As a result, a wide area of land has standing water or boggy conditions which will make pipe installation difficult. For the Single Plant Option, the Fish Creek Thoroughfare will install a raised roadway through this area that will generally address the access and constructability issues. Two lanes of the remaining sections of Fish Creek Thoroughfare are planned for installation in 2011. Pipeline construction will likely occur after this date, so these improvements can be utilized.

Robinson Road is an extension of Woodlands Parkway on the east side of IH-45. This roadway is planned for widening to 4 lanes in 2018. However, this roadway is currently fairly congested with residences and businesses in place very close to the right-of-way lines. Water, sewer, and other utilities were visible. Close coordination with Montgomery County will likely be needed to insure that this line can be placed in the right-of-way.

The drainage ditches near the intersection of Grogan's Mill and Sawmill Road are the responsibility of **Southern Montgomery County MUD**. The ditch cross section varies considerably through this area, from relatively shallow (5-10 feet) to relatively deep (20-30 feet). The top of slope width also varies. A tree buffer strip is typically provided at the edge of this ditch. Where existing room is not available, this buffer may need to be removed and replanted to allow pipeline installation to occur. Additionally, the ditches have a number of curves, roadway crossings, and bridges which could increase the cost of construction.

The south **IH-45 crossing (Sawdust/Rayford Roads)** occurs at the location of existing water facilities for Montgomery county MUD and Southern Montgomery County MUD. The proposed crossing occurs at the site of an existing overhead transmission tower. However, this area is heavily developed and limited right-of-way is available at any location in this area. A large number of utilities occur throughout this area with numerous potential conflicts. Rayford Road is being widened by the County which will limit the available space for pipeline construction. To the east of IH-45, construction of the pipeline in the existing alleys and roadways surrounding the Southern Montgomery County MUD water facilities is anticipated to be disruptive.

Longmire Road is an existing 2 lane roadway that is planned for widening to 4 lanes in 2023. The existing roadway has many curves and very limited ROW in certain stretches, with homes and businesses built on the edge of the existing right-of-way. The presence of existing utilities and the limited ROW could result in potential conflicts.

A "bottleneck" was seen along **FM 3083** along the east side of IH-45 at the frontage road. Garden Park Cemetery and Funeral Home is located on the north side of FM 3083. A gas station, fast-food restaurant, and shopping center are located on the south side of FM 3083, directly opposite the funeral home. The shopping center has a retaining wall located at the ROW line, with the parking lot constructed 5-10 feet lower than FM 3083. Additional trenchless construction beyond the IH-45 crossing may be necessary beneath the parking lot if the pipeline cannot be installed in the existing FM 3083 ROW.

The proposed alignment runs along **N. 1st Street and N. Pacific Street** from North Loop 336 E to downtown Conroe, in order to pick up two City of Conroe water facilities. The Union Pacific Railroad is located adjacent and immediately west of 1st Street and homes and businesses crowd the 1st Street ROW line to the east. Homes are also located adjacent and immediately west of the railroad. Further south, where the alignment crosses the railroad and follows Pacific Street, the railroad is adjacent and immediately east of the roadway, with historic buildings from downtown Conroe on the west side. Numerous busy streets cross Pacific Street in the vicinity of downtown. The railroad historically has allowed crossings, but has not allowed parallel waterlines to run within their ROW. As a result, the limited existing street right-of-way is likely all that is available – due to the bordering buildings. Limited ROW and the disruptions associated with construction in the downtown area of a growing city will likely result in a number of conflicts. One potential resolution to these conflicts is that if the City of Conroe is planning to add new wells further from downtown in the future, perhaps these older downtown wells could be abandoned. Connection to wells in a less heavily developed area is anticipated to be far less disruptive with more available room for pipeline construction.

Kuykendahl Road is a relatively easy alignment corridor in which to construct the waterline under current conditions because only 2 lanes of the future 4 lane divided roadway has been constructed. In some areas, none of the roadway has been built. The remaining segments of 2 lane road are planned for bid award in May 2009, with the widening to 4 lanes planned for September 2011. Ideally, this segment of pipe should be installed prior to the widening to facilitate construction and minimize disruptions. The possibility of including this segment of pipe with the roadway widening project should be considered if possible.

4.2.2.3 Environmental Impacts

The Single Plant Alternative includes a treatment facility located on the northern end of the project area south of the Lake Conroe Dam and the headwaters of the West Fork of the San Jacinto River (WFSJR). Transmission lines extend to the east and west of the treatment plant site. This alternative includes a treatment site (#1) and water transmission lines.

Archeological site records indicated a concentration of resources near Lake Creek where the proposed transmission line for the Single Plant Alternative traverses the creek. Record #100 was the closest site to the proposed alignment and may be impacted. An investigation was preformed under Texas Antiquities Permit #2979 of Record #100 (previously recorded Site 41MQ100) in 2004 in association with the Fish Creek Thoroughfare expansion project. The portion of this site (Record #100) located within the Fish Creek Thoroughfare right-of-way was shovel tested and appeared to have been impacted by previous construction activities. All artifacts were non-diagnostic, and therefore noted in the field and left in place. However, much of the site appears to be intact and located east of the Fish Creek Thoroughfare right-of-way on private property, therefore no shovel tests were preformed within this portion of the site. In this investigation, the archeologist recommended that no further work would be required on the portion of the site located within the Fish Creek Thoroughfare right-of-way. A field visit is recommended to determine the extent of impacts to this site and if additional archeological work would be necessary. Coordination with the THC is also recommended.

One cemetery was located in the vicinity of the common transmission line for the Single and Dual Plant Alternatives. Garden Park Cemetery is located near the northeast intersection of SH 45 and FM 3083 (Teas Road). The cemetery is approximately 1.3 acres and is owned by Cashner Funeral Home and Cemeteries in Conroe, Texas. The water transmission lines for both alternatives travel along the north side of FM 3083 and potentially encroach on the existing cemetery which has burial sites as close as 62 feet from the edge of pavement. Further analysis is recommended to determine impacts to the property. Consideration for shifting the alignment south or to the opposite side of the road may eliminate impacts to burial sites. Coordination is recommended with the property owner and THC.

Refer to the table below for a list of pipelines crossed by the Single Plant alternative. A concentration of crossings occurs in the City of Oak Ridge North where the water transmission lines for both alternatives are located. Approximately 1.5 miles of the water transmission line for the Single Plant Alternative between Gosling Road and College Park Drive follows a corridor containing the BP Pipelines and Magellan Pipeline Company pipelines. Depending on the proposed construction method for the water transmission lines, no interference may occur if the lines are constructed by tunneling around existing pipelines and the appropriate coordination is conducted. Once the alignments are finalized, further research is recommended to confirm pipeline location, their ownership, and any easements associated with each line.

Table 53 Pipeline Crossings

Pipelines	Single Plant
Koch Pipeline	1
Valero Logistics	1
Acacia Natural Gas	2
Trunkline Gas	1
Copano Pipeline/GP Gulf Coast	
Houston Pipeline	
Gulf South Pipeline	
Teppco Crude Pipeline	1
Exxon Mobil Pipeline	
Genesis Pipeline Texas	
BP Pipelines	1
Magellan	
Tennessee Gas Pipelines	
Kinder Morgan Texas Pipeline	

Source: Railroad Commission of Texas, 2005.

Travis Intermediate School and Pathways School are in the Conroe Independent School District (ISD) and are located directly west of the proposed water transmission lines for both alternatives. The schools are on the opposite side of North Pacific Street from the lines off of West Austin Street. No impact is anticipated to these schools.

Houser Elementary is also in the Conroe ISD and is located in Oak Ridge. The proposed water transmission lines for both alternatives border the western edge of the school's campus. Coordination with the City of Conroe and the Conroe ISD is recommended as the project design progresses and alignments are finalized to determine construction impacts to the Houser Elementary Campus.

Bear Branch Junior High is located west of FM 2978 on Oil Field Road in Magnolia. The school is in Magnolia ISD. The proposed water transmission lines for both alternatives are adjacent to the western border of the Bear Branch Junior High campus. Potential impacts to the property may occur and coordination with the Magnolia ISD and Bear Branch Junior High is recommended.

The proposed transmission lines for both alternatives are adjacent to Oak Ridge High School and CD York Junior high in Oak Ridge. Both schools are in the Conroe ISD. Potential impacts to CD York Junior High may occur along the northern and eastern ends of property where the transmission lines travel along Oak Ridge School Road.

The water transmission line for the Single Plant Alternative has 34 stream intersections (one tributary of Lake Creek, one on Fish Creek, one on Base Creek, two on unnamed tributaries draining into Lake Conroe, two on Bear Branch, one on Carters Slough, two on Nickaburr Branch, two on Panther Branch, one on Sam Bell Gully, one on a tributary of Dry Creek, two on unnamed tributaries into Foley Lake, ten on tributaries of Panther Branch, one on a tributary of Spring Creek, one tributary of Stone Branch, one on a tributary of the West Fork of the San Jacinto River, three on tributaries of White Oak Creek and one on

White Oak Creek). The water transmission lines that are common to both the Single and Dual Plant Alternatives include 29 of the stream intersections mentioned above.

A portion of the proposed treatment plant (#1) for the Single Plant Alternative is located in an area mapped as wetlands. Throughout the project area wetlands are present and segments of the proposed water transmission lines cross these wetlands. Through initial desktop research of the proposed project an area of potential impact in acreage by the water transmission lines was estimated by establishing a 20' buffer along the proposed lines. Approximately 9.09 acres of wetlands are impacted by the Single Plant Alternative.

The treatment plant site (#1) for both alternatives is located near the Conroe Dam and the beginning of the impaired segment of the WFSJR. The intake site for the Dual Plant Alternative is located on an impaired area of the WFSJR as well. The water transmission line for the Single Plant Alternative crosses the impaired segment of the WFSJR.

The water transmission line for the Dual Plant Alternative travels along and intersects the impaired portion of Panther Branch where it parallels FM 242 (College Park Drive). The water transmission lines for both the Single and Dual Plant Alternatives cross the impaired portion of Panther Branch west of the community of Shenandoah.

Water transmission lines for both the Single and Dual Plant Alternatives cross tributaries to Spring Creek. However, these intersections occur more than two miles upstream from the creek.

The proposed water treatment facilities, intake facility, and many segments of the water transmission lines are located in existing floodplains mapped as Zone A or AE by the Federal Emergency Management Agency (FEMA) on the Flood Insurance Rate Maps (FIRM). Construction and modification of these floodplains may require coordination with the local Montgomery County Floodplain Administrator.

One superfund site, United Creosoting, is located directly adjacent to the proposed transmission lines for both the Single and Dual Plant Alternatives. Refer to the Environmental Constraints Map in *Appendix J* for the location of this site. The site is on the west side of North First Street, near the intersection of Hilbig Road in the City of Conroe. The site is under the EPA Region 6 Office and is approximately 100 acres. The TCEQ is the lead for operations and maintenance of the ground water monitoring system and the EPA completed a second Five-Year Review in September 2005. A summary of the site's description, status, and detailed location map can be found in *Appendix K.* A visual reconnaissance of the project limits is recommended to confirm the location of the listed regulatory facilities; look for evidence of underground or aboveground storage tanks; and look for ground stains or other indications that contaminated soils occur within the project.

4.2.3 Capital Costs

For the single plant option, the water treatment plant and the pipeline are the primary facilities to be constructed. Probable construction costs for the single-plant option are shown in *Table 54*. A total of \$0.5M (\$0.4M capital cost plus 25% contingency) connection cost per delivery point is added to the capital costs. This will cover disinfection, additional pumping capacity, tank modifications, additional piping, etc. See *Appendix G* for detailed capital cost development.

Table 54 Single Plant Option – Probable Construction Costs

Phase (Year) **Construction Improvement**	**I (2015)** *(Million $)*	**II (2025)** *(Million $)*	**III (2035)** *(Million $)*	**IV (2045)** *(Million $)*
Pipeline [2]	$216	$0	$57	$52
Plant [3]	$62	$62	$62	$62
Delivery Point Cost [4]	$12	$0	$8	$4
TOTAL	**$290**	**$62**	**$127**	**$118**

[1] Values as of January 2008. [2] Pipeline cost includes 25% Contingency. [3] Plant cost includes 35% Contingency. [4] Delivery point cost comprises $0.5M ($0.4M capital cost plus 25% contingency) connection cost per delivery point.

The total project capital cost includes not just the probable construction costs, but all of the other "soft" costs for services and land to allow the construction to occur. Project engineering, program management, environmental studies and mitigation, construction management, financial, and legal services are all required to implement the construction project. Easements and surveying must be performed so that land can be obtained for installation of the facilities. The capital costs in January 2008 dollars, shown in *Table 55*, do not include any financing costs related to the project. The capital costs in future dollars for the single plant option are shown in *Table 56*.

Table 55 Single Plant Option – Probable Capital Costs in 2008 Dollars

Phase (Year) **Capital Improvements**	**I (2015)** *(Million $)*	**II (2025)** *(Million $)*	**III (2035)** *(Million $)*	**IV (2045)** *(Million $)*
Construction (Capital) Costs	$290	$62	$127	$118
Engineering, Financial, & Legal [2]	$87	$19	$38	$36
Land & Easements	$8	$0	$6	$5
TOTAL	**$385**	**$81**	**$171**	**$159**

[1] Values as of January 2008.
[2] Engineering, Financial, & Legal Services (30% of probable construction costs which include the following: Engineering 10%, Program Management 3%, Environmental Studies and Mitigation 5%, Surveying 1%, Construction Management 6%, Financial 3% and Legal 2%.).

Table 56 Single Plant Option – Probable Capital Costs in Future Dollars

Phase (Year) **Capital Improvements**	**I (2015)** *(Million $)*	**II (2025)** *(Million $)*	**III (2035)** *(Million $)*	**IV (2045)** *(Million $)*
Construction (Capital) Costs	$408	$142	$472	$718
Engineering, Financial, & Legal [2]	$123	$43	$142	$216
Land & Easements	$11	$0	$23	$31
TOTAL	**$542**	**$185**	**$637**	**$964**

[1] Values as of the year cost will incur computed at a 5% annual inflation rate.
[2] Engineering, Financial, & Legal Services (30% of probable construction costs which include the following: Engineering 10%, Program Management 3%, Environmental Studies and Mitigation 5%, Surveying 1%, Construction Management 6%, Financial 3% and Legal 2%.).

4.2.4 Annual Costs

Annual costs are a sum of the cost to repay the construction loan debt (debt service) and the operations & maintenance (O&M) cost of the system. Debt service constitutes the majority of the annual cost and is dependent on the interest rate and the funding mechanism. The O&M costs, shown in *Table 57*, consist of consumables, chemical, and supplies, pumping energy costs, labor, and sludge hauling and disposal. See *Appendix G* for detailed O&M cost development.

Table 57 Single Plant Option – Operations & Maintenance Costs

Phase (Year) **Operations & Maintenance Costs**	**I (2015)** *(Million $)*	**II (2025)** *(Million $)*	**III (2035)** *(Million $)*	**IV (2045)** *(Million $)*
Pipeline [2]	$2.2	$2.2	$2.8	$3.3
Plant [3]	$5.1	$9.1	$12.8	$17.3
TOTAL	**$7.3**	**$11.4**	**$15.7**	**$20.7**

[1] Values as of January 2008. [2] Pipeline O&M (1% Pipeline construction costs). [3] Plant O&M costs based on prior experience.

The annual costs, including debt service and raw water purchase, are shown below in *Table 58*. The cost of raw water, $137/ac-ft, assumes the water in Lake Conroe is purchased from the City of Houston. If SJRA is required to import the water from another basin, the raw water cost can increase significantly.

Table 58 Single Plant Option – Annual Costs

Phase (Year) **Annual Costs**	**I (2015)** *(Million $)*	**II (2025)** *(Million $)*	**III (2035)** *(Million $)*	**IV (2045)** *(Million $)*
Debt Service	$33.6	$40.7	$22.0	$28.8
Operations & Maintenance	$7.3	$11.4	$15.7	$20.7
Raw Water Purchase	$3.5	$6.9	$10.3	$13.7
TOTAL	**$44.4**	**$59.0**	**$48.0**	**$63.2**

[1] Values as of January 2008.

4.2.5 Annual Water Rates

Alternate financing mechanisms were analyzed for the single plant alternative and the anticipated water rates necessary to support the operation and debt service requirements. In all alternative scenarios, it is assumed that engineering/legal services and land purchases must begin six years prior to the operational date of each respective phase. Construction is assumed to begin three years prior to the operational date of each phase. An inflation rate of 5% per year is also factored into the rate assumptions. Rates are adjusted every five years and groundwater pumping fees are assumed to be $0.40 less than the rate for wholesale surface water. The $0.40 differential between groundwater and surface water rates accounts for the operation and maintenance cost that groundwater providers must continue to bear, and is intended to equalize costs. Because of the lack of an initial revenue stream from sale of surface water, no financing scenarios were modeled without an additional revenue source sufficient to cover the debt service until revenues from the sale of surface water are available. For the purposes of this exercise, the additional revenues are assumed to be from pumping fees placed on municipal groundwater users throughout Montgomery County. Alternative sources of additional revenue would affect the projected rate in some manner. Four bond issues, covering the cost of each of the operational phases, were contemplated to cover the capital expenses of engineering/legal services, land acquisition and construction.

Initial analysis was performed using 20 year conventional municipal bond financing at 6% interest. This is the most conservative case and requires the highest level of funding of all of the alternatives to meet operating and debt service requirements. To supply the debt service requirements, an initial groundwater pumping fee of $1.06 would be necessary starting in 2009, which would provide the entire revenue stream until the sale of surface water begins in 2015. A compilation of ground and surface water rates necessary to meet expenses as well as maintain minimal reserves under this scenario are listed in *Table 59*.

Table 59 Single Plant System Rates for Conventional 20 Year Municipal Financing

Year	Groundwater		Surface Water	
	Demand (mgd)	Anticipated Rate ($/1,000 gal)	Demand (mgd)	Anticipated Rate ($/1,000 gal)
2009	59.6	1.62		
2015	49.3	1.77	21.0	2.17
2020	59.7	2.12	21.0	2.52
2025	48.6	2.66	41.0	3.06
2030	58.5	3.76	41.0	4.16
2035	48.0	5.10	61.0	5.50
2040	58.6	6.69	61.0	7.09
2045	46.7	8.18	86.0	8.58
2050	60.8	9.02	86.0	9.42
2055	76.1	10.17	86.0	10.57

Rates are in future dollars at a 5% annual inflation Rate

Conventional 30 year financing at a reduced interest rate of 5% would moderate the initial rates down about 30%. Under this scenario, the requirement to obtain initial revenues from groundwater pumping fees, or some other source would still be necessary to meet the revenue stream requirements. In the long run, the rates would actually increase due to longer term of the financing.

An advantageous initial financing option for the single plant option would be through utilization of the “deferred” Water Infrastructure Fund (WIF) loan program offered by the TWDB. This funding option allows the utility to defer both principal and interest payments for a period of up to ten years or through completion of construction, whichever is sooner for all of the costs associated with Engineering and legal services only. By deferring the payment, a significantly smaller revenue stream is needed from the groundwater pumping fee or other revenue source before surface water sale begins. An example scenario using an initial $0.40/1,000 gal groundwater pumping fee results in rates depicted in *Table 60*. This scenario utilizes the WIF with a six year deferment for the initial engineering and legal services for Phase I, a WIF 20 year loan at 3% for the Phase I construction activities and for the remaining phases. This allows for meeting all projected debt service and operations. While reducing the initial costs, those costs are only deferred, not avoided. Thus, when deferred payments come due, they actually become due at a higher cost than the annual debt service for a comparable non-deferred WIF loan.

Table 60 Single Plant System Rates: Water Infrastructure Fund Financing

Year	Groundwater		Surface Water	
	Demand (mgd)	Anticipated Rate ($/1,000 gal)	Demand (mgd)	Anticipated Rate ($/1,000 gal)
2009	59.6	0.58		
2015	49.3	1.74	21.0	2.14
2020	59.7	1.95	21.0	2.35
2025	48.6	2.59	41.0	2.99
2030	58.5	3.94	41.0	4.34
2035	48.0	4.58	61.0	4.98
2040	58.6	6.22	61.0	6.62
2045	46.7	7.75	86.0	8.15
2050	60.8	8.83	86.0	9.23
2055	76.1	9.96	86.0	10.36

Rates are in future dollars at a 5% annual inflation Rate

Additional financing savings are available through utilization of the TWDB State Participation loan fund. Under this plan, the cost of the oversized transmission line can be "purchased" by the state until such time as the additional capacity is utilized by the water system. In this particular case, assuming that 25% of the cost of the phase I transmission line ($54,000,000) can be purchased by the state until the phase II plant expansion is put into place, would result in an initial cost savings. However, because the deferred interest would start becoming due in 2025, the rates would be increased starting in 2025 until all of the deferred interest is paid back. *Table 61* provides a projected rate scenario for the combination WIF and State Participation.

Table 61 Single Plant System Rates for Initial WIF Financing And State Participation

Year	Groundwater		Surface Water	
	Demand (mgd)	Anticipated Rate ($/1,000 gal)	Demand (mgd)	Anticipated Rate ($/1,000 gal)
2009	59.6	0.51		
2015	49.3	1.65	21.0	2.05
2020	59.7	1.93	21.0	2.33
2025	48.6	2.64	41.0	3.04
2030	58.5	3.95	41.0	4.35
2035	48.0	4.50	61.0	4.90
2040	58.6	5.23	61.0	5.63
2045	46.7	6.77	86.0	7.17
2050	60.8	7.95	86.0	8.35
2055	76.1	9.15	86.0	9.55

Rates are in future dollars at a 5% annual inflation Rate

4.2.6 Present Worth Value

The detailed rate analysis corresponding to the system rates in Table 59 is shown in Appendix H, Table H1. As Table H1 shows, the cash flow for this project is complex: multiple bonds are issued over the life of the project to finance infrastructure expansions; inflation is taken into account; rehabilitation costs are incurred; etc. To facilitate comparison with the dual plant alternative (Section 4.3), the Present Worth (PW) method is used to determine a single amount at the present (2008 dollars) that is equivalent to the project's cash flow pattern. Using the Total Operating Expenses in Table H1 and a discount rate of 6%, the PW of the single plant option is $1.81 Billion in 2008 dollars. PW calculations can be found in Appendix I.

4.3 Dual Plant Alternative

4.3.1 Water Treatment Plant

4.3.1.1 Proposed Capacity and Phasing

As previously discussed, an ultimate combined plant treatment capacity of 90 mgd is required. The dual plant option consists of a northern plant and a southern plant that each serve different demand regions with separate pipeline systems. The north and south area existing demands are different and will likely increase at different rates, requiring that the treatment capacities of the two plants be different initially and expanded at different rates. Four phases will be utilized at each plant.

The demands for the north and south regions of the system were estimated to increase as shown in *Table 62*.

Table 62 Dual Plant Treatment Demand by Plant and Phase

Phase (Year)	Anticipated System Demand (including losses)		
	North	South	Total
I (2015)	5.6 MGD	16.9 MGD	22.5 MGD
II (2025)	12.4 MGD	32.6 MGD	45 MGD
III (2035)	30 MGD	37.5 MGD	67.5 MGD
IV (2045)	48 MGD	42 MGD	90 MGD

Based on the estimated demand allocations, the phasing of the north and south treatment plants capacities was determined such that enough treatment capacity was available to meet the required demands.

Table 63 Dual Plant Treatment Capacity by Plant and Phase

Phase (Year)	Proposed Plant Treatment Capacity		
	North Plant	South Plant	Both Plants
I (2015)	6 MGD	18 MGD	24 MGD
II (2025)	12 MGD	30 MGD	42 MGD
III (2035)	30 MGD	36 MGD	66 MGD
IV (2045)	48 MGD	42 MGD	90 MGD

Minor variations between the demand and the treatment capacity may require that one additional treatment train being constructed in an earlier or later phase to correctly align with actual growth patterns. The relatively small train size (6 mgd) will allow adjustments to be made between phases as needed to account for demand growth as it actually occurs throughout the system.

The northern plant site at the Lake Conroe Dam would serve the City of Conroe and demands in the northern service area of the system. Four phases that provide 6 mgd in each of the first two phases and 18 mgd in each of the second two phases would satisfy the required demands. *Table 64* below shows how eight 6 mgd trains would meet the anticipated demands.

Table 64 Dual Plant Treatment Capacity by Phase – North Plant

Phase	Added Capacity per Phase	Total Plant Capacity
I (2015)	6 MGD (1 train @ 6 MGD)	6 MGD (1 train @ 6 MGD)
II (2020)	6 MGD (1 train @ 6 MGD)	12 MGD (2 trains @ 6 MGD)
III (2030)	18 MGD (3 trains @ 6 MGD)	30 MGD (5 trains @ 6 MGD)
IV (2040)	18 MGD (3 trains @ 6 MGD)	48 MGD (8 trains @ 6 MGD)

The southern plant site is located near the significant demand center at The Woodlands and would serve The Woodlands and immediately surrounding areas. Four phases that provide 18 mgd in the first phase, 12 mgd in the second phase, and 6 mgd in each of the last two phases would satisfy the required demands. Table 65 below shows how seven 6 mgd trains would meet the anticipated demands.

Table 65 Dual Plant Treatment Capacity by Phase – South Plant

Phase	Added Capacity per Phase	Total Plant Capacity
I (2015)	18 MGD (3 trains @ 6 MGD)	18 MGD (3 trains @ 6 MGD)
II (2025)	12 MGD (2 trains @ 6 MGD)	30 MGD (5 trains @ 6 MGD)
III (2035)	6 MGD (1 train @ 6 MGD)	36 MGD (6 trains @ 6 MGD)
IV (2045)	6 MGD (1 train @ 6 MGD)	42 MGD (7 trains @ 6 MGD)

The combined capacities of the two plants as installed in each phase are summarized in *Table 66*.

Table 66 Dual Plant Treatment Capacity by Phase – Both Plants Combined

Phase	Added Capacity per Phase	Combined Plant Capacity
I (2015)	24 MGD (4 trains @ 6 MGD)	24 MGD (4 trains @ 6 MGD)
II (2025)	18 MGD (3 trains @ 6 MGD)	42 MGD (7 trains @ 6 MGD)
III (2035)	24 MGD (4 train @ 6 MGD)	66 MGD (11 trains @ 6 MGD)
IV (2045)	24 MGD (4 train @ 6 MGD)	90 MGD (15 trains @ 6 MGD)

4.3.1.2 Site Assessment

Both of the two Lake Conroe dam sites, shown in *Exhibit 22*, were evaluated as possible locations for the North Plant in the Dual Plant Option. A minimum of 30 acres of site was determined to be necessary to accommodate the planned 48 mgd plant. The useable area (28 acres) of the East Site was not considered to be adequate, especially given the triangular shape of the parcel. The West Site is the recommended north plant site for both planning alternatives. The proposed layout of the north plant on the West Site is shown in *Exhibit 16* through *Exhibit 18*.

A single site, shown in *Exhibit 24*, was evaluated for the proposed South Plant, near the confluence of Lake Creek and the West Fork of the San Jacinto River. This site was found to be adequate to accommodate the proposed south plant, including room for the proposed forebays. The proposed layout of the south plant on the site is shown in *Exhibit 19* through *Exhibit 21*. Only one site was evaluated due to the limited amount of available, undeveloped land near the West Fork of the San Jacinto River that is partially outside the floodway and the 100-year floodplain. The site must also be near the proposed alignment and existing facilities to be served, as well as large enough to accommodate the large 80-acre proposed plant site. Given these criteria, only one potential site was identified for consideration.

4.3.1.3 Site Specific Design Considerations

4.3.1.3.1 North Plant

The same design considerations that were discussed in Section 4.2.1.3, for the Single Plant alternative, will apply to the northern plant for the Dual Plant alternative. The actual constraints presented by the floodplain at the west edge of the useable property need to be further evaluated. Geotechnical and structural analysis is needed to determine what constraints are needed for a water treatment plant constructed downstream and adjacent to a major dam. A raw water intake, which may require a crossing through the dam, will be needed to draw water into the plant from the lake by gravity and by pumping when low lake levels may occur. Additional land is recommended to allow greater flexibility in the design layout, room to allow plant buffers, ability to mitigate the impact on the dam of deeper filter structures at the lower end of the property, ability to mitigate the steep contours, and allowing additional space for potential future use. Acquiring additional property is not as significant a consideration for the 48 mgd (Dual Plant alternative) plant as it is for the 90 mgd (Single Plant alternative) plant.

4.3.1.3.2 South River Intake Pump Station

The south plant will require a river intake pumping station to be constructed on the West Fork of the San Jacinto River. This stretch of the river is very shallow with minimal flows during normal conditions. A USGS monitoring station 08068000 indicates that the flow is typically 2 to 4 feet deep with average flows ranging up to 600 mgd. The City of Conroe Wastewater Treatment Plant, located at 2400 Sgt. Ed Holcomb Blvd, is located directly east and just north of the proposed south plant site. This plant is currently permitted by the TCEQ for a daily flow of 10 mgd. The proposed river intake pump station is recommended to be constructed upstream of this wastewater treatment plant in order to avoid receiving treated effluent discharges from the plant.

Construction of some form of impoundment or dam may be necessary in order to ensure that water levels are deep enough at the river intake structure to allow water to be pumped at the required rates at all times. Such an impoundment could potentially be temporary, such as an inflatable dam, to minimize impacts to the river and surrounding floodplain. However, such an impoundment would cause some level of modification to the natural course of the river and should be carefully considered along with any required permitting requirements prior to implementation.

The river intake pump station itself would be a relatively simple structure that consists of separate intake channels with mechanical screens or trash racks to keep river debris out of the channels. Vertical pumps are likely the best alternative to keep the motors and electrical components up out of the floodplain. The pumps would pump the water 0.7 mile through a pipeline to raise it some 30 feet into the forebays.

4.3.1.3.3 South Multiple Low Service Pumping Stations

The south plant site will require multiple low service pump stations to operate continuously in order to supply water due to the required configuration of the site.

Initially, water must be pumped from the river to the forebays. Gravity flow from the river to the forebays is not feasible since the elevation of the available plant site is approximately 30 feet higher than the river water surface.

After settling in the forebays, water would need to be pumped to the head of the plant. While it is potentially feasible to construct the forebays south of the plant at a higher elevation to allow for gravity flow into the plant, the entire south plant site would have to be moved much further to the south to keep the plant out of the 100-year floodplain. Such a move would push the forebays toward the top of the hill and into much steeper terrain which would result in much higher forebay construction costs. To facilitate forebay construction and keep the plant as close to the river intake station, pumping is required to move water from the forebays to the head of the plant.

Water must also be pumped to the 35-feet tall ground storage tanks after passing through the filters. Finally, a high service pump station is needed to pump water from the ground storage tanks to the pipeline distribution system. Both of these final two steps are typical and will be required at the north plant alternatives as well. However, the two low service pump stations that must be operated continuously to move water from the river into the plant will be costly to maintain and operate.

4.3.1.3.4 South Forebays

The layout of the two required forebays is discussed in the previous section. These forebays are necessary to equalize the water coming into the plant and reduce the high concentration of suspended solids that is expected in the normal river flows. A recommended detention time of 3 days is recommended at this conceptual level. A smaller forebay may be found to be acceptable, based on the treatability studies. Each forebay would hold approximately 126 million gallons (MG) if constructed 15 feet deep with a 10 feet side-water-depth (SWD). The required surface area of each forebay would be approximately 19.4 acres, or 38.7 acres total. Deeper forebay construction is possible in order to reduce the required footprint size, but would likely be more expensive to construct. Construction so that the tops of the perimeter slopes are above the 100-year floodplain is recommended to keep floodwaters from affecting the water quality. A substantial network of ponds, which may be abandoned sand-mining pits, is visible from the aerial photos immediately to the east of the site. Further investigation into this area should be provided as this area could potentially be modified to serve part of the forebay requirements.

4.3.1.3.5 Access

The south plant site is not easily accessible. The roadway to the east of the plant is blocked by a gate and signage indicates that the road is a private driveway to the east of the intersection of Old Smith Road and Old Conroe/Magnolia Road. Old Smith Road / Park Avenue provide public access to the west side of the plant. Park Avenue is a small residential road that does not appear to be well suited for high levels of truck and heavy machinery traffic. The site itself is almost entirely covered with trees.

4.3.1.3.6 Geotechnical and Structural Analysis

The topography consists of a high elevation of 200 feet at the top of a hill located near and along Park Avenue to the southwest of the site. Lake Creek flows at near elevation 115 feet at the north edge of the site. Geotechnical and structural analysis is recommended to determine what vertical arrangement of the plant components can be accommodated. Construction of the forebays to avoid flooding will require a balanced cut and fill to allow construction inside the 100-year floodplain. Slope stability and retaining wall analysis will likely be required to determine what layouts can be accommodated at this site.

4.3.1.3.7 Land Acquisition

As illustrated in *Exhibit 18*, the Montgomery County Appraisal District records show no recorded property ownership tracts in an approximately 1,700 acre area between existing subdivisions. The proposed site is located within this 1,700 acre area in a location with no apparent residential development on it. The actual property ownership needs to be researched to determine if this 80 acre portion of the property can be obtained and who the legal owner of the existing property is. A large number of trailer homes and other buildings are in place along the east side of Park Avenue without any clear property lines or fences being visible. More substantial stock ponds and buildings are visible on the west side of Park Avenue, but no clear fences or property lines are visible on this side of the road. The property to the east of the site that has a gated private driveway does not show up as a recorded tract in appraisal district records. An abstract/title search is recommended to verify the issues associated with obtaining the property, should this alternative be considered further.

4.3.2 Proposed Alignments

4.3.2.1 Right of Way Issues

The right-of-way issues that the revised alignment corridor faces were discussed in Section 3.2.2.2. The Dual Plant alternative utilizes all of the proposed alignment corridor except for the Lake West (1) segment, the Fish Creek Thoroughfare North (2) segment, the Bear Branch Reservoir (7) / Research Forest West (7A) segment, the Kuykendahl (8) segment, and the Lakeland West (10) segment.

4.3.2.2 Conflict Identification

Table 67 below summarizes the major potential conflicts for the Dual Plant pipeline alignment. A discussion of the potential conflicts associated with the proposed alignments of both alternatives is discussed in Section 4.2.2.2 above. Since the common issues have been discussed, the issues associated only with the Dual Plant alternative are discussed in additional detail after *Table 67*. Each potential conflict is marked in bold letters to facilitate identifying the discussion.

Table 67 Dual Plant Option – Potential Conflicts

Potential Conflicts	Description	Affected Planning Alternative
Alden Bridge Park	A residential park, with a large lake, 36'x48' pavilion/ gazebo, swimming pool, playground, and other amenities. Located at Alden Bridge Road and Drainage Easement.	Dual Plant
Riding & Nature Trail (Sendera-Conroe)	Proposed alignment between residential lots coincides with horse riding and nature trail. Potential resistance from surrounding homeowners to construction in this corridor.	Dual Plant
Lake Creek	Lake Creek is a relatively small creek with a flat, wide floodplain that does not drain well, resulting in a wide area of boggy land that could present constructability issues.	Both Alternatives
Robinson Road	Robinson Road is a narrow roadway with utilities through a residential area with homes and businesses on either side. This road is planned to be widened to 4 lanes in 2018.	Both Alternatives
Montgomery Co. MUD Drainage Ditches (Woodlands area)	The drainage ditches near Grogan's Mill and Sawmill Road often have narrow top banks and varying sections. Ditches have many curves and bridge/roadway crossings.	Both Alternatives
South IH-45 Crossing (Sawdust/Rayford)	Required IH-45 crossing location is heavily built out and congested with many utilities and limited ROW. This will likely be the most difficult segment to construct.	Both Alternatives
Longmire Road	Narrow 2 lane road has residential and businesses at edge of right-of-way line and several utilities. Road is planned for widening to 4 lanes in 2023.	Both Alternatives
FM 3083 Bottleneck (east of IH-45 feeder)	Immediately east of the IH-45 frontage road, a cemetery/funeral home is located north of the ROW and a gas station located low with a retaining wall is to south. Limited room outside ROW.	Both Alternatives
N. 1st Street N. Pacific Street	This north-south route to downtown Conroe is directly adjacent to the Union Pacific Railroad. Homes and businesses are on ROW lines both sides of RR/street ROW.	Both Alternatives
Kuykendahl Road	Kuykendahl Road is currently only constructed with 2 lanes on the west side, making construction along the east side of ROW relatively easy. Widening to 4 lanes is planned for 09/2011.	Both Alternatives

Alden Bridge Park is a park that is located on the existing creek greenbelt/drainage easement under the Alden Bridge Road bridge. The park consists of a large lake surrounded by paved walking trails, a 36'x48' pavilion under a gazebo, sport fields, tennis courts, fishing, playground, swimming pool, and a parking lot with 77 parking spaces. The park extends under the bridge at Alden Bridge Road and spreads out to the north and south of the bridge, across the width of the drainage easement. Installation of a pipeline through this park is anticipated to be very disruptive and may encounter resistance from local residents. An alternative alignment is recommended that runs north along Kuykendahl Road, turns east on private property just south of FM 1488, and connects to the dual plant alignment at the transmission easement.

This Kuykendahl Road alignment would provide an alternative to using the drainage easement from Kuykendahl Road to Greenbridge Drive. The alternative would allow Alden Bridge Park and the surrounding area to be avoided.

A horse riding and nature trail currently exists along a significant portion of the **Sendera-Conroe** segment in the vicinity of Cattle Drive and Windcrest Drive. This riding and nature area is a cleared dirt trail, roughly 20 feet wide, that is located immediately adjacent to the east-west property fenceline. The deep residential lots have dense trees and vegetation. Markers are located at the roadway crossings. While this trail would make a good access area for constructing and maintaining the pipeline, construction of a waterline on this nature and riding trail would cause disruptions that could encounter local homeowner resistance. Close communication and coordination with the local homeowners to provide trail extensions and improvements as part of the pipeline construction could help address this potential conflict.

Lake Creek was discussed previously as a common issue to both alignments. For the Single Plant alternative, the construction of the raised Fish Creek Thoroughfare will help address the constructability and access issues that Lake Creek's boggy floodplain area presents. For the Dual Plant alternative, the proposed alignment would cross Lake Creek and the adjacent West Fork of the San Jacinto River in a different location from the Single Plant alternative. This area is also very flat and subject to flooding and will likely encounter constructability and maintenance access issues. Fish Creek Thoroughfare will offer no improvements in this area. Fortunately, the length of alignment in this area is limited (0.7 miles), but construction and O&M costs are likely to be higher in this segment as a result.

4.3.2.3 Environmental Impacts

The Dual Plant Alternative includes a second treatment plant site (#2) which is located near Lake Creek close to its confluence with the West Fork of the San Jacinto River (WFSJR). The Dual Plant Alternative includes an intake facility on the WFSJR and a water transmission line that crosses Lake Creek to connect to the treatment plant (#2). The water transmission line extends from the plant south and then east and west. The Dual Plant Alternative includes treatment plant (#1), treatment plant (#2), an intake site for treatment plant (#2), and the water transmission lines.

One cemetery was located in the vicinity of the common transmission line for the Single and Dual Plant Alternatives. Garden Park Cemetery is located near the northeast intersection of SH 45 and FM 3083 (Teas Road). The cemetery is approximately 1.3 acres and is owned by Cashner Funeral Home and Cemeteries in Conroe, Texas. The water transmission lines for both alternatives travel along the north side of FM 3083 and potentially encroach on the existing cemetery which has burial sites as close as 62 feet from the edge of pavement. Further analysis is recommended to determine impacts to the property. Consideration for shifting the alignment south or to the opposite side of the road may eliminate impacts to burials sights. Coordination is recommended with the property owner and THC.

Refer to the *Table 68* below for a list of pipelines crossed by the Dual Plant alternative. A concentration of crossings occurs in the City of Oak Ridge North where the water transmission lines for both alternatives are located. Approximately one mile of the Dual Plant Alternative south of Gosling Road in the Woodlands follows a corridor containing the BP Pipelines and Magellan Pipeline Company pipelines. Depending on the proposed construction method for the water transmission lines, no interference may occur if the lines are constructed by tunneling around existing pipelines and the appropriate coordination is conducted. Once the alignments are finalized, further research is recommended to confirm pipeline location, their ownership, and any easements associated with each line.

Table 68 Pipeline Crossings

Pipelines	Dual Plant
Koch Pipeline	
Valero Logistics	
Acacia Natural Gas	
Trunkline Gas	
Copano Pipeline/GP Gulf Coast	3
Houston Pipeline	1
Gulf South Pipeline	3
Teppco Crude Pipeline	3
Exxon Mobil Pipeline	8
Genesis Pipeline Texas	3
BP Pipelines	9
Magellan	1
Tennessee Gas Pipelines	2
Kinder Morgan Texas Pipeline	1

Source: Railroad Commission of Texas, 2005.

Travis Intermediate School and Pathways are in the Conroe Independent School District and are located directly west of the proposed water transmission lines for both alternatives. The schools are on the opposite side of North Pacific Street from the lines off of West Austin Street. No impact is anticipated to these schools.

Houser Elementary is also in the Conroe ISD and is located in Oak Ridge. The proposed water transmission lines for both alternatives border the western edge of the school's campus. Coordination with the City of Conroe and the Conroe ISD is recommended as the project design progresses and alignments are finalized to determine construction impacts to the Houser Elementary Campus.

Bear Branch Junior High is located west of FM 2978 on Oil Field Road in Magnolia. The school is in Magnolia ISD. The proposed water transmission lines for both alternatives are adjacent to the western border of the Bear Branch Junior High campus. Potential impacts to the property may occur and coordination with the Magnolia ISD and Bear Branch Junior High is recommended.

The proposed transmission lines for both alternatives are adjacent to Oak Ridge High School and CD York Junior high in Oak Ridge. Potential impacts to CD York Junior High may occur along the northern and eastern ends of property where the transmission lines travel along Oak Ridge School Road.

The water transmission line for the Dual Plant Alternative has 40 stream intersections (three on tributaries of Lake Creek, two on Bear Branch, one on Carters Slough, two on Nickaburr Branch, one on Sam Bell Gully, one on a tributary of Dry Creek, two on unnamed tributaries into Foley Lake, 11 on tributaries of Panther Branch, eight on Panther Branch, one on a tributary of Spring Creek, one tributary of Stone Branch, one on a tributary of the WFSJR, one on the WFSJR, three on tributaries of White Oak Creek and one on White Oak Creek). The water transmission lines that are common to both the Single and Dual Plant Alternatives include 29 of the stream intersections mentioned above.

The proposed intake site on the WFSJR for treatment plant (#2) for the Dual Plant Alternative is located in an area mapped as wetland. Throughout the project area wetlands are present and segments of the proposed water transmission lines cross these wetlands. Through initial desktop research of the proposed project an area of potential impact in acreage by the water transmission lines was estimated by establishing a 20' buffer along the proposed lines. Approximately seven acres of wetlands are impacted by the Dual Plant Alternative. The greatest concentrations of wetlands are mapped near the WFSJR, near Lake Conroe, and around Lake Creek.

The treatment plant site (#1) for both alternatives is located near the Conroe Dam and the beginning of the WFSJR in the impaired area. The intake site for the Dual Plant Alternative is also located on an impaired area of the WFSJR.

The water transmission line for the Dual Plant Alternative travels along and intersects Panther Branch where it parallels FM 242 (College Park Drive). The water transmission lines for both the Single and Dual Plant Alternatives cross Panther Branch west of the community of Shenandoah.

Water transmission lines for both the Single and Dual Plant Alternatives cross tributaries to Spring Creek. However, these intersections occur more than two miles upstream from the creek.

The proposed water treatment facilities, intake facility, and many segments of the water transmission lines are located in existing floodplains mapped as Zone A or AE by the Federal Emergency Management Agency (FEMA) on the Flood Insurance Rate Maps (FIRM). Construction and modification of these floodplains may require coordination with the local Montgomery County Floodplain Administrator.

One superfund site, United Creosoting, is located directly adjacent to the proposed transmission lines for both the Single and Dual Plant Alternatives. Refer to the Environmental Constraints Map in *Appendix J* for the location of this site. The site is on the west side of North First Street, near the intersection of Hilbig Road in the City of Conroe. The site is under the EPA Region 6 Office and is approximately 100 acres. The TCEQ is the lead for operations and maintenance of the ground water monitoring system and the EPA completed a second Five-Year Review in September 2005. A summary of the site's description, status, and detailed location map can be found in *Appendix K*. A visual reconnaissance of the project limits is recommended to confirm the location of the listed regulatory facilities; look for evidence of underground or aboveground storage tanks; and look for ground stains or other indications that contaminated soils occur within the project.

4.3.3 Capital Costs

Capital costs are generally known as construction costs. For the dual plant option, additional facilities are required beyond just the water treatment plants and the pipelines. The south plant requires the construction of dual forebays and a river intake pump station and pipeline to convey water from the river to the forebays. A total of $0.5M ($0.4M capital cost plus 25% contingency) connection cost per delivery point is added to the capital costs. This will cover disinfection, additional pumping capacity, tank modifications, additional piping, etc. Probable construction costs for the dual-plant option are shown in *Table 69*.

Table 69 Dual Plant Option – Probable Construction Costs

Phase (Year) **Construction Improvement**	**I (2015)** *(Million $)*	**II (2025)** *(Million $)*	**III (2035)** *(Million $)*	**IV (2045)** *(Million $)*
Pipeline [2]	$163	$0	$64	$52
Plants[3] & Other (Forebays[3], South River Intake Pump Station[3], South River Intake Pipeline[2])	$93	$65	$77	$77
Delivery Point Cost [4]	$12	$0	$8	$4
TOTAL	**$268**	**$65**	**$149**	**$133**

[1] Values as of January 2008. [2] Pipeline cost includes 25% Contingency.
[3] Water Treatment Plant, River Intake PS, Forebays cost includes 35% Contingency.
[4] Delivery point cost comprises $0.5M ($0.4M capital cost plus 25% contingency) connection cost per delivery point.

The total project capital costs, shown in *Table 70*, include not just the probable construction costs, but all of the other "soft" costs for services and land to allow the construction to occur. Project engineering, program management, environmental studies and mitigation, construction management, financial, and legal services are all required to implement the construction project. Easements and surveying must be performed so that land can be obtained for installation of the facilities. The capital costs in future dollars for the dual plant option are shown in *Table 71*.

Table 70 Dual Plant Option – Probable Capital Costs

Phase (Year) **Capital Costs**	**I (2015)** *(Million $)*	**II (2025)** *(Million $)*	**III (2035)** *(Million $)*	**IV (2045)** *(Million $)*
Construction (Capital) Costs	$268	$65	$149	$133
Engineering, Financial, & Legal [2]	$81	$20	$45	$40
Land & Easements	$11	$0	$6	$5
TOTAL	**$360**	**$85**	**$200**	**$178**

[1] Values as of January 2008.
[2] Engineering, Financial, & Legal Services (30% of probable construction costs which include the following: Engineering 10%, Program Management 3%, Environmental Studies and Mitigation 5%, Surveying 1%, Construction Management 6%, Financial 3% and Legal 2%.).

Table 71 Dual Plant Option – Probable Capital Costs in Future Dollars

Phase (Year) **Capital Improvements**	**I (2015)** *(Million $)*	**II (2025)** *(Million $)*	**III (2035)** *(Million $)*	**IV (2045)** *(Million $)*
Construction (Capital) Costs	$377	$149	$555	$809
Engineering, Financial, & Legal [2]	$114	$45	$167	$243
Land & Easements	$16	$0	$23	$31
TOTAL	**$507**	**$194**	**$744**	**$1,082**

[1] Values as of the year cost will incur computed at a 5% annual inflation rate.
[2] Engineering, Financial, & Legal Services (30% of probable construction costs which include the following: Engineering 10%, Program Management 3%, Environmental Studies and Mitigation 5%, Surveying 1%, Construction Management 6%, Financial 3% and Legal 2%.).

4.3.4 Annual Costs

Annual costs are a sum of the cost to repay the construction loan debt (debt service) and the operations & maintenance (O&M) cost of the system. Debt service constitutes the majority of the annual cost and is dependent on the interest rate and the funding mechanism. The O&M costs, shown in *Table 72*, consist of consumables, chemical, and supplies, pumping energy costs, labor, and sludge hauling and disposal.

Table 72 Dual Plant Option – Operations & Maintenance Costs

Phase (Year) **Operations & Maintenance Costs**	**I (2015)** *(Million $)*	**II (2025)** *(Million $)*	**III (2035)** *(Million $)*	**IV (2045)** *(Million $)*
Pipeline	$1.7	$1.7	$2.3	$2.8
Plants[5] & Other (Forebays[3], South River Intake Pump Station[4], South River Intake Pipeline[2])	$6.2	$9.7	$14.2	$18.7
TOTAL	**$7.9**	**$11.4**	**$16.5**	**$21.5**
[1] Values as of January 2008. [2] Pipeline O&M (1% Pipeline construction costs). [3] Forebay O&M (1.5% reservoir construction costs). [4] Intake Pump Station O&M (2.5% intake PS construction costs). [5] Plant O&M costs based on prior experience.				

The annual costs, including debt service and the purchase of raw water, are shown below in *Table 73*. The cost of raw water, $137/ac-ft, assumes the water in Lake Conroe is purchased from the City of Houston. If SJRA is required to import the water from another basin, the raw water cost can increase significantly.

Table 73 Dual Plant Option – Annual Costs

Phase (Year) **Annual Costs**	**I (2015)** *(Million $)*	**II (2025)** *(Million $)*	**III (2035)** *(Million $)*	**IV (2045)** *(Million $)*
Debt Service	$31.4	$38.9	$24.9	$33.0
Operations & Maintenance	$7.9	$11.4	$16.5	$21.5
Raw Water Purchase	$3.5	$6.9	$10.3	$13.7
TOTAL	**$42.8**	**$57.2**	**$51.7**	**$68.2**
[1] Values as of January 2008.				

4.3.5 Annual Water Rates

As with the single plant scenario, alternate financing mechanisms were analyzed for the dual plant alternative and the anticipated water rates necessary to support the operation and debt service requirements. In all dual plant alternative scenarios, it is assumed that engineering/legal services and land purchases must begin six years prior to the operational date of each respective phase. Construction is assumed to begin three yeas prior to the operational date of each phase. An inflation rate of 5% per year is also factored into the rate assumptions. Rates are adjusted every five years and groundwater pumping fees are assumed to be $0.40 less than the rate for wholesale surface water. The $0.40 differential between groundwater and surface water rates accounts for the operation and maintenance cost that groundwater providers must continue to bear, and is intended to equalize costs. Because of the lack of an initial revenue stream from sale of surface water, no financing scenarios were modeled without an additional revenue source sufficient to cover the debt service until revenues from the sale of surface water are available. For the purposes of this exercise, the additional revenues are assumed to be from pumping fees placed on municipal groundwater users throughout Montgomery County. Alternative sources of additional revenue would affect the projected rate in some manner. Four bond issues, covering the cost of each of the operational phases, were contemplated to cover the capital expenses of engineering/legal services, land acquisition and construction.

Initial analysis was performed using 20 year conventional municipal bond financing at 6% interest. This is the most conservative case and requires the highest level of funding of all of the alternatives to meet operating and debt service requirements. To supply the debt service requirements, an initial groundwater pumping fee of $1.06 would be necessary starting in 2009, which would provide the entire revenue stream until the sale of surface water begins in 2015. A compilation of ground and surface water rates necessary to meet expenses as well as maintain reserves under this scenario are listed in *Table 74*.

Table 74 Dual Plant System Rates for Conventional 20 Year Municipal Financing

Year	Groundwater		Surface Water	
	Demand (mgd)	Anticipated Rate ($/1,000 gal)	Demand (mgd)	Anticipated Rate ($/1,000 gal)
2009	59.6	1.51		
2015	49.3	1.73	21.0	2.13
2020	59.7	2.12	21.0	2.52
2025	48.6	2.66	41.0	3.06
2030	58.5	3.90	41.0	4.30
2035	48.0	5.31	61.0	5.71
2040	58.6	7.03	61.0	7.43
2045	46.7	8.49	86.0	8.89
2050	60.8	9.29	86.0	9.69
2055	76.1	10.47	86.0	10.87

Rates are in future dollars at a 5% annual inflation Rate

As this example demonstrates, the differential in rates needed to fund this scenario compared to the same type of funding for the single plant option, are noticeable, in the Range of $0.05 to $0.20 per 1,000 gal of water. This was found to be the same with all dual plant scenarios when compared to the single plant options.

The most advantageous initial financing for the dual plant option would be through utilization of the Water Infrastructure Fund (WIF) loan program offered by the TWDB. Unlike the single plant option, the dual plant alternative has no major capital expenditure where excess capacity of the constructed facility could be purchased by the state until needed. The WIF funding option allows the utility to defer both principal and interest payments for a period of up to ten years or through completion of construction, whichever is sooner for all of the costs associated with Engineering and legal services only. By deferring the payment under the WIF, a significantly smaller revenue stream is needed from the groundwater pumping fee or other revenue source before surface water sale begins. A compilation of ground and surface water rates necessary to meet expenses as well as maintain resources are listed in *Table 75*.

Table 75 Dual Plant System Rates for Water Infrastructure Fund Financing

Year	Groundwater		Surface Water	
	Demand (mgd)	Anticipated Rate ($/1,000 gal)	Demand (mgd)	Anticipated Rate ($/1,000 gal)
2009	59.6	0.56		
2015	49.3	1.70	21	2.10
2020	59.6	1.92	21	2.32
2025	48.6	2.58	41	2.98
2030	58.5	3.98	41	4.38
2035	48	4.78	61	5.18
2040	58.6	6.50	61	6.90
2045	46.7	7.99	86	8.39
2050	60.8	9.07	86	9.47
2055	76.1	10.24	86	10.64

Rates are in future dollars at a 5% annual inflation Rate

Additional financing savings are available through utilization of the TWDB State Participation loan fund. Under this plan, the cost of the oversized transmission line can be "purchased" by the state until such time as the additional capacity is utilized by the water system. In this particular case, assuming that 25% of the cost of the phase I transmission line ($40,750,000) can be purchased by the state until the phase II plant expansion is put into place, would result in an initial cost savings. However, because the deferred interest would start becoming due in 2025, the rates would be increased starting in 2025 until all of the deferred interest is paid back. *Table 76* provides a projected rate scenario for the combination WIF and State Participation.

Table 76 Dual Plant System Rates for Initial WIF Financing And State Participation

Year	Groundwater		Surface Water	
	Demand (mgd)	Anticipated Rate ($/1,000 gal)	Demand (mgd)	Anticipated Rate ($/1,000 gal)
2009	59.6	0.51		
2015	49.3	1.63	21.0	2.03
2020	59.7	1.91	21.0	2.31
2025	48.6	2.61	41.0	3.01
2030	58.5	4.02	41.0	4.42
2035	48.0	4.64	61.0	5.04
2040	58.6	5.37	61.0	5.77
2045	46.7	6.90	86.0	7.30
2050	60.8	8.09	86.0	8.49
2055	76.1	9.32	86.0	9.72

Rates are in future dollars at a 5% annual inflation Rate

4.3.6 Present Worth Value

The detailed rate analysis corresponding to the system rates in Table 74 is shown in Appendix H, Table H4. As Table H4 shows, the cash flow for this project is complex: multiple bonds are issued over the life of the project to finance infrastructure expansions; inflation is taken into account; rehabilitation costs are incurred; etc. To facilitate comparison with the single plant alternative (Section 4.2), the Present Worth (PW) method is used to determine a single amount at the present (2008 dollars) that is equivalent to the project's cash flow pattern. Using the Total Operating Expenses in Table H4 and a discount rate of 6%, the PW of the dual plant option is $1.84 Billion in 2008 dollars. PW calculations can be found in Appendix I.

Section 5 Comparison of Alternatives

5.1 Advantages and Disadvantages

5.1.1 Water Treatment Plant Locations

The Single Plant and Dual Plant both make use of the same "East Site" at the existing SJRA property on the south side of the Lake Conroe Dam, so there really is not a significant difference in the alternatives for the "North Plant" location. The primary difference in the alternatives is the presence or absence of the South Plant site. The advantages of the Dual Plant alternative are summarized in *Table 77*.

Table 77 Dual Plant Advantages

Issue	Description
North Plant Site	The smaller Dual Plant alternative North Plant is easier to accommodate on the existing site owned by SJRA than the Single Plant alternative plant.
Proximity to Woodlands	The South Plant provides treatment capacity closer to the Woodlands and allows water to be pumped a shorter distance to the demand locations.

The disadvantages of the Dual Plant alternative are summarized in *Table 78*.

Table 78 Dual Plant Disadvantages

Issue	Description
River Intake Pump Station	The South Plant requires a river intake pump station to be constructed on a very shallow stretch of the West Fork San Jacinto River. A dam may also be needed.
Dual Forebay	The South Plant requires dual forebays, requiring 40 acres, to match water quality from the North Plant site. Requires pumping from the forebays to the Plant.
Land Acquisition	The North Plant site is on existing SJRA property. The South Plant site (80 acres) is not. Ownership of the south site is unknown and may present acquisition issues.
Additional Operating Coordination	Releases from the dam, operation of the river intake pump station, and operation of the plant will need to be carefully coordinated to insure water is always available and not wasted downstream. The North and South Plants will have to be coordinated. Chemical stockpiles will have to be monitored at and delivered to two sites.
Demand Flexibility	The Single Plant can provide treatment capacity to any part of the pipeline system. The North Plant cannot feed the south pipeline, nor the South Plant the north pipeline.
Operations and Maintenance	The river intake pump station, forebays, forebay low service pump station, and multiple plants will require additional O&M costs to run.
Additional Staff	Two plants will require more staff to operate and maintain.

5.1.2 Proposed Alignment

The Single Plant and Dual Plant alternatives share much of the same alignment, but do have distinct differences in alignment in certain locations. The primary difference is that the Dual Plant alternative has two separate pipelines where the Single Plant alternative has only one. Additionally, the 55.8 miles of pipeline in the Single Plant alternative is roughly 5.8 miles more than the 50.0 miles of pipeline in the Dual Plant alternative. The additional pipeline is more expensive to install and maintain. However, differences in alignment result in different potential conflicts.

The advantages of the Dual Plant alternative pipeline alignment are summarized in *Table 79*.

Table 79 Dual Plant Pipeline Advantages

Issue	Description
Fish Creek Thoroughfare	The entire length of pipeline along the proposed Fish Creek Thoroughfare does not serve any existing facilities and is not required in the Two Plant alternative.
Cost	The Dual Plant alignment is 5.8 miles less than the Single Plant alignment. Less pipeline costs less to construct, operate, and maintain.

The disadvantages of the Dual Plant pipeline alignment are summarized in *Table 80*.

Table 80 Dual Plant Pipeline Disadvantages

Issue	Description
Riding and Nature Trail	The Sendera-Conroe segment is only required in the Dual Plant alternative. This segment is located on an existing nature and riding trail and could encounter resistance from local residents. No alternate alignment is readily available.
Woodlands Plant Segment	The Woodlands Plant segment, including the pipeline feeding water from the West Fork San Jacinto River across the problematic Lake Creek floodway to the South Plant forebays, is only required by the Dual Plant alternative.
Redundancy & Flexibility	The Dual Plant pipeline is not interconnected and therefore is less redundant and has less operational flexibility than the Single Plant pipeline.

5.1.3 Environmental and Historical

Many of the impacts associated with the Single Plant alternative as opposed to the Dual Plant alternative would be the same however there are some differences. The Single Plant alternative would not require the construction of two facilities in different locations nor would it require two intakes. However there are some advantages to the Dual Plant alternative.

The advantages of the Dual Plant alternative pipeline alignment are summarized in *Table 81*.

Table 81 Dual Plant Pipeline Advantages

Issue	Description
Water Crossings	The selection of the Dual Plant alternative would consist of 16 water crossings versus 20 intersections which would occur with selection of the Single Plant alternative. This would potentially reduce the amount of permitting required and would impact fewer natural resources.
Wetlands	The Dual Plant alternative would only impact approximately 7 acres of wetlands versus approximately 85 acres of wetlands associated with the Single Plant alternative. This would potentially reduce the amount of permitting required and would impact fewer natural resources.
Pipeline Crossings	The selection of the Dual Plant alternative would result in only 7 pipeline crossings versus 34 pipeline crossings associated with the single Plant alternative.

The disadvantages of the Dual Plant pipeline alignment are summarized in *Table 82*.

Table 82 Dual Plant Pipeline Disadvantages

Issue	Description
Treatment Plant Facilities	The selection of the Dual Plant alternative would require the construction of the two treatment plants and two intakes. This alternative would require construction activities to occur in two locations and place water intakes in two locations. Since the footprints of these facilities are rather large, building two different facilities could potentially impact more natural and cultural resources than would the selection of the Single Plant alternative.

5.1.4 Relationship and Opportunity to Serve Future Planned Development

The opportunity to serve future planned development associated with the Single Plant alternative as opposed to the Dual Plant alternative would be the same for all but the area just to the west and southwest of Conroe. The Single Plant alternative pipe alignment proposes to take the transmission line down the proposed Fish Creek Thoroughfare between Hwy 105 and Sendera Ranch Road. The proposed Fish Creek Thoroughfare is expected to provide the accessibility necessary to further develop that area. Access to the high capacity line provides a convenient mechanism for expanding developments to provide connecting lines to existing, expanding or new pumping facilities in that area. This section of transmission is not included in the Dual Plant alternative.

There are no advantages related to the Dual Plant alternative pipeline alignment in relation to the opportunity to serve future development. The disadvantages of the Dual Plant pipeline alignment are summarized in *Table 83*.

Table 83 Dual Plant Pipeline Disadvantages: Serving Future Development

Issue	Description
Fish Creek Thoroughfare	The pipeline along the proposed Fish Creek Thoroughfare is not required in the Dual Plant alternative and access to surface water connections for future developments in that area would more difficult than with the Single Plant alternative, if not impractical.

5.2 Comparison of Costs

Table 84 summarizes the construction costs of the two planning alternatives.

Table 84 Alternative Comparison – Probable Construction Costs

Phase (Year)	I (2015) *(Million $)*	II (2025) *(Million $)*	III (2035) *(Million $)*	IV (2045) *(Million $)*
Single Plant Alternative	$290	$62	$127	$118
Dual Plant Alternative	$268	$65	$149	$133
[1] *Values as of January 2008.*				

Table 85 summarizes the total project costs of the two planning alternatives in 2008 dollars. The Single Plant alternative is more expensive ($8M) to construct in 2015 than the Dual Plant alternative. However, the future Dual Plant phased expansions are expected to offset those savings and result in a significantly higher Dual Plant alternative total cost through 2045.

Table 85 Alternative Comparison – Probable Capital Costs

Phase (Year)	I (2015) *(Million $)*	II (2025) *(Million $)*	III (2035) *(Million $)*	IV (2045) *(Million $)*
Single Plant Alternative	$385	$81	$171	$159
Dual Plant Alternative	$360	$85	$200	$178
[1] *Values as of January 2008.*				

Table 86 summarizes the total project costs of the two planning alternatives in future dollars.

Table 86 Alternative Comparison – Probable Capital Costs in Future Dollars

Phase (Year)	I (2015) *(Million $)*	II (2025) *(Million $)*	III (2035) *(Million $)*	IV (2045) *(Million $)*
Single Plant Alternative	$542	$185	$637	$964
Dual Plant Alternative	$507	$194	$744	$1,082
[1] *Values as of the year cost will incur computed at a 5% annual inflation rate.*				

Table 87 summarizes the operations and maintenance costs of the two planning alternatives. In general, the O&M costs are higher for the dual plant alternative compared to its single plant counterpart.

Table 87 Alternative Comparison – Operation & Maintenance Costs

Phase (Year)	**I (2015)** *(Million $)*	**II (2025)** *(Million $)*	**III (2035)** *(Million $)*	**IV (2045)** *(Million $)*
Single Plant Alternative	$7.3	$11.4	$15.7	$20.7
Dual Plant Alternative	$7.9	$11.4	$16.5	$21.5
[1] *Values as of January 2008.*				

Table 88 summarizes the annual costs of the two planning alternatives, including financing (debt service).

Table 88 Alternative Comparison – Annual Costs

Phase (Year)	**I (2015)** *(Million $)*	**II (2025)** *(Million $)*	**III (2035)** *(Million $)*	**IV (2045)** *(Million $)*
Single Plant Alternative	$44.4	$59.0	$48.0	$63.2
Dual Plant Alternative	$42.8	$57.2	$51.7	$68.2
[1] *Values as of January 2008.*				

Table 89 compares the Present Worth of annual costs for each alternative.

Table 89 Alternative Comparison – Present Worth of Annual Costs

Year	**2008** *(Billion $)*
Single Plant Alternative	$1.81
Dual Plant Alternative	$1.84

Section 6 Preferred Alternative

Two alternatives for the surface water system were compared; a single-plant option where the plant is located at the Lake Conroe dam, and a dual-plant option where a plant is located at the Lake Conroe dam (north plant) and a plant is located on the West Fork of the San Jacinto River (WFSJR) north of the Woodlands (south plant).

For the Lake Conroe treatment plant proposed for both the single-plant and dual-plant options, two sites were evaluated; a west site and an east site based on land parcels currently owned by SJRA. The east site is the only location along the dam that has enough room for the plant required for both the single and dual plant options, therefore the east site is the only location considered for both the single-plant and dual-plant options, simplifying the comparison.

The single plant option, with the treatment plant located at the Lake Conroe dam east location, is the preferred alternative. The criteria for selection and details of the single plant alternative are provided below.

6.1 Selection Criteria and Stakeholder Acceptance

6.1.1 Selection Criteria

The following comparisons were made in Section 5 for the single-plant and dual-plant options:

- Advantages / Disadvantages of treatment plant locations;
- Advantages / Disadvantages of proposed pipeline alignments;
- Advantages / Disadvantages related to environmental and historical considerations;
- Advantages / Disadvantages related to the opportunity to serve future developments;
- Present Worth Value (PWV) of annual costs.

The Present Worth Value of the annual costs for each alternative is the overriding criteria for selection. The major disadvantages of the dual-plant option are related to the operation of a second plant off-channel; these disadvantages are reflected in the higher operations and maintenance costs of the dual-plant option. In all cases the comparisons of advantages/disadvantages and costs were evaluated in the context of the study assumptions, limitations, and practical considerations of implementing a system by 2015.

6.1.2 Stakeholder Acceptance

The planning for conversion to surface water began in June 2004 when the District and SJRA obtained the Phase I Study grant from TWDB. Over the last several years the District has held a number of public meetings on conversion to surface water and has taken advantage of any opportunity to give presentations to city officials, water district boards, and system operators regarding their regulatory plans and the overall concept of the infrastructure required and cost to implement a regional conversion to surface water.

In August 2006, as part of the current study, the District invited representatives from over 30 cities and water districts in the Conroe/I-45 corridor/Woodlands area to attend a meeting that discussed the technical considerations of introducing surface water to their systems, requested input on preferred routes, and requested information on system problems and planned system expansions. In February 2008 the District held a public meeting to present the progress of the current study and discuss details of the single-plant and dual-plant options. No public comment was received after that meeting.

Over the last six months, as the District has developed and adopted its Phase II (A) regulatory plan, SJRA has been moving on several fronts; negotiating to secure a larger share of water rights in Lake Conroe, hiring a Program Manager to oversee the planning, design, and construction of a surface water system, and developing a Water Resources Assessment Plan (WRAP) to comply with the Districts' Phase II (A) District Regulatory Plan (Phase II (A) DRP, adopted 2/12/2008). SJRA's plan is to construct, maintain, and operate a surface water system that will become operational by January 1, 2015 and that will supply enough surface water to meet the overall goal of the District's Phase II (A) DRP; a 30% countywide reduction of groundwater use by 2015.

As discussed in this study, relatively few PWSs would likely receive surface water from the SJRA system in 2015. District permittees that do not receive surface water from the SJRA system, or do not develop their own alternative supply that will replace 30% of their groundwater demand by 2015, still have to meet the Phase II (A) DRP requirements. Those permittees can accomplish this by joining the WRAP of another entity who is over-converting enough to handle their 30% reduction, whether it be SJRA or any other entity. SJRA is currently inviting districts to join their WRAP.

Every District permittee that is subject to the Phase II (A) DRP has the flexibility to adopt any solution that will meet the requirements; i.e. there is no requirement to accept the SJRA solution by joining their WRAP. It is SJRA's goal to incorporate as many permittees as possible in their WRAP: towards that end SJRA has initiated meetings with permittees, welcomed any and all opportunities to discuss the process, and has held two workshops on the SJRA WRAP.

The preferred alternative presented in this study is based on a set of assumptions that may change as SJRA's water supply options change and as they move forward beginning with the development of a WRAP. SJRA supports the general concepts of the preferred approach although route alignment, pipe sizes, delivery points, phase and plant capacities may change.

6.2 Identification and Phasing of Conversion for Existing Facilities

Overall conversion and phasing requirements are the same for both options. The minimum phasing requirements are given in *Table 22*. Minimum conversion amounts are 17.8, 39.4, 60.6, and 86.2 mgd for Phase I – IV respectively. The single plant treatment capacity and phasing is discussed in Section 4.2.1.1, and shown in *Table 50* and *Table 51*. The initial treatment plant will be constructed with a capacity of 22.5 mgd, consisting of two 11.25 mgd trains. Plant expansions in 2025, 2035, and 2045 will consist of two 11.25 trains each. The treatment plant capacities by phase are 22.5 mgd, 45 mgd, 67.5 mgd, and 90 mgd.

The preferred pipeline route is predicated on the ability to deliver water to some of the largest groundwater permittees in the County in order to minimize the size of the pipeline network. *Table 90* lists the PWSs identified for conversion in 2015 and 2025 along with the proposed delivery points for 2015 and 2025.

Table 90 Delivery Points for 2015 and 2025 Conversions

PWS	Water Plants Served
The Woodlands	All five water plants.
City of Conroe	Plants at wells 4, 5, 6, 8, 12, and 14
Rayford Road MUD	Both water plants
Southern Montgomery County MUD	Both water plants
City of Oak Ridge North	Robinson plant
City of Shenandoah	Memorial Dr and Country Lane plants
Montgomery County MUD #19	All three plants
Chateau Woods MUD	Both plants
Woodlands Oaks Subdivision	Forest West plant

The conversion rate for each system will be 60% in 2015 and 90% in 2025.

The 2035 and 2045 conversions (Phases III and IV) expand the system to pick up PWSs on the east and west sides of Lake Conroe, west of the City of Conroe, south of the City of Conroe, southwest of The Woodlands, and west of Rayford Road MUD. The PWSs to be served are shown in *Exhibit 6*. All PWSs are anticipated to convert 90%.

6.3 Preferred Treatment Plant Location

The Single Plant option is the preferred surface water delivery alternative. The preferred option has the convenience of having to build and maintain one treatment plant and one intake point. The preferred treatment plant site is located at the "East Site" at the existing SJRA property on the south side of the Lake Conroe Dam which had enough land to situate a treatment plant with sufficient capacity. Detailed discussion on the preferred treatment plant site can be found in Section 4.2.1.2.2. The location of the preferred treatment plant site is shown in *Exhibits 13*, *14* and *15*.

Probable capital cost for the single plant alternative is lower than the dual plant alternative for all of the phases; Phase I (2015), Phase II (2025), Phase III (2035) and Phase IV (2045). The single plant option has lower O &M and annual costs in all phases as well.

Environmental considerations did not suggest significant preference for any one of the alternatives. From the environmental perspective, many of the impacts associated with the Single Plant alternative as opposed to the Dual Plant alternative would be the same with some differences.

6.4 Preferred Pipeline Alignment

The preferred pipeline alignment is the one with the single treatment plant option. This alignment is chosen for the same reasons discussed in *Section 6.3*. Detailed discussion on the preferred treatment plant site can be found in *Section 3.2.2*. The single plant pipeline alignment layout, timeline, segments and sizes are presented in *Exhibits 6, 7, 8* and *11*.

6.5 Final Capital Costs

The final capital cost for the preferred single plant alternative is presented in *Table 91*. Detailed information on the construction costs, capital costs, O &M and annual costs for the single plant option can be found in Sections 4.2.3 and 4.2.4.

Table 91 Single Plant Option – Probable Capital Costs

Phase (Year) **Capital Improvements**	**I (2015)** *(Million $)*	**II (2025)** *(Million $)*	**III (2035)** *(Million $)*	**IV (2045)** *(Million $)*
Construction (Capital) Costs	$290	$62	$127	$118
Engineering, Financial, & Legal [2]	$87	$19	$38	$36
Land & Easements	$8	$0	$6	$5
TOTAL	**$385**	**$81**	**$171**	**$159**

[1] *Values as of January 2008.*
[2] *Engineering, Financial, & Legal Services (30% of probable construction costs which include the following: Engineering 10%, Program Management 3%, Environmental Studies and Mitigation 5%, Surveying 1%, Construction Management 6%, Financial 3% and Legal 2%.).*

6.6 Rate Analysis

For each of the single and dual plant alternatives, multiple potential financing mechanisms were evaluated for the best overall resulting rate structure. The preferred single plant alternative produces the most advantageous rate structure when financed through a combination of Water Infrastructure Fund (WIF) loans and State Participation loans available through the Texas Water Development Board. The rates for the combination WIF/State Participation funding alternative are summarized in *Table 92* below.

Table 92 Single Plant System Rates for Initial WIF Financing And State Participation

Year	Groundwater		Surface Water	
	Demand (mgd)	Anticipated Rate ($/1,000 gal)	Demand (mgd)	Anticipated Rate ($/1,000 gal)
2009	59.6	0.51		
2015	49.3	1.65	21.0	2.05
2020	59.7	1.93	21.0	2.33
2025	48.6	2.64	41.0	3.04
2030	58.5	3.95	41.0	4.35
2035	48.0	4.50	61.0	4.90
2040	58.6	5.23	61.0	5.63
2045	46.7	6.77	86.0	7.17
2050	60.8	7.95	86.0	8.35
2055	76.1	9.15	86.0	9.55

Rates are in future dollars at a 5% annual inflation Rate

While funding for both the WIF and State participation loans may be limited in availability during any year, pursuit of these funds would provide the lowest overall rates as well as a significant initial rate reduction over conventional funding through municipal bond sales. The combination of below market interest rates for the WIF and the deferred up front costs available under both the WIF and State Participation fund make this combination the preferred funding and rate alternative. An additional benefit of utilizing these deferral options would be found if county wide pumping fees could not be utilized in the initial states. The reduction in up front revenue stream requirements would make this funding option preferable should only a subset of the groundwater users be charged a groundwater pumping fee or some other revenue limitation occur.

6.7 Conversion Incentives and Disincentives

Providing incentives to convert to surface water or disincentives for remaining tied exclusively to groundwater may provide a major component needed to promote participation in the regional surface water system. Monetary incentives or disincentives provide perhaps the most easily recognized motivator of change. However, other motivators such as public or environmental benefits are also useful.

Since the conversion to surface water is largely built upon regulatory requirements of the District, utilizing mechanisms available to the District to achieve the stated goals of the DRP Phase II (A) should be essential to providing monetary or other drivers. Since the District’s goal is to reduce groundwater demand by 30% by 2015, providing a monetary disincentive to any provider who fails to participate in the District’s Water Resource Assessment Plan requirements, should be a major step in promoting compliance with the DRP. Additional monetary drivers can be established through pumping fees for groundwater. Establishing groundwater pumping fees, at a rate that makes the overall cost of locally producing treated groundwater come very close to or even exceed the cost of producing and delivering treated surface water to the individual water systems, provides a disincentive to staying on groundwater. However, a balance must be struck so not to produce an excessive demand for surface water that cannot be met.

Additional motivators, in the form of subsidies, provide an extension of the pumping fee disincentive. This is the case used in the rate analysis in Section 4.2.5 and 4.3.5. This moves beyond just establishing fees which create increased costs for groundwater production, but moves that money to a fund which would subsidize the surface water capital expenses as well as production and treatment costs. This would provide an incentive in the form of cost reduction for purchasing surface water.

An economic incentive for joining the development of a regional surface water supply is the economy of scale provided to the participants in such a project. By comparison, individual projects to supply surface water from some source may require very high capital expenses in comparison to amount of water to be delivered. Regional water systems have the advantage of keeping those capital costs low by sharing the costs among a larger group of participants.

Providing incentives in the form of appealing to stakeholders' sense of stewardship could be used as an additional driver. This usually takes the form of educational activities. Presenting the effects of extended long term over-drafting of the groundwater resource and its human and environmental impacts have proved to be useful tools for inspiring conservation and reduced water usage.

Studies by the SJRA Woodlands Division have estimated the loss in production over time attributed to falling groundwater levels. These studies indicate that wells producing water from the Evangeline aquifer are losing capacity at a rate of 2.2% per year and from the Jasper aquifer at a rate of 0.5% per year. The studies further indicate that at the projected growth of the Woodlands, the wells in one of the pressure planes would not have sufficient capacity to supply the maximum daily water demand by 2015. The cost of additional wells developed to the depth and pumping capacity needed to supply the anticipated water needs may run as high as $3 Million Million for this system. Smaller water systems with less capacity needs may not require as large a capacity, but the declining water levels would still require that wells be drilled (or re-drilled) to ever increasing depths if groundwater water use is not curtailed.

Future economic growth of the county could be in jeopardy if surface water conversion does not take place. Businesses looking to relocate frequently use water supply as a key factor in determining prospective locations. Failure to provide alternate water supplies other than an ever decreasing groundwater source could be a major disincentive for attracting future businesses to the area.

Section 7 References

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Appendix A Exhibits

Appendix B Raw Water Quality Data for Lake Conroe

Appendix C Alignment Narrative

Appendix D Computer Modeling Results for Pipe Sizing

Appendix E Utility Coordination

Appendix F Developed Unit Costs

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Appendix G Capital Costs

Appendix H Rate Analysis

Appendix I Present Worth Analysis

Appendix J Environmental Constraints Map

Appendix K Environmental Constraints Reference Documents

Appendix L Stakeholder Meeting Minutes

Appendix M Public Comments

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