FINAL MEMORANDUM

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TO: David Parkhill, Matt Barrett

FROM: Spandana Tummuri

SUBJECT: Detailed Strategy Evaluation (Task 1105)

DATE: 2018/03/02

PROJECT: Raw Water Supply Master Plan 16-015-1 (SJR15616)

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INTRODUCTION

The San Jacinto River Authority (SJRA) retained Freese and Nichols, Inc. (FNI) to develop a raw water supply master plan (RWSMP) for their Highlands and Lake Conroe Divisions which, in turn, serves the Groundwater Reduction Plan (GRP) and The Woodlands Divisions. The initial scope of work included completion of Tasks 1102 through 1105 listed below. An amendment was issued to the initial scope of work to perform additional work in Task 1105 and for the completion of Task 1107.

1. Task 1102: Evaluation of Demand Scenarios
2. Task 1103: Evaluation of Supply Scenarios and Needs
3. Task 1104: Preliminary Strategy Identification and Evaluation
4. Task 1105: Strategy Evaluation and Selection
5. Task 1107: Strategy Portfolio and Implementation Plan Development

The purpose of this technical memorandum is to summarize the analyses developed for the various water supply strategies considered for detailed strategy evaluation. Technical Memoranda for Tasks 1102, 1103, and 1104 summarize the evolution of the RWSMP by way of describing the future demands for the SJRA service area, available supplies, the projected needs/surplus in the SJRA service area, and the preliminary strategy identification and evaluation. The objective of the detailed strategy evaluation task was to conduct a detailed review of select strategies of particular interest to SJRA and determine the feasibility of considering these strategies as potential future source of supply to be included in the SJRA supply portfolio.

In Task 1104, preliminary strategy identification and evaluation, a list of approximately 30 projects were developed for the Lake Conroe and Highlands service areas. The purpose of Task 1104 was to identify the most promising supply options for detailed evaluation and a screening process was developed to uniformly evaluate the universe of supply options on a high-level, preliminary basis. Of the 30 projects identified in Task 1104, SJRA will eventually select the supply option that is most viable for its planning triple bottom line approach (economics, environment, and social benefits). Evaluation of each and every supply options in a detailed manner and determination of the feasibility of the supply option in meeting the planning triple bottom line is an expensive process. Therefore, SJRA has selected a short list of strategies to be considered for detailed review and additional strategy evaluation.

Supply Strategies

SJRA's Montgomery County service includes providing supplies to various commercial and industrial customers and the current and potential future Groundwater Reduction Plan (GRP) Participants in the County. SJRA's Highlands service area includes various industrial, irrigation, and municipal customers in eastern Harris County. The Task 1104 Technical Memorandum includes the list of future supply sources or strategies considered as the potentially viable sources for meeting SJRA's future needs in the two service areas. Below, is a short list of the strategies that SJRA has selected for a detailed strategy evaluation and feasibility analysis for the Montgomery County and Highlands service areas.

A) Projects to supply water to the Montgomery County service area

1) Transfer of water from Lake Livingston to Lake Conroe
2) Catahoula Aquifer Supplies
3) Regional return flows above Lake Conroe and within West Fork San Jacinto River for collection and transmission to Lake Conroe
4) Water Conservation

B) Projects to supply water to the Highlands service area

1) Regional return flows above Lake Houston
2) Transfer of water from Lake Livingston to Highlands

Strategy Descriptions

<u>Lake Livingston Transfer</u> – SJRA has entered into an agreement with the Trinity River Authority (TRA) for the option to purchase up to 50,000 acre-feet of water per year from TRA's existing supplies within Lake Livingston. The 50,000 acre-feet of supply is apportioned from TRA's existing rights associated with Lake Livingston and the Wallisville Saltwater Barrier. The supplies from the Lake Livingston agreement with TRA could potentially be delivered using existing means or through new conveyance facilities. In the Highlands system, SJRA currently contracts with CWA to convey its Trinity River Basin run-of-river rights to the Highlands system service area through the existing CWA Main Canal. An additional new conveyance system is required to deliver the water from Trinity River Basin to the Montgomery County service area. Water may be delivered to Lake Conroe or directly to the treatment plant SJRA owns and operates for the GRP Division. A new inter-basin transfer permit is required to move these Livingston supplies to Montgomery County.

<u>Catahoula Aquifer Supplies</u> – This project represents various options for the development of groundwater wells in the Catahoula Aquifer in Montgomery County. Some approaches to the project can be implemented by SJRA customers within the county while others will require active participation by SJRA. A previous study focused on multiple strategies that would be developed by SJRA. The Catahoula groundwater supplies can be discharged to Lake Conroe as a raw water supply, transferred to the existing (expanded) Water Treatment Plant (WTP) to develop treated supplies, or blended with the WTP product water to develop a combined supply of adequate quality. Similarly, the participants can develop the Catahoula groundwater supplies either as a treated option or a blended option.

<u>Regional Return Flows</u> – The projected population growth in Montgomery and Harris Counties is expected to result in the generation of significant volumes of future return flows. Three different scenarios are

considered in this study for using this supply strategy: permitting return flows generated in the Montgomery County service area for diversion from Lake Conroe for reuse, permitting return flows generated in the Lake Houston watershed for diversion at Lake Houston for reuse in the Highlands system, and permitting return flows from the Lake Creek watershed area and other West Fork San Jacinto tributaries for treatment at the SJRA water treatment plant for use by GRP customers. Opportunities exist through existing contractual arrangements to acquire some of these return flows and other opportunities may be developed through new contractual arrangements.

Conservation – Water conservation decreases or attenuates future supply needs through demand reduction. The demands projected for SJRA and all of Montgomery County as part of the 2016 Regional Water Plan for Region H have an embedded quantity of conservation savings. This quantity has been estimated by the Texas Water Development Board (TWDB) based on the assumption that water will be saved as a result of anticipated future natural installation of plumbing fixtures and appliances. The reduction in demands because of these basic efforts is termed as the baseline conservation recommended by TWDB. Regional conservation estimates were developed as part of the Goldwater Study and included in the Region H Regional Water Plan. These estimates provide an additional set of potential conservation savings resulting from further regional efforts. These opportunities were considered along with the specific targets in SJRA's current water conservation plan to evaluate these opportunities at water demand reduction.

Detailed Strategy Evaluation

Each of the strategies described in the previous section were considered for the detailed strategy evaluation. In the detailed strategy evaluation, the multiple alternatives for developing each strategy were considered and discussed. The detailed strategy evaluation includes better defining the strategy, determining the infrastructure required to develop the strategy, identifying potential environmental and permitting requirements, estimating planning level opinions of probable costs, and conducting a revised screening of the strategy to determine the feasibility of the strategy to serve as the most viable alternative for SJRA's future needs as compared to the others.

Technical memorandums were developed for each of the strategy types and are attached to this memorandum. It should be noted that the purpose of Task 1105 is to provide information on the strategies based on a detailed technical evaluation. Selection of preferred strategies amongst those evaluated in Task 1105 and sorting of these strategies into various portfolios (groups of strategies) is addressed in Task 1107 Technical Memorandum.

Each strategy type considered for detailed evaluation was analyzed for the multiple alternatives in which the strategy could be implemented, either by SJRA or their customers. The detailed strategy Technical Memoranda include strategy definition, infrastructure requirements, cost estimates, environmental and permitting requirements, and an overall scoring of the strategy based on the multiple scoring criterion identified by SJRA in Task 1104. The planning-level cost estimates were based on August 2017 price indices. Where applicable, pipeline routes and the associated environmental and permitting issues were also identified and discussed. However, it should be noted that the pipeline alignments were selected based on preliminary information available from a desktop survey and these routes and the analyses must be refined during a more detailed feasibility phase of the strategy evaluations. The strategy Technical Memoranda are attached to this section.

SAN JACINTO RIVER AUTHORITY RAW WATER SUPPLY MASTER PLAN DETAILED STRATEGY EVALUATION TECHNICAL MEMORANDUM

Project Name:	Lake Livingston to Lake Conroe Transfer
Project Type:	Existing Surface Water Source
Potential Supply Quantity (Rounded):	50,000 acre-feet/year (45 mgd)
Development Timeline:	10 years
Project Capital Cost:	\$96,100,000- \$241,179,000 (August 2017)
Unit Water Cost (Rounded):	\$293 - \$601 per acre-feet (during loan period) \$132 - \$197 per acre-feet (after loan period)

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STRATEGY DESCRIPTION

The San Jacinto River Authority (SJRA) is a wholesale water provider for various municipal, industrial, and irrigation retail customers in the San Jacinto River Basin. In Montgomery County, Lake Conroe is SJRA's only source of surface water supply. Montgomery County is currently in the process of reducing groundwater withdrawal by converting excess Gulf Coast groundwater demand and future anticipated growth of demand to surface water and other sources. This process is being carried out by the Large Volume Groundwater Users (LVGUs) in the county and can be accomplished by individual LVGUs or collectively in a joint Groundwater Reduction Plan (GRP). SJRA represents the largest surface water provider and provides a means of conversion within the county to several LVGUs in its joint GRP. Current supplies from Lake Conroe are adequate for initial phases of conversion but future growth will likely require the introduction of additional water strategy alternatives.

In April 2013, SJRA secured an option agreement with the Trinity River Authority (TRA) for the purchase of up to 50,000 acre-feet of water per year from Lake Livingston. Currently under state regulations, this water supply is only permitted to be used within the Trinity River Basin and adjoining coastal basins; however, it can be permitted in the future through TCEQ for transfer out of the Trinity Basin to either the Montgomery County or the Highlands service area. As part of this feasibility study, strategies to deliver Lake Livingston water were developed both for the Montgomery County and the Highlands service areas for the full amount of the water available under this option agreement from TRA.

The current option agreement essentially provides SJRA a right of first refusal to enter into a Water Supply Contract with TRA for an initial contract term of not less than 50 years, with provisions in the contract to reserve water at a reservation fee rate for up to 20 years or until water supply is actually used, when at such time the full take-or-pay system rate would go into effect. The option agreement requires SJRA and TRA to enter into a Service Area Agreement by April 2023 and a Water Supply Contract by April 2028.

It should be noted that the 50,000 acre-feet of water purchased from TRA may potentially be used to serve any location of the SJRA service area. When comparing the strategies for future selection, it should be noted that the Highlands and the Montgomery County strategies for delivering Livingston water must be treated as mutually exclusive. Alternatively, the strategy can be developed for both service areas in reduced capacities as long as the combined total strategies do not exceed the 50,000 acre-feet included in the option contract. Any volume in excess of this amount would require additional contracting with TRA or other parties.

STRATEGY ANALYSES

The project analyses for Lake Livingston to Lake Conroe Transfer include evaluations of the potential supply to be created, environmental factors involved in the project, permitting and development considerations, and an analysis of project cost.

Supply Development

The identified supply of 50,000 acre-feet per year is allocated out of TRA's existing rights associated with Lake Livingston and the Wallisville Saltwater Barrier. This total supply of 403,200 acre-feet per year was determined to be firm and available for use by TRA in the 2016 Region H Regional Water Plan (RWP). Use of this water by SJRA will require at least one of various potential approaches to delivering the supply to demands within SJRA's Montgomery County service area. This includes the development of a new conveyance to divert water from the Trinity River Basin and deliver it to Montgomery County.

Seven different potential transmission alternatives were evaluated for transferring water from the TRA's Lake Livingston to Lake Conroe in Montgomery County. The purpose for developing seven different alternatives was to identify the most likely choice of transmission routes and determine the challenges associated with each one of the alternatives. When a more detailed feasibility study is conducted for this strategy, the transmission route options can be narrowed down and further refined based on the preliminary evaluation presented in this study. For the scope and purpose of this study, all six alternatives are considered viable alternatives and the difference in the transmission systems are reflected in the environmental issues associated with the route and the resulting cost estimates.

Exhibit 1 shown in this technical memorandum includes an overall exhibit showing the general confines of all the transmission routes considered for transferring supplies from Lake Livingston to Lake Conroe. *Exhibits 2* through *7* include location maps for the individual routes and are included at the end of the technical memorandum. *Exhibits 8* through *13* include the hydraulic grade lines for the pipeline routes and the infrastructure details specific to each one of the routes such as the length of the pipeline route, the pipe diameter required to transfer the supplies, and the need for intakes and booster pump stations for transferring the supplies. *Table 1* below summarizes the infrastructure details.

Table 1. Infrastructure Details for the Transmission Routes Transferring Supplies from Lake Livingston to Lake Conroe

Transmission Route Option	Pipeline Length Feet/[Miles]	Booster Pump Station
1	143,415/ [27]	1
1a	135,552/ [26]	1
2	129,928/ [25]	1

3	97,124/ [18]	None
4	204,575/ [39]	1
5	184,860/ [35]	1

Transmission route Option 1 begins at a diversion take-off point near the tributary flowing into Lake Livingston at the location where the Trinity River intersects with Highway 19 near Riverside, Texas. The pipeline alignment would then follow Highway 19, loop around the southern border of the City of Huntsville, follow Veterans Memorial Parkway, FM 1374, and finally terminate at the intersection of FM 1374 and FM 215 at one of the tributaries flowing into Lake Conroe at the upstream and north-most point of the Lake Conroe watershed. The water conveyed in this option will be discharged to a tributary of Lake Conroe and allowed to flow by gravity into the reservoir. It should be noted that the intake location for this route is near a boat ramp and this must be taken into consideration when coordinating with TCEQ on permitting requirements.

Transmission route Option 1a follows a similar corridor to Option 1 but instead of following the corridor for Highway 19, Option 1a will follow a corridor further southeast of Highway 19 and along less-developed portions of Walker County. After the intersection of Highway 19 and Highway 30, Option 1a loops around the southern border of the City of Huntsville and follows the same corridor as Option 1. It should be noted that the intake location for this route is also located near a boat ramp and this must be taken into consideration when coordinating with TCEQ on permitting requirements.

Transmission route Option 2 has the same intake location as Options 1 and 1a at the intersection of Highway 19 and the Trinity River near Riverside, Texas. The transmission route for Option 2 follows a route south of Highway 19, thus avoiding the developed portions of Walker County alongside Highway 19. Upon approaching the City of Huntsville, the Option 2 route loops around the northern border of the city along FM 2821 and FM 1791, and finally terminates and discharges into a tributary to Lake Conroe near McGary Creek and allowed to flow by gravity into Lake Conroe.

Transmission route Option 3 is further north of Huntsville and north of the routes for Options 1, 1a, and 2. The route begins at the Trinity River diversion location on the Trinity River near Horseshoe Lake. The alignment follows rural farm roads, across FM 247, Interstate 45, State Highway 75 N, and FM 1696. The water transmitted in this alternative is delivered and charges into a tributary of Lake Conroe, upstream of McGary Creek.

The transmission route for Option 4 would begin at an intake pump station situated near the southwestern shore of Lake Livingston where it may benefit from access to lower levels of the reservoir to guard against reduced water availability during periods of low lake levels. From that point, the pipeline travels along State Highway 150 and Farm to Market 1097 to the east side of Willis. Upon circumventing Willis, the pipeline would terminate in the vicinity of Lake Conroe where the conveyed water may be discharged to Lake Conroe or fed directly to treatment infrastructure operated by SJRA. However, it should be noted that feeding the water directly to the treatment plant is likely to cause operational issues with the facility that may require additional expense and effort to mitigate.

Transmission route Option 5 would begin at a pump station located near one of the deeper portions of Lake Livingston on the West side of the lake, with access to lower levels of water from the reservoir. The transmission alignment would follow Highway 190 all the way to the City of Huntsville, loop around the southern border of the city and follow Highway 190 the rest of the way to discharge near McGary Creek flowing into Lake Conroe.

All options include a 60-inch diameter pipeline and an intake pumping station. The need for booster pump stations along the pipeline was assessed and determined based on the topography along the pipeline alignment and the pipeline length. As noted, all options except Option 5 are limited to discharging water to Lake Conroe, whereas Option 4 provides the option of either discharging the supplies to Lake Conroe or feeding the water directly to SJRA's treatment plant, depending on the supply volume being diverted and the need to treat the water or store it in Lake Conroe. However, as noted above, direct introduction of water to the treatment facility may present technical issues. Options 1, 1a, 2, and 3 divert supplies from the upper reaches of Lake Livingston and are thus limited to the availability of water at the diversion location. In addition to this, these options discharge flows at the north-most tributaries to Lake Conroe and it is uncertain if all the supplies discharged at this location would be available at Lake Conroe. Whereas, Options 4 and 5 divert water from Lake Livingston with access to stored water at deeper locations and are discharged at the Lake Conroe dam location or the northeast portions of Lake Conroe where the supplies are more immediately accessible from Lake Conroe.

All transmission routes are considered viable at this stage of the feasibility evaluation. Therefore, the environmental considerations, the permitting requirements, and cost details for all the alternatives are discussed in this technical memorandum. The strategy evaluation matrix was developed for all seven alternatives.

Environmental Considerations

Following are some of the general environmental considerations associated with the potential transmission alignments identified for transferring supplies from Lake Livingston to Lake Conroe. A desktop-level survey was conducted to identify any environmental issues associated with the specific routes. The details of the survey are summarized below.

1. The inter-basin transfer of water from one basin to another is usually associated with potential impacts to water resources and the potential for transmission of undesirable species. Consideration should be given to impacts to both the source and receiving basins in developing a viable project.

2. A large portion of the pipeline alignment travels through the Sam Houston National Forest. One option for development would be through privately-owned lands within the forest. However, coordination with the United States Forest Service (USFS) indicated that it may be preferable to follow existing corridors through the forest in order to limit impacts to habitat associated with making additional cuts through forested land. This is a sensitive issue requiring further consideration prior to development and resulting in potential significant cost issues and schedule delays.

3. Permitting coordination with the USACE, TPWD, and other natural resource agencies that may be required to construct the project may encounter obstacles pertaining to the potential of the water supply pipeline to serve as a conduit for transferring the exotic invasive mollusk species *Dreissena polymorpha* (zebra mussel). The TPWD confirmed a population of zebra mussels residing within Lake Livingston during June 2016.

4. The USFWS IPaC webservice was consulted to obtain a list of federally-listed species and designated critical habitat segments that could occur within the general project area. The federally-protected species listed below, comprised of five bird species and four flowering plant species, were identified by the IPaC query as potentially occurring within the general project area. Though some of these species have designated critical habitats, no critical habitat tracts/segments occur within the overall project area.

    I. Least tern (*Sterna antillarum*)
    II. Piping plover (*Charadrius melodus*)
    III. Red knot (*Calidris canutus rufa*)
    IV. Red-cockaded woodpecker (*Picoides borealis*)
    V. Whooping crane (*Grus americana*)
    VI. Navasota ladies' tresses (*Spiranthes parksii*)
    VII. Neches River rose-mallow (*Hibiscus dasycalyx*)
    VIII. Texas prairie dawn-flower (*Hymenoxys texana*)
    IX. Texas trailing phlox (*Phlox nivalis* spp. *texensis*)

    Of these protected species, the following have potential to be affected by the proposed project and a 404 permit, and would require a presence/absence survey of the selected/preferred pipeline alignment prior to construction should the project require permitting through the USACE for anticipated impacts to regulated waters of the U.S. (WOTUS).

    I. Red-cockaded woodpecker (Picoides borealis)
    II. Navasota ladies' tresses (Spiranthes parksii)
    III. Neches River rose-mallow (Hibiscus dasycalyx)
    IV. Texas prairie dawn-flower (Hymenoxys texana)
    V. Texas trailing phlox (Phlox nivalis spp. texensis)

5. Due to the presence of streams, wetlands, and ponds that could be deemed WOTUS and jurisdictional per Section 404 of the Clean Water Act (CWA) throughout each of the six alternative alignments, acquiring a permit through the USACE would be required prior to beginning construction activities. Pending the level of potential WOTUS impacts, project activities could likely be covered by a Nationwide Permit. The presence of zebra mussels within the Trinity River/Lake Livingston watershed could require that an Individual Permit be obtained. Nationwide Permits are typically obtained within 45 to 60 calendar days, but acquiring an Individual Permit typically requires a minimum of 180 days and a public comment period.

6. If no Federal funding or assistance would be used for construction of the proposed project, the need to complete the National Environmental Policy Act (NEPA) process would not be required. However, coordination with the USACE to obtain a CWA Section 404 permit, particularly for an Individual Permit, could trigger the need to comply with the NEPA review process.

7. *Table 2* provides a synopsis of potential archaeological/historical resources present within the alternative alignments. Historical resources were evaluated within a one-mile buffer area around the pipeline alignments.

Table 2. Summary of Desktop Archeological and Historical Constraints for the Transmission Routes for Transferring Lake Livingston Supplies to Lake Conroe

Transmission Route Option	Archeology Sites within 1-mile buffer	Cemetery	Historic Places Listed	Texas Historic Landmark
1	34	6	2	0
1a	35	4	2	0
2	35	3	2	1
3	14	1	0	0
4	28	13	1	0
5	23	9	0	0

Table 3 includes desktop environmental-constraints information pertaining to the transmission routes considered in this evaluation. The features identified below are specific to each alignment.

Table 3. Summary of Desktop Environmental Constraints for the Transmission Routes for Transferring Lake Livingston Supplies to Lake Conroe

Transmission Route Option	Ponds	Stream Crossings	Potential Wetlands	Total Wetland Acreage (Acres)	Prime Farmland Soil Tracts	Farmland Acreage (Acres)
1	7	10	8	6.29	None	None
1a	6	13	13	2.59	2	13.01
2	1	22	7	14.84	None	None
3	1	22	7	14.84	None	None
4	11	49	13	9.12	22	73.07
5	6	51	7	4.40	15	30.37

For pipeline alignment options discharging water into the upstream tributaries of Lake Conroe there is a unique challenge of discharging a significant volume of supply (50,000 acre-feet) into a very narrow channel or tributary of Lake Conroe. A preliminary review of the flow-frequency durations of the flows at USGS gage 08067548 West Fork San Jacinto River near Huntsville was conducted to determine the ability of the stream to take flows of this magnitude. The USGS gage selected was downstream of all the discharge points for alternative options discharging flows upstream of Lake Conroe. Based on the preliminary evaluation, it was determined that the mean discharges in the stream at this location exceeded the project yield of 50,000 acre-feet (70 cfs) approximately 9% of the time with an 11-year return interval. *Figure 1* includes a summary of the various historic flow percentiles in the stream at this USGS gage location.

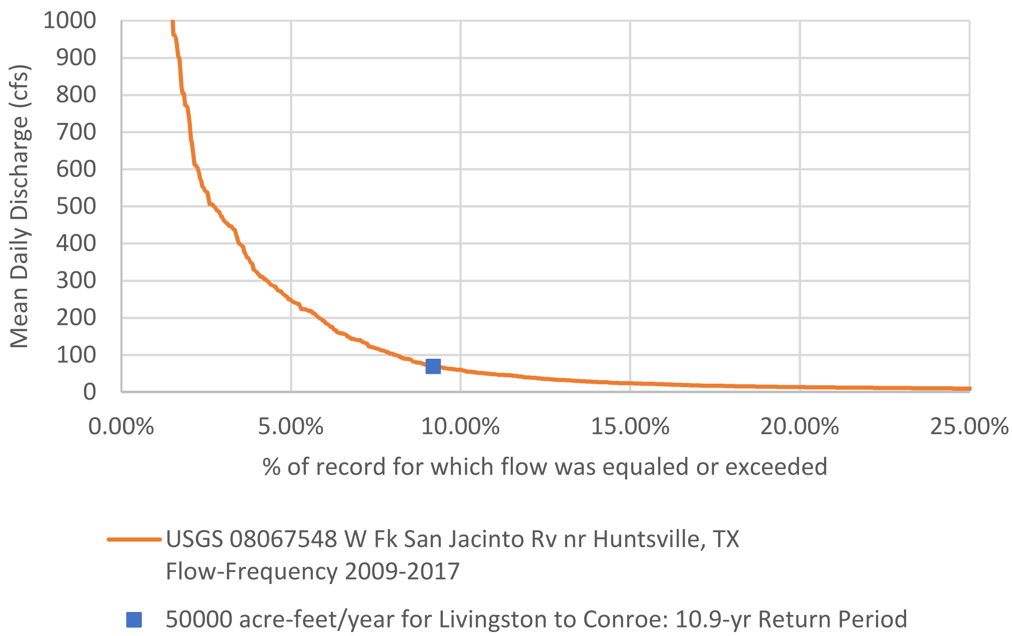


Figure 1. Summary of Flow Frequency and Discharge Volumes in the USGS Gage Downstream of Lake Conroe (USGS gage 08067548)

Based on the flow frequency analysis, it can be shown that the stream is capable of assimilating the additional 50,000 acre-feet per year of supplies added by means of the project. However, there may be adverse effects to the stream and the species in the streams and this is an issue that requires additional environmental evaluation. A brief desktop level review was conducted for the segments discharging supplies in the upstream tributaries of Lake Conroe. A summary of the analyses is presented below. If one of these pipeline alignments is chosen as the preferred alternative, additional environmental and mitigation evaluation will be required during the feasibility phases. The review assumed a water discharge rate of 50,000 acre-feet per year (137 acre-feet per day [44.6 MGD]), and assumed that the discharge would occur at only one of the four optional discharge points with proposed locations upstream of Lake Conroe.

General Comments

1) The more upstream the proposed location is from Lake Conroe; the more support facilities and/or channel improvements will likely be required to account for increased flow volumes associated with the proposed discharge. This has potential to require more USACE and State water permitting actions.
2) Hydrologic modeling is recommended to ensure the proposed discharge would not negatively affect existing channel/bank erosion rates.
3) The appropriate floodplain management agency should also be consulted to ensure the proposed discharge would not create elevated downstream flooding potential.

Transfer Option 1 and 1a (Same Discharge Location)

1) These options would discharge to McDonald Creek (perennial stream tributary of the West Fork San Jacinto River) at a point located 1.5 stream miles upstream of the McDonald Creek confluence

with the West Fork San Jacinto River. This West Fork San Jacinto River confluence is located +/- one stream mile upstream of the Lake Conroe normal pool.

2) The location of this discharge point is a small perennial tributary stream channel sufficiently upstream of the West Fork San Jacinto River that it could require channel modifications to McDonald Creek to account for the increase in flow.
3) The potential for ecological/environmental impacts would be contingent upon the level of modifications required to existing channels to sufficiently handle the increased water flow.

<u>Transfer Option 2</u>

1) This option would discharge to the West Fork San Jacinto River at a point located +/- seven stream miles upstream of the Lake Conroe normal pool.
2) The channel of the West Fork San Jacinto River at this point appears to be small and would likely require armament and/or channel modifications to account for the increased flow.
3) The potential for ecological/environmental impacts would be contingent upon the level of modifications required to existing channels to sufficiently handle increased water flow.

<u>Transfer Option 3</u>

1) This option would discharge to Rocky Creek (perennial stream tributary of the West Fork San Jacinto River) at a point located 2.5 stream miles upstream of the Rocky Creek confluence with the West Fork San Jacinto River. This West Fork San Jacinto River confluence is located +/- 12 stream miles upstream of Lake Conroe normal pool.
2) The location of this discharge point is a small perennial tributary stream channel sufficiently upstream of the West Fork San Jacinto River that it may require channel modifications to Rocky Creek and the West Fork San Jacinto River to account for the increase in flow.
3) The potential for ecological/environmental impacts would be contingent upon the level of modifications required to existing channels to sufficiently handle increased water flow.

This is a generalized ecological/environmental assessment of the three options for water transfer discharge points. The magnitude of armaments and/or channel modifications that would be required to handle the extra flow volume within such small channels is not yet known.

In summary, it can be noted that some routes have more constraints compared to other routes. All the environmental constraints must be addressed during the permitting and detailed feasibility study phases of the project development. At this stage, the environmental considerations are provided as a guide to selecting the most appropriate choice of the seven options considered in this study.

Permitting and Development

Although the TRA has an existing water right permit for the development of the Lake Livingston supply, additional permitting will be required to allow the supply to be used in the San Jacinto River Basin. The Lake Livingston to SJRA Transfer includes up to 34 miles of pipelines which will impact an associated 250-300 acres of land (assuming a 50-ft wide right-of-way needed for construction), including some in use for agricultural purposes. A portion of this route is through the Sam Houston National Forest which will require coordination to limit impacts to habitat. The project will potentially reduce water within the Trinity River Basin below Lake Livingston by as much as 50,000 acre-feet/year. However, this volume of water is already permitted for full consumptive use within the basin. The project may result in as much as 25,000 acre-feet/year of additional flow in the receiving basins assuming 50 percent return flows through municipal effluent. Finally, an Inter-Basin Transfer (IBT) permit will be required to move the Lake Livingston supplies from the Trinity River Basin to the San Jacinto River Basin. Below is a brief discussion on the process of securing an IBT and the potential issues associated with this permit. An IBT can often represent a major permitting effort including:

- Notifications to all county judges in the basin of origin.
- Notifications to mayors of cities with a population over 1,000 (in both the transferring and the receiving basins).
- Notifications to all groundwater conservation districts and water right holders (in transferring and receiving basins).
- Notifications to all legislators (in transferring and receiving basins).
- Public meetings (in both transferring and receiving basins).
- Notice in newspapers (in transferring and receiving basins).
- Demonstration of achieving the highest practicable levels of water conservation and efficiency achievable by the applicant.
- Determination of environmental and social impacts.

Cost Analysis

Preliminary opinions of probable construction costs were developed based on planning-level details considered for the seven transmission options. The cost estimates were developed using the approach adopted for the Region H regional planning strategy evaluation; however, unlike for Region H, the cost estimates were indexed to August 2017 dollars. Unlike typical cost estimates for the Region H RWP, the contract cost of water (based on the current TRA system rate of $95 per acre-feet for the $50,000 acre-feet volume) was also included in these estimates to provide a more realistic cost comparison to other strategies. *Table 4* includes an overall summary of the estimated costs for all strategy alternatives evaluated. *Tables 5* through *10* below include the overall cost estimates. It should be noted that these cost estimates are preliminary planning-level cost estimates and cannot be used for contracting or designing purposes. Detailed cost estimates must be developed during a more detailed feasibility analysis or the design phases of the project.

Table 4. Summary of Preliminary Planning Level Cost Estimates for Transferring Lake Livingston Supplies to Lake Conroe

Transmission Route Option	Capital Costs	Annual Costs (with debt service)	Annual Costs (without debt service)	Unit Cost ($/AF) (with debt service)	Unit Cost ($/AF) (without debt service)
1	$168,396,000	$22,697,000	$8,606,000	$454	$172
1a	$159,529,600	$21,798,000	$8,449,000	$436	$169
2	$150,744,000	$20,911,000	$8,297,600	$418	$166
3	$96,100,000	$14,640,000	$6,598,000	$293	$132
4	$241,180,000	$30,043,000	$9,861,000	$601	$197
5	$220,982,000	$28,002,000	$9,510,000	$560	$190

Table 5 – Lake Livingston to Lake Conroe Transfer Cost Estimate for Option 1

OPINION OF PROBABLE CONSTRUCTION COST					October 31, 2017
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
PROJECT CAPITAL COST SUMMARY					
1	CONSTRUCTION COST	1	LS	$119,419,429	$119,419,429
2	ENGINEERING, FINANCIAL, AND LEGAL SERVICES AND CONTINGENCIES	1	LS	$37,655,004	$37,655,004
3	LAND AND EASEMENTS	1	LS	$4,596,162	$4,596,162
4	ENVIRONMENTAL - STUDIES AND MITIGATION	1	LS	$1,505,712	$1,505,712
5	INTEREST DURING CONSTRUCTION	1	LS	$5,219,911	$5,219,911
	PROJECT CAPITAL COST				$168,396,217

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	DEBT SERVICE	$14,091,283	$14,091,283	$0	$0	$0	$0
2	OPERATION AND MAINTENA	$1,762,947	$1,762,947	$1,762,947	$1,762,947	$1,762,947	$1,762,947
3	PUMPING ENERGY COSTS	$2,092,959	$2,092,959	$2,092,959	$2,092,959	$2,092,959	$2,092,959
4	PURCHASE COST OF WATER	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000
	TOTAL ANNUAL COST	$22,697,189	$22,697,189	$8,605,906	$8,605,906	$8,605,906	$8,605,906
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	ANNUAL COST	$22,697,189	$22,697,189	$8,605,906	$8,605,906	$8,605,906	$8,605,906
2	YIELD	50,000	50,000	50,000	50,000	50,000	50,000
3	UNIT COST	$454	$454	$172	$172	$172	$172
	TOTAL UNIT COST						$266

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION COST SUMMARY					
1	PUMP STATIONS	1	LS	$36,583,500	$36,583,500
2	PIPELINES	1	LS	$81,797,592	$81,797,592
3	PIPELINE CROSSINGS	1	LS	$1,038,337	$1,038,337
	PROJECT COST				$119,419,429
OPERATION AND MAINTENANCE (O&M) COST SUMMARY					
1	PUMP STATIONS	2.5	%	$36,583,500	$914,588
2	PIPELINES	1.0	%	$81,797,592	$817,976
3	PIPELINE CROSSINGS	1.0	%	$1,038,337	$10,383
4	CONNECTION, ADDITION OF LIME AND CARBON DIOXIDE	40.0	%	$50,000	$20,000
	ANNUAL OPERATION AND MAINTENANCE COST				$1,762,947
PUMP STATION CONSTRUCTION COSTS					
1	4344 HP Pump Station with Intake	1.0	LS	$21,838,700	$21,838,700
2	4344 HP Pump Station Booster	1.0	LS	$14,744,800	$14,744,800
	PUMP STATIONS TOTAL COST				$36,583,500
PIPELINE CONSTRUCTION COSTS					
1	60'' Diameter Pipeline (Rural Soil)	129,073.0	LF	$519	$67,010,636
2	60'' Diameter Pipeline (Urban Soil)	14,241.0	LF	$1,038	$14,786,956
	PIPELINES TOTAL COST				$81,797,592
PIPELINE CROSSING CONSTRUCTION COST					
1	60'' Diameter Pipeline Crossing (Directional, Rock)	500.0	LF	$2,077	$1,038,337
	PIPELINE CROSSINGS TOTAL COSTS				$1,038,337

Table 6- Lake Livingston to Lake Conroe Transfer Cost Estimate for Option 1a

OPINION OF PROBABLE CONSTRUCTION COST					October 31, 2017
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
PROJECT CAPITAL COST SUMMARY					
1	CONSTRUCTION COST	1	LS	$113,100,259	$113,100,259
2	ENGINEERING, FINANCIAL, AND LEGAL SERVICES AND CONTINGENCIES	1	LS	$35,634,063	$35,634,063
3	LAND AND EASEMENTS	1	LS	$4,395,783	$4,395,783
4	ENVIRONMENTAL - STUDIES AND MITIGATION	1	LS	$1,454,477	$1,454,477
5	INTEREST DURING CONSTRUCTION	1	LS	$4,945,067	$4,945,067
	PROJECT CAPITAL COST				$159,529,649

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	DEBT SERVICE	$13,349,334	$13,349,334	$0	$0	$0	$0
2	OPERATION AND MAINTENANCE (O&M)	$1,662,198	$1,662,198	$1,662,198	$1,662,198	$1,662,198	$1,662,198
3	PUMPING ENERGY COSTS	$2,036,520	$2,036,520	$2,036,520	$2,036,520	$2,036,520	$2,036,520
4	PURCHASE COST OF WATER	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000
	TOTAL ANNUAL COST	$21,798,052	$21,798,052	$8,448,718	$8,448,718	$8,448,718	$8,448,718
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	ANNUAL COST	$21,798,052	$21,798,052	$8,448,718	$8,448,718	$8,448,718	$8,448,718
2	YIELD	50,000	50,000	50,000	50,000	50,000	50,000
3	UNIT COST	$436	$436	$169	$169	$169	$169
	TOTAL UNIT COST						$258

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION COST SUMMARY					
1	PUMP STATIONS	1	LS	$34,079,700	$34,079,700
2	PIPELINES	1	LS	$77,982,222	$77,982,222
3	PIPELINE CROSSINGS	1	LS	$1,038,337	$1,038,337
	PROJECT COST				$113,100,259
OPERATION AND MAINTENANCE (O&M) COST SUMMARY					
1	PUMP STATIONS	2.5	%	$34,079,700	$851,993
2	PIPELINES	1.0	%	$77,982,222	$779,822
3	PIPELINE CROSSINGS	1.0	%	$1,038,337	$10,383
4	CONNECTION, ADDITION OF LIME AND CARBON DIOXIDE	40.0	%	$50,000	$20,000
	ANNUAL OPERATION AND MAINTENANCE COST				$1,662,198
PUMP STATION CONSTRUCTION COSTS					
1	4192 HP Pump Station with Intake	1.0	LS	$20,053,400	$20,053,400
2	4192 HP Pump Station Booster	1.0	LS	$14,026,300	$14,026,300
	PUMP STATIONS TOTAL COST				$34,079,700
PIPELINE CONSTRUCTION COSTS					
1	60'' Diameter Pipeline (Rural Soil)	122,896.0	LF	$519	$63,803,732
2	60'' Diameter Pipeline (Urban Soil)	13,655.0	LF	$1,038	$14,178,490
	PIPELINES TOTAL COST				$77,982,222
PIPELINE CROSSING CONSTRUCTION COST					
1	60'' Diameter Pipeline Crossing (Directional, Rock)	500.0	LF	$2,077	$1,038,337
	PIPELINE CROSSINGS TOTAL COSTS				$1,038,337

Table 7- Lake Livingston to Lake Conroe Transfer Cost Estimate for Option 2

OPINION OF PROBABLE CONSTRUCTION COST					October 31, 2017
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
PROJECT CAPITAL COST SUMMARY					
1	CONSTRUCTION COST	1	LS	$106,913,736	$106,913,736
2	ENGINEERING, FINANCIAL, AND LEGAL SERVICES AND CONTINGENCIES	1	LS	$33,657,861	$33,657,861
3	LAND AND EASEMENTS	1	LS	$4,195,126	$4,195,126
4	ENVIRONMENTAL - STUDIES AND MITIGATION	1	LS	$1,304,311	$1,304,311
5	INTEREST DURING CONSTRUCTION	1	LS	$4,672,724	$4,672,724
	PROJECT CAPITAL COST				$150,743,757

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	DEBT SERVICE	$12,614,137	$12,614,137	$0	$0	$0	$0
2	OPERATION AND MAINTENANCE (O&M)	$1,564,259	$1,564,259	$1,564,259	$1,564,259	$1,564,259	$1,564,259
3	PUMPING ENERGY COSTS	$1,982,432	$1,982,432	$1,982,432	$1,982,432	$1,982,432	$1,982,432
4	PURCHASE COST OF WATER	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000
	TOTAL ANNUAL COST	$20,910,828	$20,910,828	$8,296,691	$8,296,691	$8,296,691	$8,296,691
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	ANNUAL COST	$20,910,828	$20,910,828	$8,296,691	$8,296,691	$8,296,691	$8,296,691
2	YIELD	50,000	50,000	50,000	50,000	50,000	50,000
3	UNIT COST	$418	$418	$166	$166	$166	$166
	TOTAL UNIT COST						$250

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION COST SUMMARY					
1	PUMP STATIONS	1	LS	$31,674,800	$31,674,800
2	PIPELINES	1	LS	$74,200,599	$74,200,599
3	PIPELINE CROSSINGS	1	LS	$1,038,337	$1,038,337
	PROJECT COST				$106,913,736
OPERATION AND MAINTENANCE (O&M) COST SUMMARY					
1	PUMP STATIONS	2.5	%	$31,674,800	$791,870
2	PIPELINES	1.0	%	$74,200,599	$742,006
3	PIPELINE CROSSINGS	1.0	%	$1,038,337	$10,383
4	CONNECTION, ADDITION OF LIME AND CARBON DIOXIDE	40.0	%	$50,000	$20,000
	ANNUAL OPERATION AND MAINTENANCE COST				$1,564,259
PUMP STATION CONSTRUCTION COSTS					
1	4046 HP Pump Station with Intake	1.0	LS	$18,338,500	$18,338,500
2	4046 HP Pump Station Booster	1.0	LS	$13,336,300	$13,336,300
	PUMP STATIONS TOTAL COST				$31,674,800
PIPELINE CONSTRUCTION COSTS					
1	60'' Diameter Pipeline (Rural Soil)	116,936.0	LF	$519	$60,709,488
2	60'' Diameter Pipeline (Urban Soil)	12,993.0	LF	$1,038	$13,491,111
	PIPELINES TOTAL COST				$74,200,599
PIPELINE CROSSING CONSTRUCTION COST					
1	60'' Diameter Pipeline Crossing (Directional, Rock)	500.0	LF	$2,077	$1,038,337
	PIPELINE CROSSINGS TOTAL COSTS				$1,038,337

Table 8- Lake Livingston to Lake Conroe Transfer Cost Estimate for Option 3

OPINION OF PROBABLE CONSTRUCTION COST					October 31, 2017
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
PROJECT CAPITAL COST SUMMARY					
1	CONSTRUCTION COST	1	LS	$67,584,706	$67,584,706
2	ENGINEERING, FINANCIAL, AND LEGAL SERVICES AND CONTINGENCIES	1	LS	$21,112,694	$21,112,694
3	LAND AND EASEMENTS	1	LS	$2,577,778	$2,577,778
4	ENVIRONMENTAL - STUDIES AND MITIGATION	1	LS	$1,845,788	$1,845,788
5	INTEREST DURING CONSTRUCTION	1	LS	$2,978,883	$2,978,883
	PROJECT CAPITAL COST				$96,099,849

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	DEBT SERVICE	$8,041,571	$8,041,571	$0	$0	$0	$0
2	OPERATION AND MAINTENANCE (O&M)	$947,032	$947,032	$947,032	$947,032	$947,032	$947,032
3	PUMPING ENERGY COSTS	$901,266	$901,266	$901,266	$901,266	$901,266	$901,266
4	PURCHASE COST OF WATER	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000
	TOTAL ANNUAL COST	$14,639,869	$14,639,869	$6,598,298	$6,598,298	$6,598,298	$6,598,298
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	ANNUAL COST	$14,639,869	$14,639,869	$6,598,298	$6,598,298	$6,598,298	$6,598,298
2	YIELD	50,000	50,000	50,000	50,000	50,000	50,000
3	UNIT COST	$293	$293	$132	$132	$132	$132
	TOTAL UNIT COST						$186

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION COST SUMMARY					
1	PUMP STATIONS	1	LS	$16,745,650	$16,745,650
2	PIPELINES	1	LS	$50,423,721	$50,423,721
3	PIPELINE CROSSINGS	1	LS	$415,335	$415,335
	PROJECT COST				$67,584,706
OPERATION AND MAINTENANCE (O&M) COST SUMMARY					
1	PUMP STATIONS	2.5	%	$16,745,650	$418,641
2	PIPELINES	1.0	%	$50,423,721	$504,237
3	PIPELINE CROSSINGS	1.0	%	$415,335	$4,153
4	CONNECTION, ADDITION OF LIME AND CARBON DIOXIDE	40.0	%	$50,000	$20,000
	ANNUAL OPERATION AND MAINTENANCE COST				$947,032
PUMP STATION CONSTRUCTION COSTS					
1	3559 HP Pump Station with Intake	1.0	LS	$16,745,650	$16,745,650
	PUMP STATIONS TOTAL COST				$16,745,650
PIPELINE CONSTRUCTION COSTS					
1	60'' Diameter Pipeline (Rural Soil)	97,124.0	LF	$519	$50,423,721
	PIPELINES TOTAL COST				$50,423,721
PIPELINE CROSSING CONSTRUCTION COST					
1	60'' Diameter Pipeline Crossing (Directional, Rock)	200.0	LF	$2,077	$415,335
	PIPELINE CROSSINGS TOTAL COSTS				$415,335

Table 9- Lake Livingston to Lake Conroe Transfer Cost Estimate for Option 4

OPINION OF PROBABLE CONSTRUCTION COST					October 31, 2017
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
PROJECT CAPITAL COST SUMMARY					
1	CONSTRUCTION COST	1	LS	$171,247,536	$171,247,536
2	ENGINEERING, FINANCIAL, AND LEGAL SERVICES AND CONTINGENCIES	1	LS	$53,991,276	$53,991,276
3	LAND AND EASEMENTS	1	LS	$6,495,051	$6,495,051
4	ENVIRONMENTAL - STUDIES AND MITIGATION	1	LS	$1,969,818	$1,969,818
5	INTEREST DURING CONSTRUCTION	1	LS	$7,476,039	$7,476,039
	PROJECT CAPITAL COST				$241,179,719

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	DEBT SERVICE	$20,181,757	$20,181,757	$0	$0	$0	$0
2	OPERATION AND MAINTENANCE (O&M)	$2,517,580	$2,517,580	$2,517,580	$2,517,580	$2,517,580	$2,517,580
3	PUMPING ENERGY COSTS	$2,593,858	$2,593,858	$2,593,858	$2,593,858	$2,593,858	$2,593,858
4	PURCHASE COST OF WATER	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000
	TOTAL ANNUAL COST	$30,043,196	$30,043,196	$9,861,438	$9,861,438	$9,861,438	$9,861,438
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	ANNUAL COST	$30,043,196	$30,043,196	$9,861,438	$9,861,438	$9,861,438	$9,861,438
2	YIELD	50,000	50,000	50,000	50,000	50,000	50,000
3	UNIT COST	$601	$601	$197	$197	$197	$197
	TOTAL UNIT COST						$332

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION COST SUMMARY					
1	PUMP STATIONS	1	LS	$52,340,300	$52,340,300
2	PIPELINES	1	LS	$116,830,562	$116,830,562
3	PIPELINE CROSSINGS	1	LS	$2,076,674	$2,076,674
	PROJECT COST				$171,247,536
OPERATION AND MAINTENANCE (O&M) COST SUMMARY					
1	PUMP STATIONS	2.5	%	$52,340,300	$1,308,508
2	PIPELINES	1.0	%	$116,830,562	$1,168,306
3	PIPELINE CROSSINGS	1.0	%	$2,076,674	$20,767
4	CONNECTION, ADDITION OF LIME AND CARBON DIOXIDE	40.0	%	$50,000	$20,000
	ANNUAL OPERATION AND MAINTENANCE COST				$2,517,580
PUMP STATION CONSTRUCTION COSTS					
1	5696 HP Pump Station with Intake	1.0	LS	$32,019,300	$32,019,300
2	5696 HP Pump Station Booster	1.0	LS	$20,321,000	$20,321,000
	PUMP STATIONS TOTAL COST				$52,340,300
PIPELINE CONSTRUCTION COSTS					
1	60'' Diameter Pipeline (Rural Soil)	184,118.0	LF	$519	$95,588,266
2	60'' Diameter Pipeline (Urban Soil)	20,458.0	LF	$1,038	$21,242,296
	PIPELINES TOTAL COST				$116,830,562
PIPELINE CROSSING CONSTRUCTION COST					
1	60'' Diameter Pipeline Crossing (Directional, Rock)	1,000.0	LF	$2,077	$2,076,674
	PIPELINE CROSSINGS TOTAL COSTS				$2,076,674

Table 10- Lake Livingston to Lake Conroe Transfer Cost Estimate for Option 5

OPINION OF PROBABLE CONSTRUCTION COST						October 31, 2017
ITEM	DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	TOTAL
PROJECT CAPITAL COST SUMMARY						
1	CONSTRUCTION COST		1	LS	$156,886,510	$156,886,510
2	ENGINEERING, FINANCIAL, AND LEGAL SERVICES AND CONTINGENCIES		1	LS	$49,527,903	$49,527,903
3	LAND AND EASEMENTS		1	LS	$5,897,576	$5,897,576
4	ENVIRONMENTAL - STUDIES AND MITIGATION		1	LS	$1,820,455	$1,820,455
5	INTEREST DURING CONSTRUCTION		1	LS	$6,849,967	$6,849,967
	PROJECT CAPITAL COST					$220,982,410

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	DEBT SERVICE	$18,491,660	$18,491,660	$0	$0	$0	$0
2	OPERATION AND MAINTENANCE (O&M)	$2,327,450	$2,327,450	$2,327,450	$2,327,450	$2,327,450	$2,327,450
3	PUMPING ENERGY COSTS	$2,432,771	$2,432,771	$2,432,771	$2,432,771	$2,432,771	$2,432,771
4	PURCHASE COST OF WATER	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000	$4,750,000
	TOTAL ANNUAL COST	$28,001,881	$28,001,881	$9,510,221	$9,510,221	$9,510,221	$9,510,221
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	ANNUAL COST	$28,001,881	$28,001,881	$9,510,221	$9,510,221	$9,510,221	$9,510,221
2	YIELD	50,000	50,000	50,000	50,000	50,000	50,000
3	UNIT COST	$560	$560	$190	$190	$190	$190
	TOTAL UNIT COST						$313

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION COST SUMMARY					
1	PUMP STATIONS	1	LS	$49,239,000	$49,239,000
2	PIPELINES	1	LS	$105,570,836	$105,570,836
3	PIPELINE CROSSINGS	1	LS	$2,076,674	$2,076,674
	PROJECT COST				$156,886,510
OPERATION AND MAINTENANCE (O&M) COST SUMMARY					
1	PUMP STATIONS	2.5	%	$49,239,000	$1,230,975
2	PIPELINES	1.0	%	$105,570,836	$1,055,708
3	PIPELINE CROSSINGS	1.0	%	$2,076,674	$20,767
4	CONNECTION, ADDITION OF LIME AND CARBON DIOXIDE	40.0	%	$50,000	$20,000
	ANNUAL OPERATION AND MAINTENANCE COST				$2,327,450
PUMP STATION CONSTRUCTION COSTS					
1	5260 HP Pump Station with Intake	1.0	LS	$30,468,650	$30,468,650
2	5260 HP Pump Station Booster	1.0	LS	$18,770,350	$18,770,350
	PUMP STATIONS TOTAL COST				$49,239,000
PIPELINE CONSTRUCTION COSTS					
1	60'' Diameter Pipeline (Rural Soil)	166,374.0	LF	$519	$86,376,140
2	60'' Diameter Pipeline (Urban Soil)	18,486.0	LF	$1,038	$19,194,696
	PIPELINES TOTAL COST				$105,570,836
PIPELINE CROSSING CONSTRUCTION COST					
1	60'' Diameter Pipeline Crossing (Directional, Rock)	1,000.0	LF	$2,077	$2,076,674
	PIPELINE CROSSINGS TOTAL COSTS				$2,076,674

WATER MANAGEMENT STRATEGY EVALUATION

Based on the analysis provided above, the Lake Livingston to SJRA Transfer project was evaluated across eleven different criteria for the purpose of quick comparison against alternative projects that may be incorporated into the Regional Water Plan. The results of this evaluation can be seen in *Table 11* below.

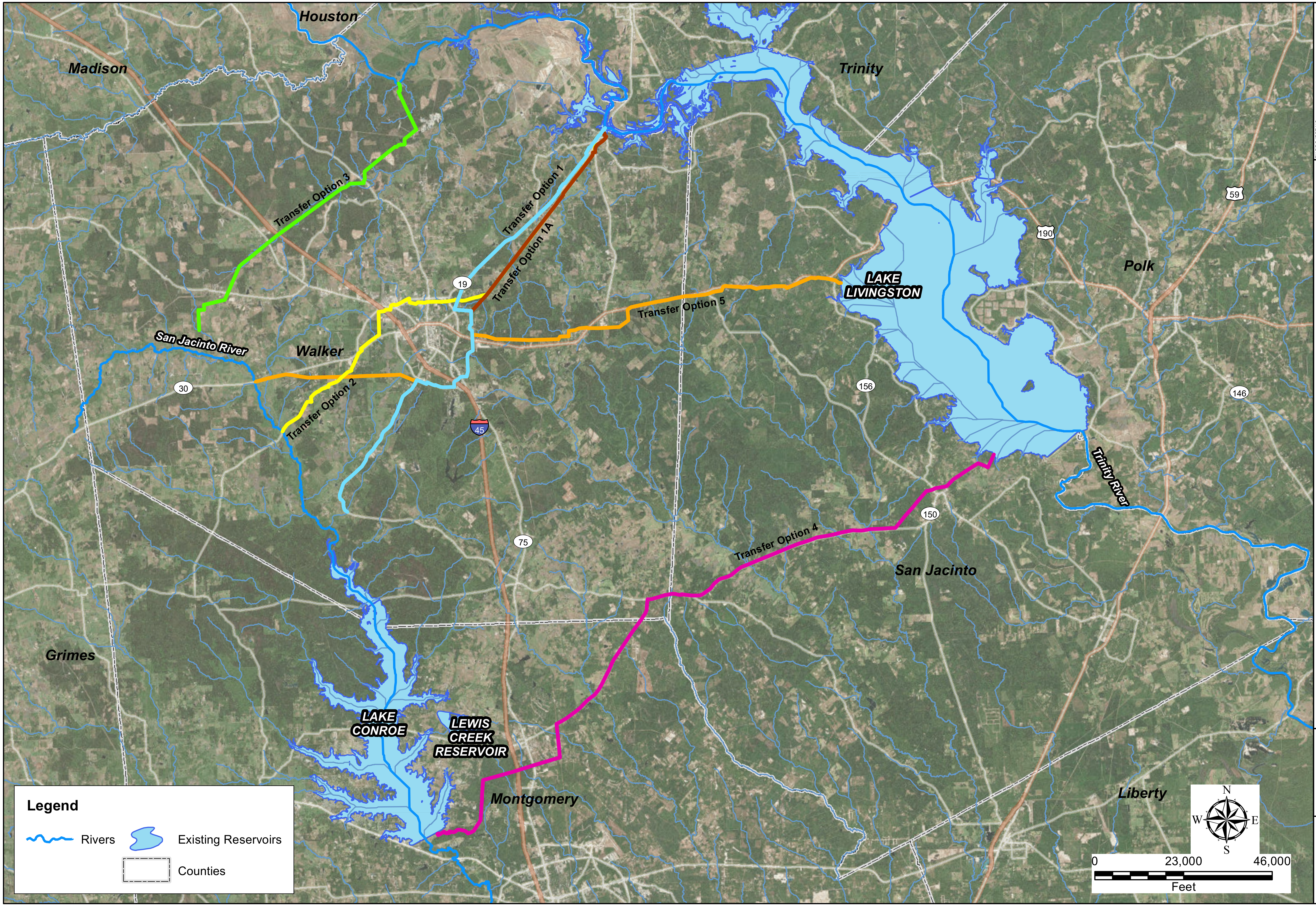
Table 11 - Screening Criteria and Scores for the Lake Livingston to Lake Conroe Transfer Strategy

Criteria	Rating					
	Option 1	Option 1A	Option 2	Option 3	Option 4	Option 5
Cooperation	3	3	3	3	3	3
Cost	3	3	3	3	2	2
Diversification	3	3	3	3	3	3
Environmental	2	2	2	1	3	3
Funding	2	2	2	2	2	2
Land Acquisition	2	2	2	2	2	2
Legal	2	2	2	2	3	3
Location	1	1	1	1	1	1
Magnitude	3	3	3	3	3	3
Other Supplies	4	4	4	4	4	4
Public	3	3	3	3	3	3
Scalability	1	1	1	1	1	1
Schedule	2	2	2	2	2	2
Yield Risk	3	3	3	2	4	4
Weighted Score*	**256**	**256**	**256**	**244**	**234**	**234**

*Based on weighting methodology adopted in Preliminary Strategy Identification and Evaluation (Task 1104)

REFERENCES

2016 Regional Water Plan. Region H Water Planning Group, 2015.



FN PROJECT NO. SJR15616
DATE CREATED 3/5/2018
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central
FILE NAME Exhibit_1_LakeLivingstonToLakeConroe
PREPARED BY DML

SJRA RAW WATER SUPPLY MASTER PLAN

Montgomery County Service Area

All Alternatives
Lake Livingston to Lake Conroe Transfer Strategy

FREESE AND NICHOLS, INC.
10497 TOWN AND
COUNTRY WAY, SUITE 600
HOUSTON, TEXAS 77024
P: (713) 600-6800
F: (713) 600-6801

EXHIBIT

1

Date Saved: 3/5/2018 9:35:11 AM

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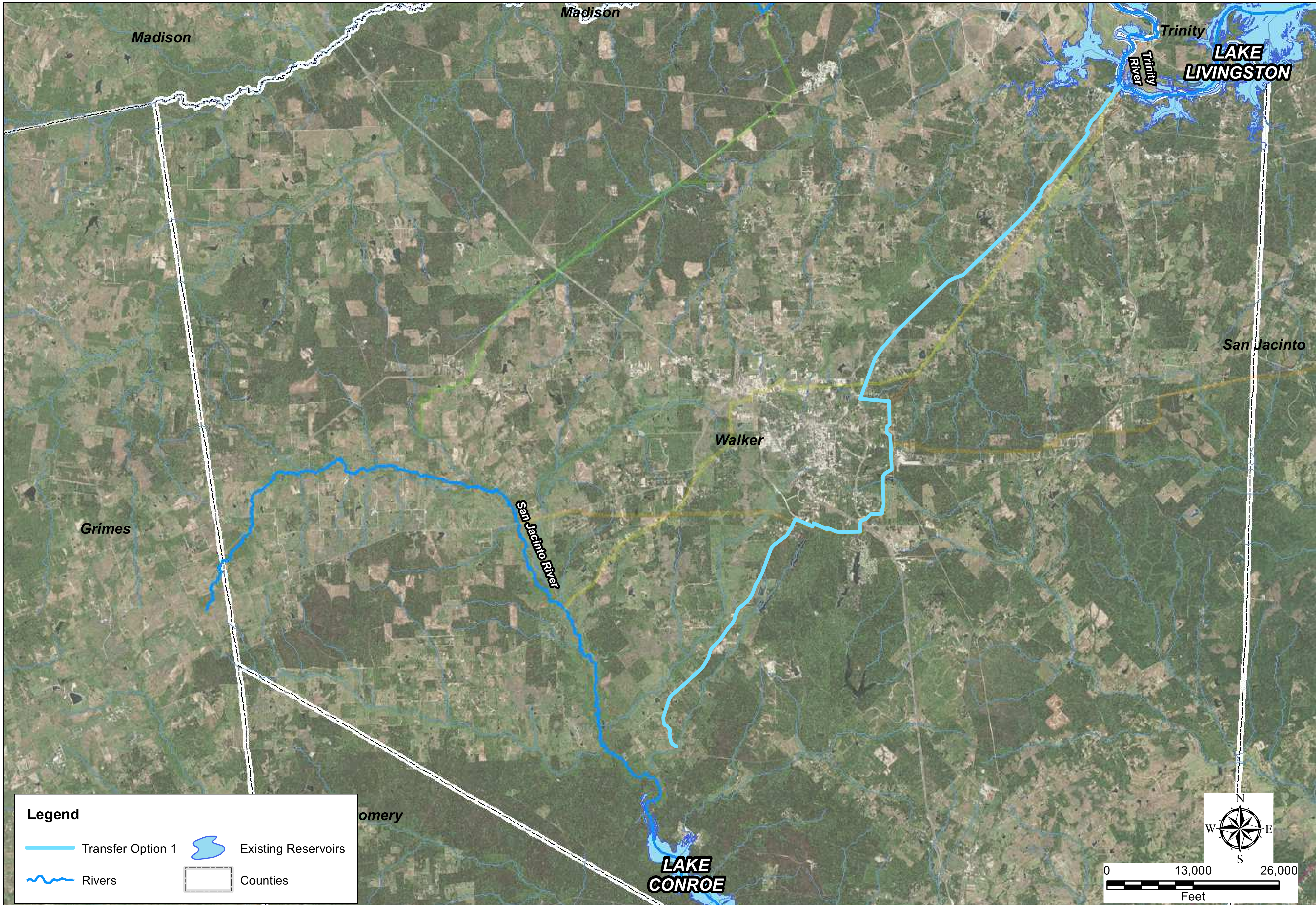

FN PROJECT NO.	SJR15616
DATE CREATED	11/30/2017
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas South Central
FILE NAME	Exhibit_2_Transfer1_Strategy
PREPARED BY	DML

SJRA RAW WATER SUPPLY MASTER PLAN

Montgomery County Service Area

Alternative 1
Lake Livingston to Lake Conroe Transfer Strategy

FREESE AND NICHOLS, INC.
10497 TOWN AND
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EXHIBIT

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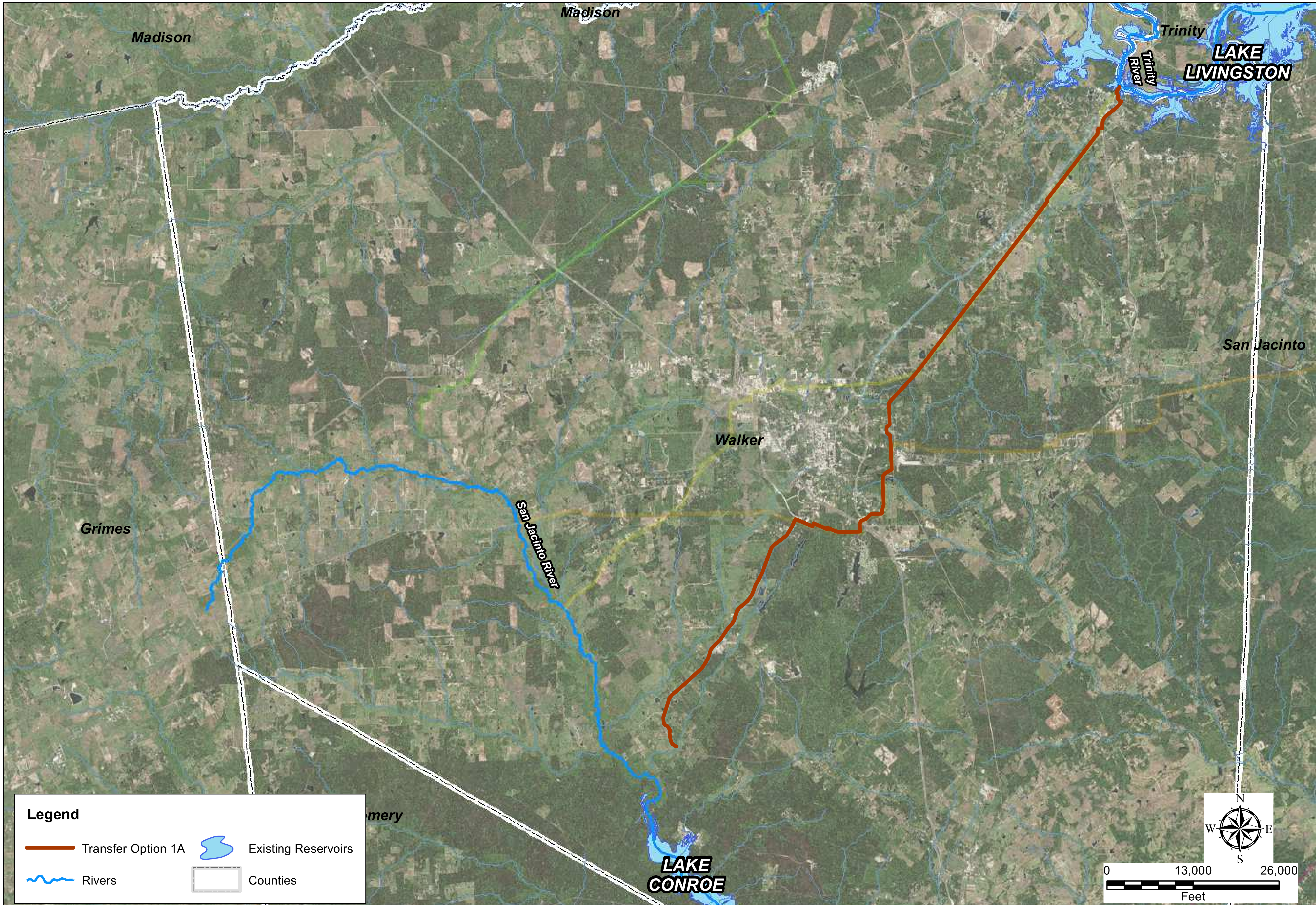

SJRA RAW WATER SUPPLY MASTER PLAN

Montgomery County Service Area

Alternative 1A

Lake Livingston to Lake Conroe Transfer Strategy

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DATE CREATED	11/30/2017
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas South Central
FILE NAME	Exhibit_3_Transfer1A_Strategy
PREPARED BY	DML

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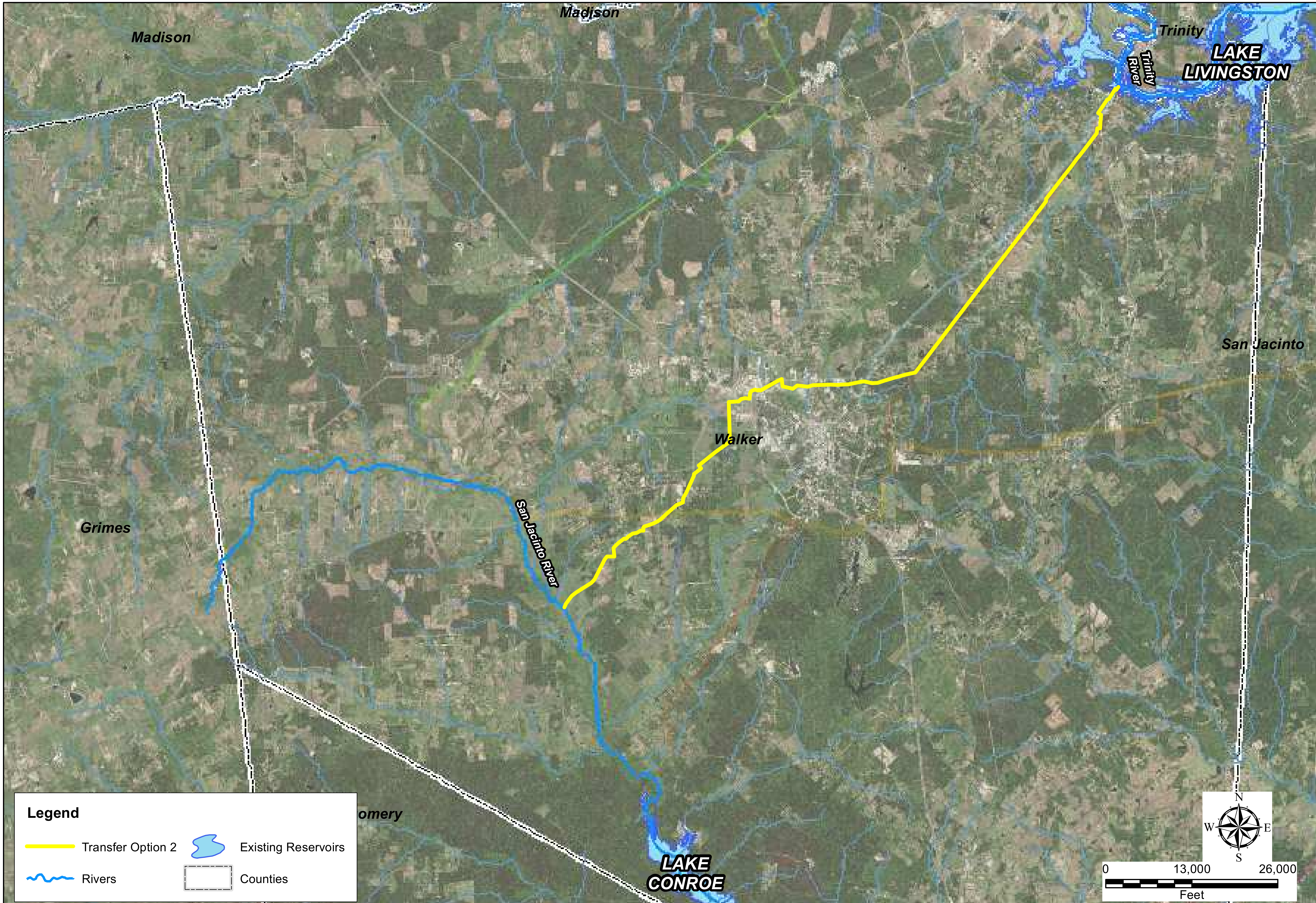

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DATE CREATED 11/30/2017
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central
FILE NAME Exhibit_4_Transfer2_Strategy
PREPARED BY DML

SJRA RAW WATER SUPPLY MASTER PLAN

Montgomery County Service Area

Alternative 2

Lake Livingston to Lake Conroe Transfer Strategy

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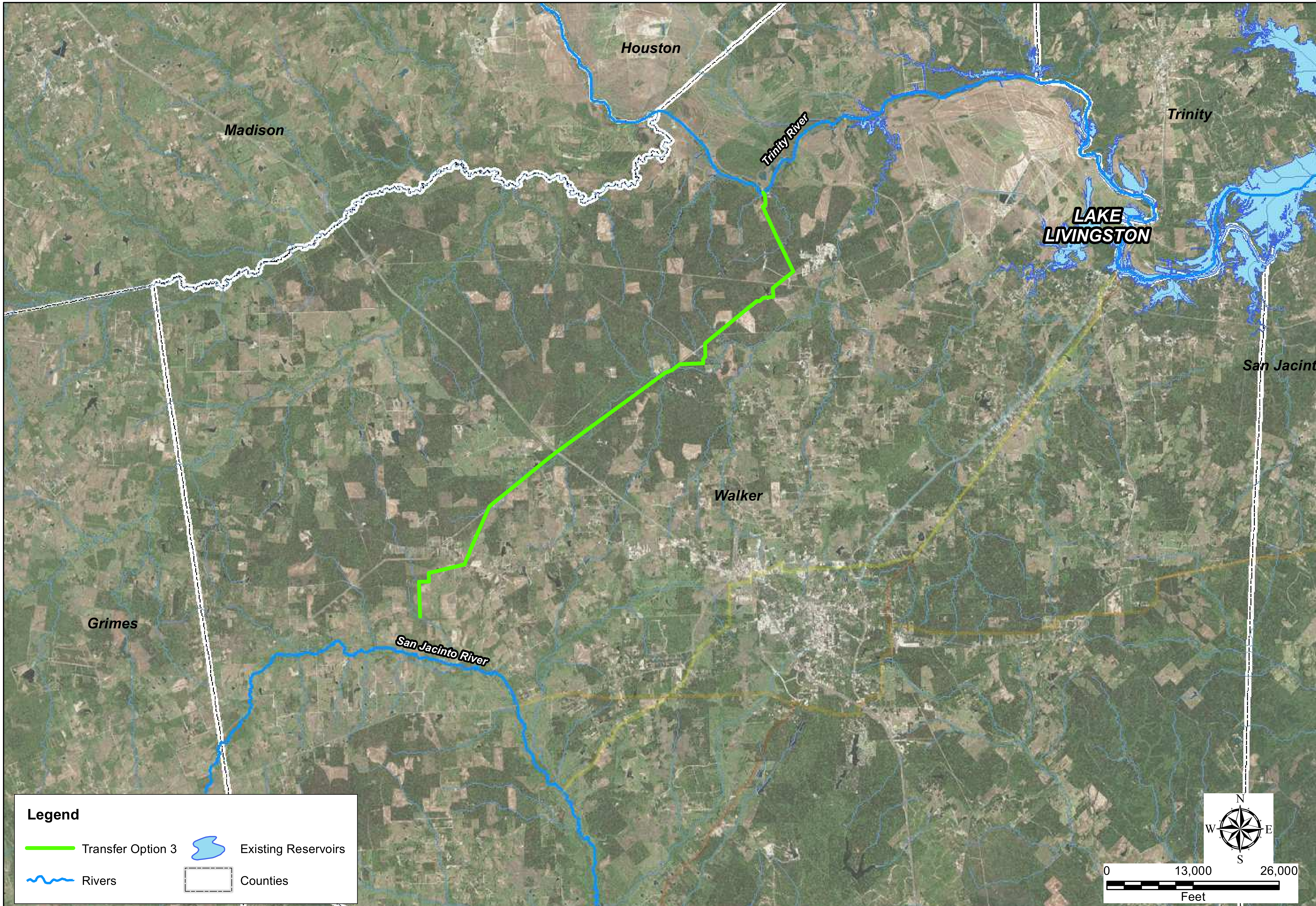

FN PROJECT NO. SJR15616
DATE CREATED 11/30/2017
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central
FILE NAME Exhibit_5_Transfer3_Strategy
PREPARED BY DML

SJRA RAW WATER SUPPLY MASTER PLAN

Montgomery County Service Area

Alternative 3

Lake Livingston to Lake Conroe Transfer Strategy

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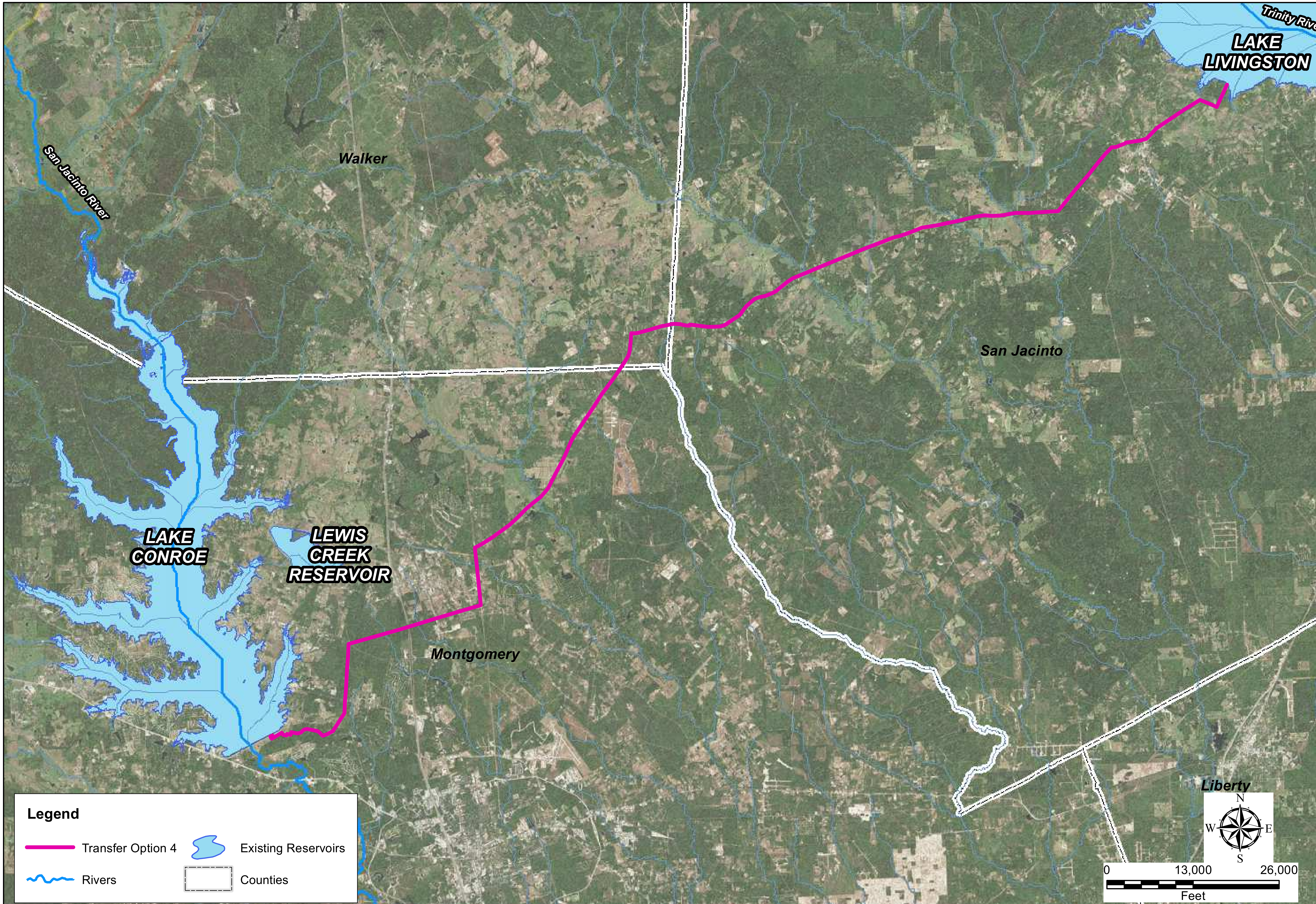

SJRA RAW WATER SUPPLY MASTER PLAN

Montgomery County Service Area

Alternative 4

Lake Livingston to Lake Conroe Transfer Strategy

FN PROJECT NO. SJR15616

DATE CREATED 11/30/2017

DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central

FILE NAME Exhibit_6_Transfer4_Strategy

PREPARED BY DML

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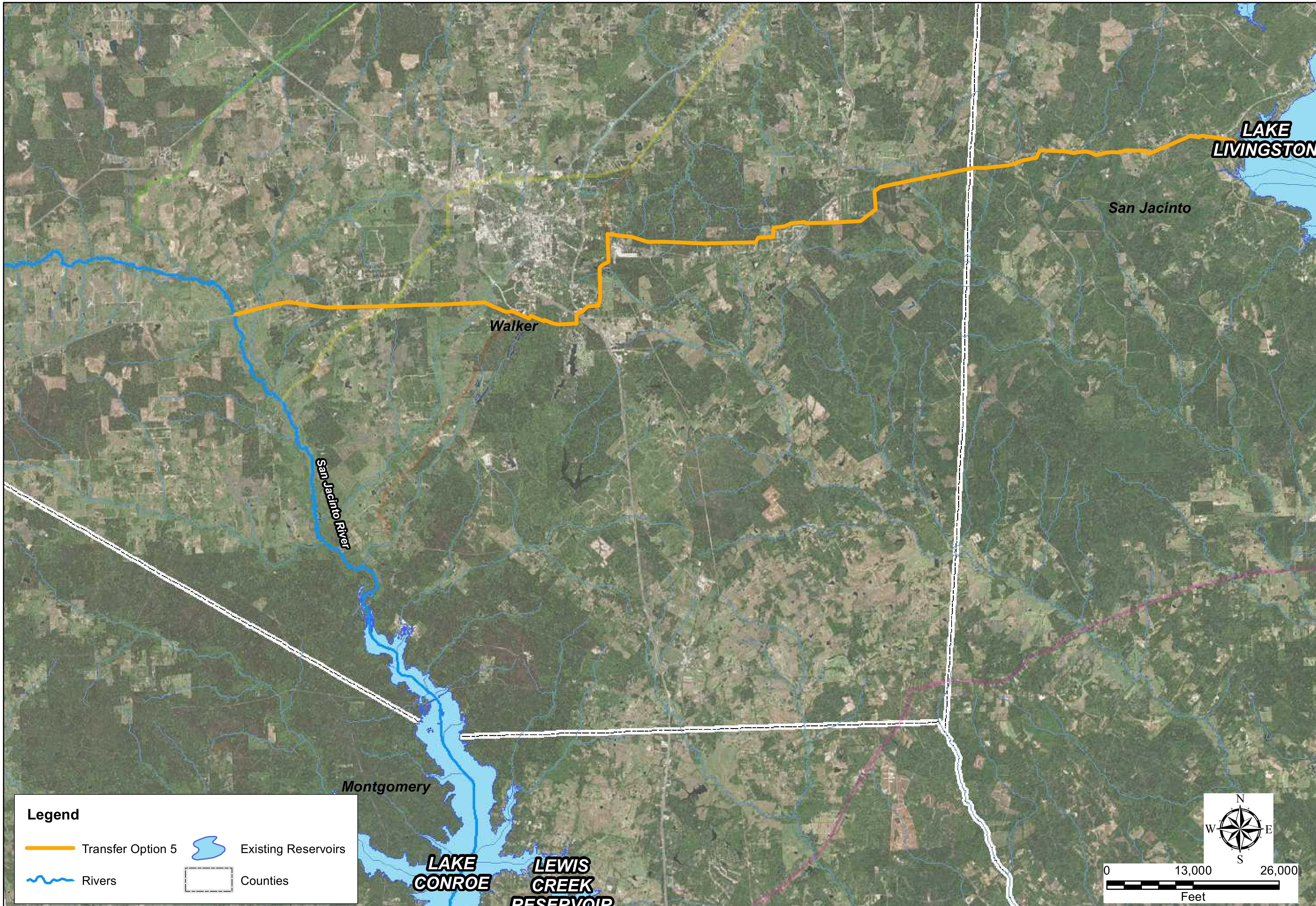

SJRA RAW WATER SUPPLY MASTER PLAN

Montgomery County Service Area

Alternative 5

Lake Livingston to Lake Conroe Transfer Strategy

FN PROJECT NO. SJR15616

DATE CREATED 11/30/2017

DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central

FILE NAME Exhibit_7_Transfer5_Strategy

PREPARED BY DML

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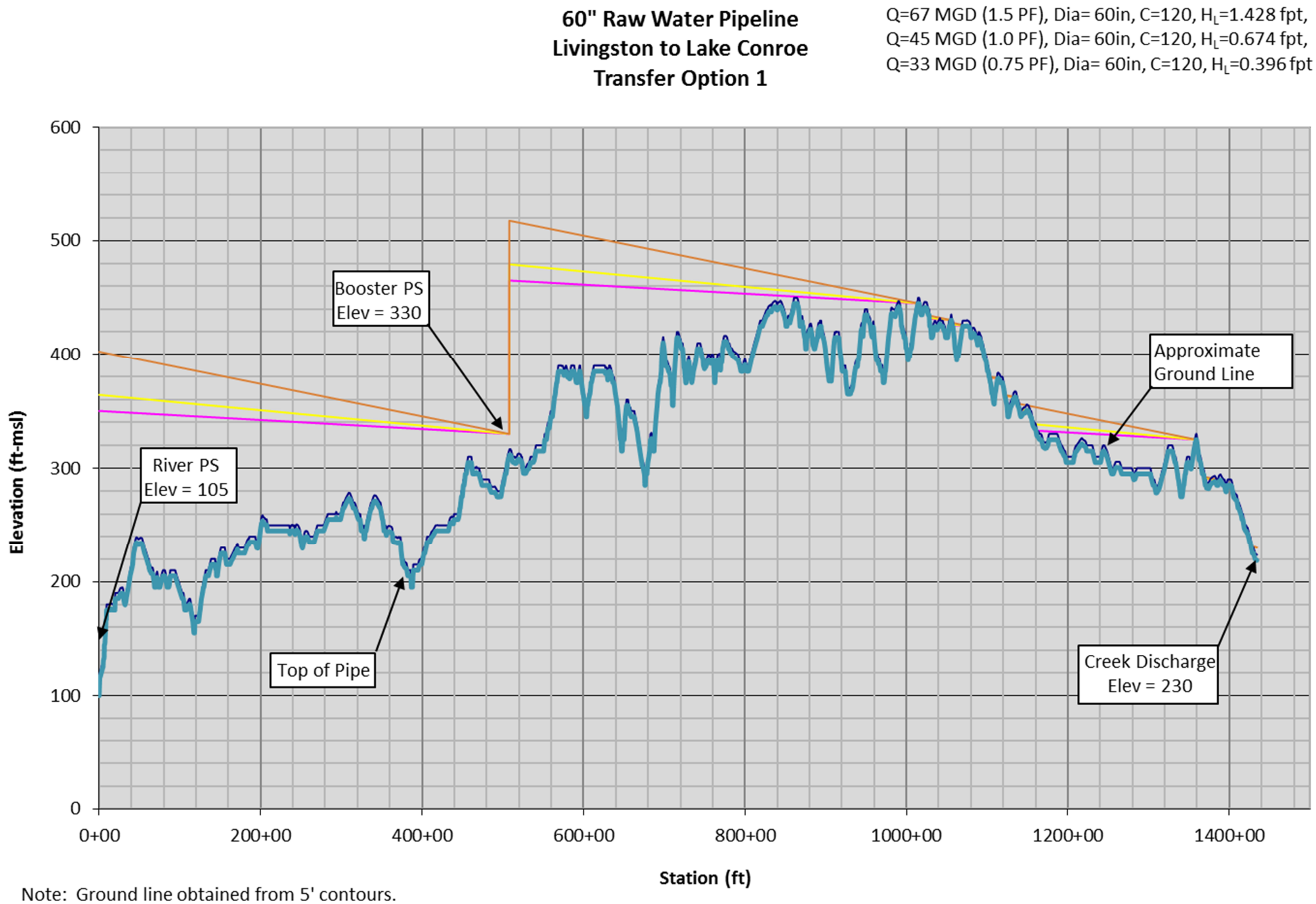
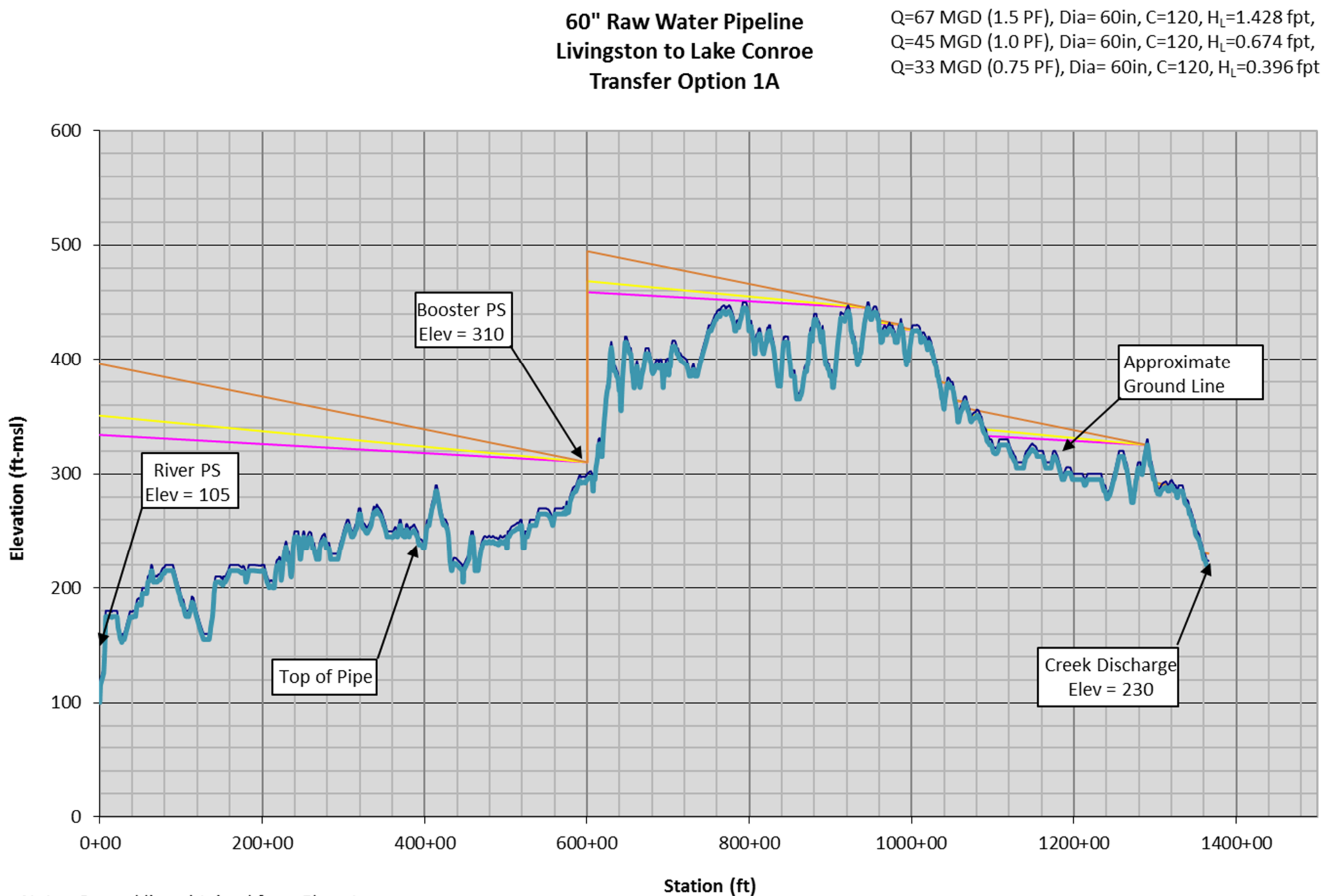
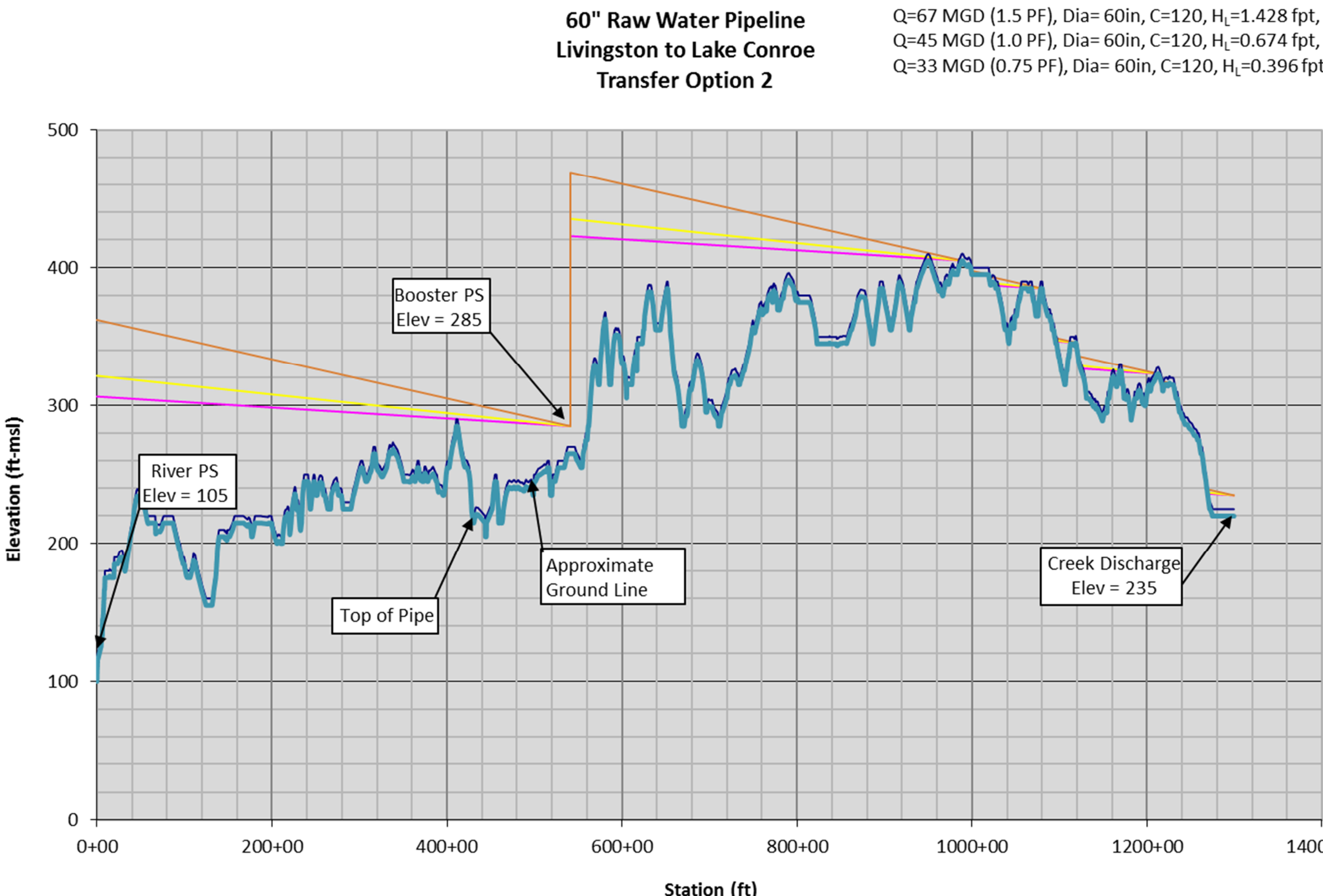


Exhibit 8. Lake Livingston to Lake Conroe Transfer Strategy Hydraulic Grade Line – Transfer Option 1



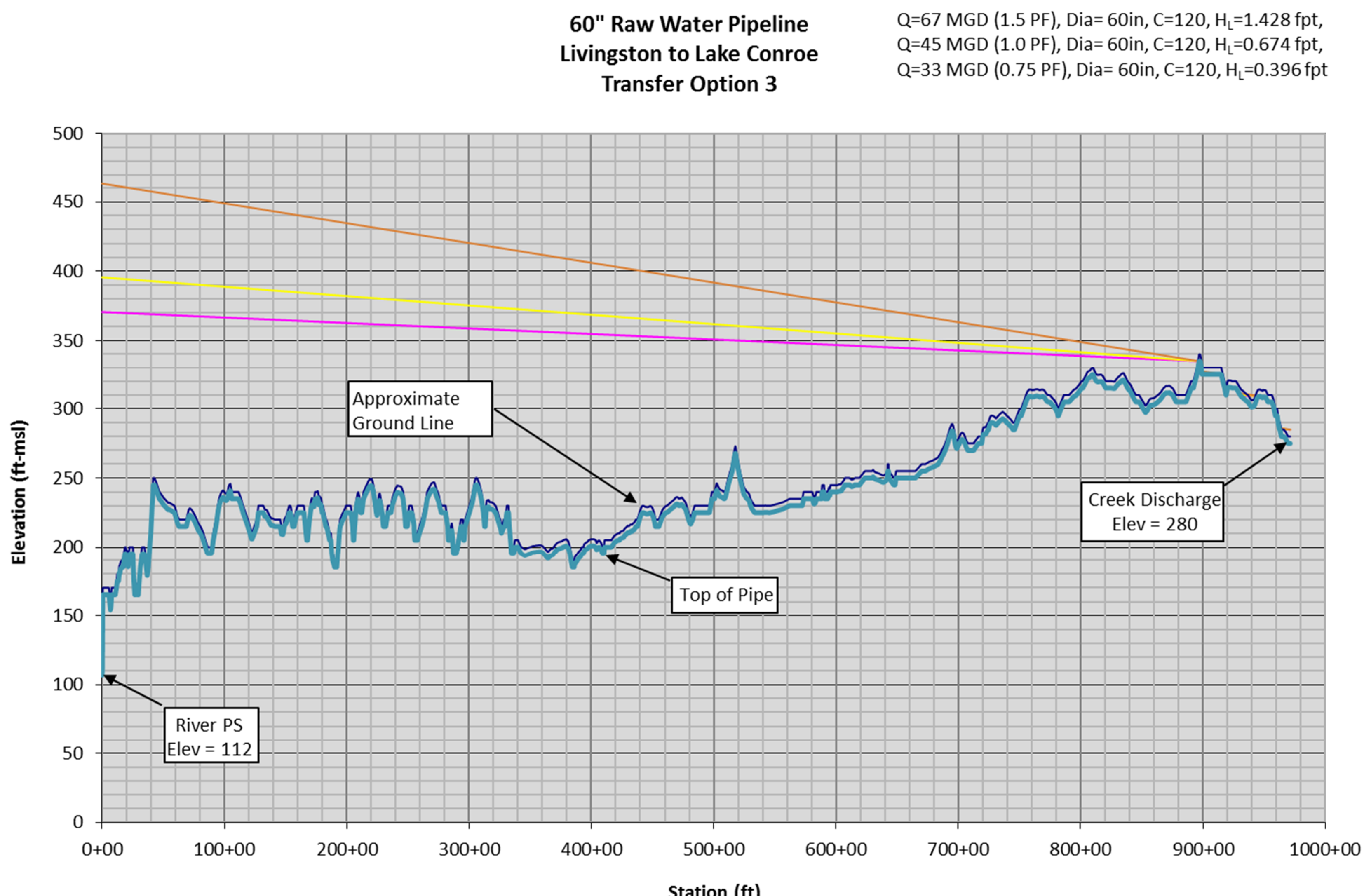
Note: Ground line obtained from 5' contours.

Exhibit 9. Lake Livingston to Lake Conroe Transfer Strategy Hydraulic Grade Line – Transfer Option 1a



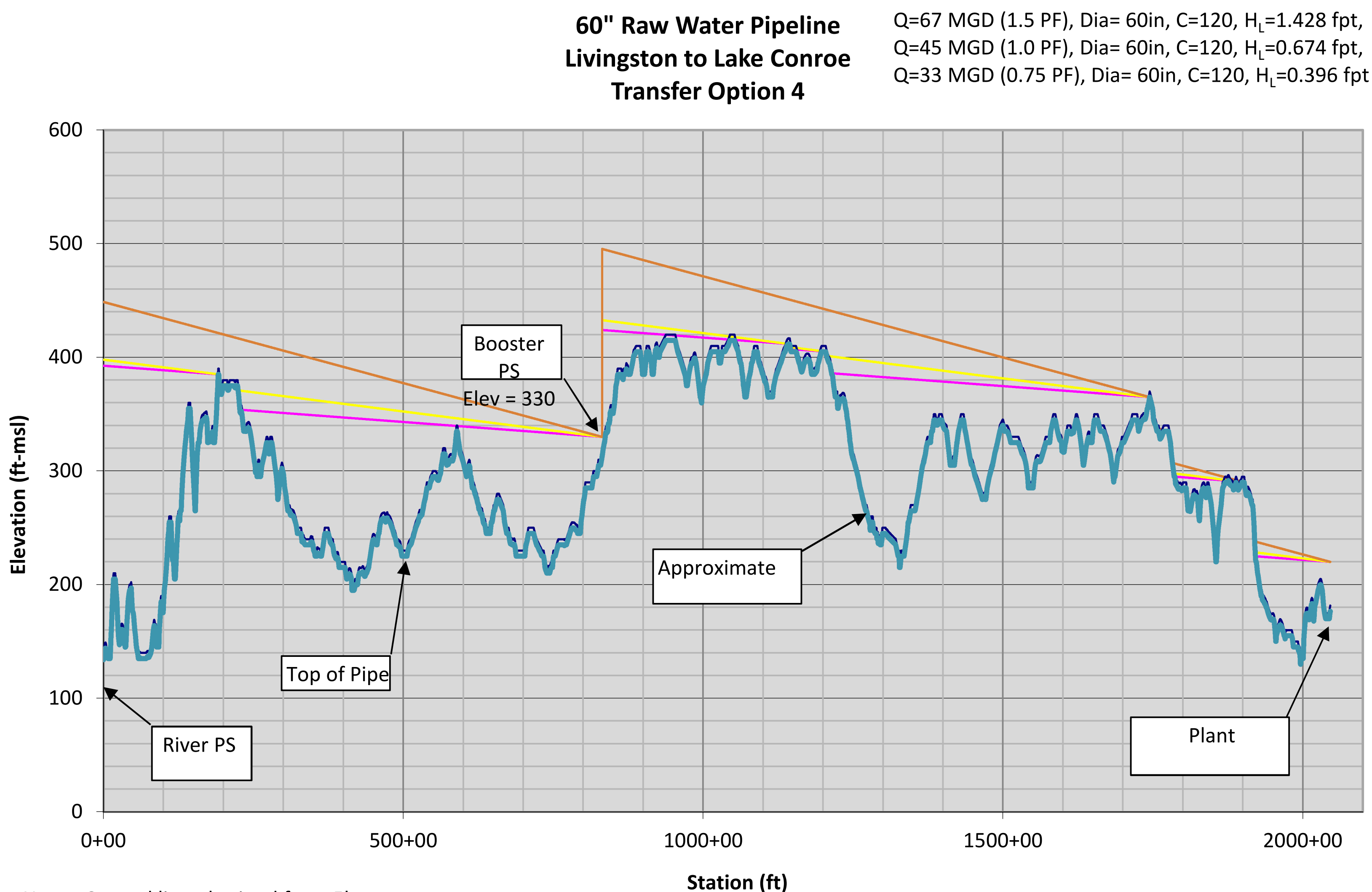
Note: Ground line obtained from 5' contours.

Exhibit 10. Lake Livingston to Lake Conroe Transfer Strategy Hydraulic Grade Line – Transfer Option 2



Note: Ground line obtained from 5' contours.

Exhibit 11. Lake Livingston to Lake Conroe Transfer Strategy Hydraulic Grade Line – Transfer Option 3



Note: Ground line obtained from 5' contours.

Exhibit 12. Lake Livingston to Lake Conroe Transfer Strategy Hydraulic Grade Line – Transfer Option 4

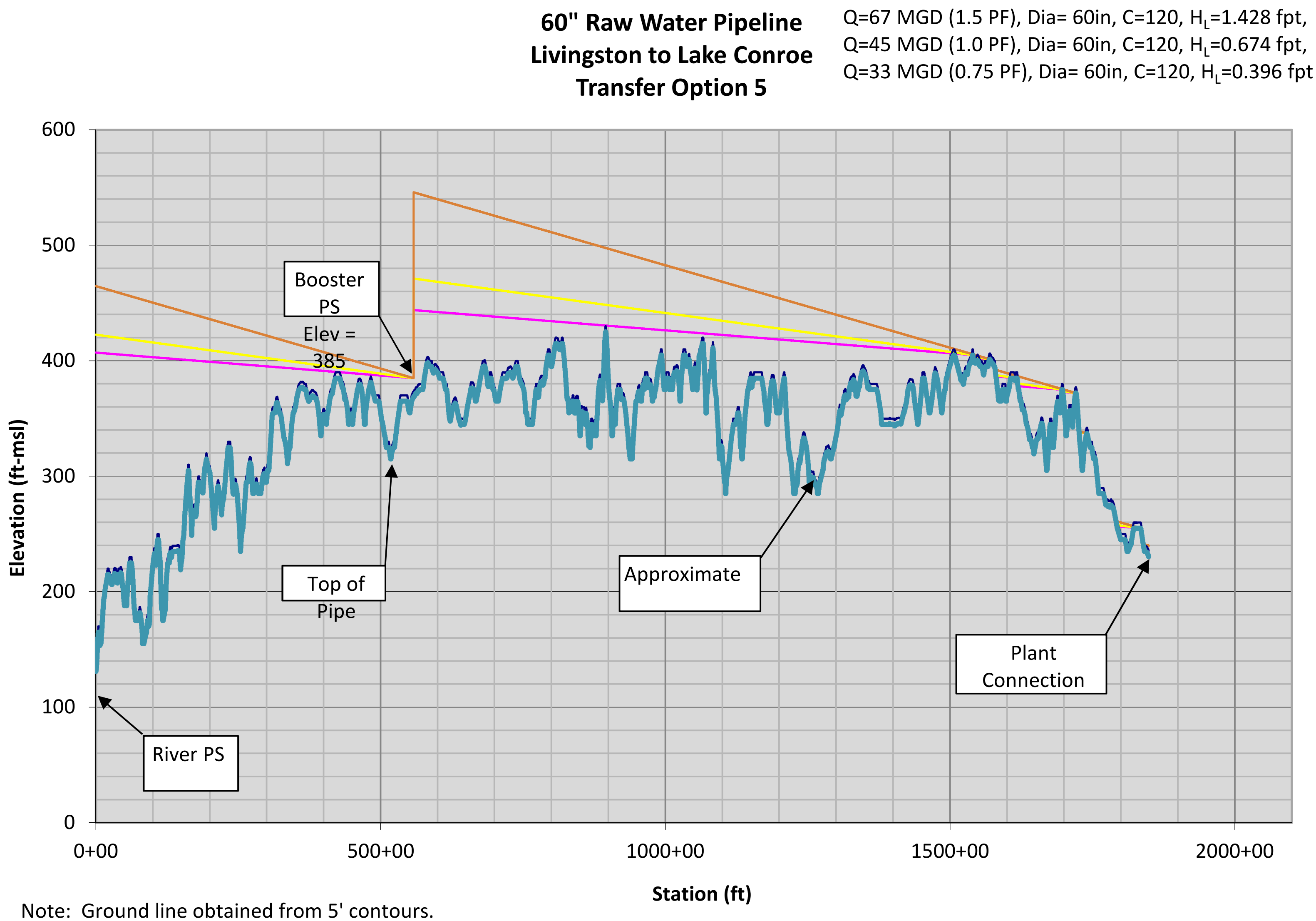


Exhibit 13. Lake Livingston to Lake Conroe Transfer Strategy Hydraulic Grade Line – Transfer Option 5

SAN JACINTO RIVER AUTHORITY RAW WATER SUPPLY MASTER PLAN
DETAILED STRATEGY EVALUATION TECHNICAL MEMORANDUM

Project Name:	Catahoula Aquifer Supplies
Project Type:	New Groundwater Source
Potential Supply Quantity (Rounded):	560 - 10,500 ac-ft/yr (0.5 - 9.4 MGD)
Development Timeline:	2.5 years
Project Capital Cost:	$4,681,000 - $68,582,500 (August 2017 Index)
Unit Water Cost (Rounded):	$520 - $3,346 per ac-ft (during loan period) $384 - $2,899 per ac-ft (after loan period)

STATE OF TEXAS
SPANDANA TUMMURI
107802
LICENSED
PROFESSIONAL ENGINEER

FREESE AND NICHOLS, INC.
TEXAS REGISTERED
ENGINEERING FIRM
F-2144

STRATEGY DESCRIPTION

The San Jacinto River Authority (SJRA) provides water for a variety of municipal, industrial, and irrigation demands in the San Jacinto River Basin. Within Montgomery County, SJRA is responsible for providing alternative water supplies to customers of their Groundwater Reduction Plan (GRP) in order to provide the required reduction in the level of groundwater use. These customer needs are currently met using surface water from Lake Conroe, but another alternative supply exists in the form of groundwater from the Catahoula aquifer which is not regulated in the same way as other aquifer layers in Montgomery County.

The Catahoula aquifer underlays and is not considered part of the Gulf Coast aquifer system, which includes the water-bearing Chicot, Evangeline, and Jasper layers above it. Water from the aquifer has a significant variation in salinity (i.e., Total Dissolved Solids (TDS)), and is recognized by the Lone Star Groundwater Conservation District (LSGCD) as an alternative water supply. The aquifer is currently being used by a small number of public water systems near Lake Conroe through blending with fresher sources. The locations of existing Catahoula aquifer production wells are shown in *Exhibit 1* and contours of TDS are shown in *Exhibit 2*.

Alternative sources, such as the Catahoula aquifer, may be used in conjunction with the existing Lake Conroe supply as an alternative to Gulf Coast aquifer supplies. This project considers the use of the Catahoula aquifer to provide an alternative groundwater supply for meeting GRP participant needs and also explores the opportunity to introduce Catahoula water as a potential raw water source.

STRATEGY ANALYSES

The project analyses for Catahoula aquifer supplies include evaluations of the potential supply to be created, environmental factors involved in the project, permitting and development considerations, and an analysis of project cost.

Supply Development

The proposed strategy is composed of four project options:

1. Blending treated Catahoula water with raw surface water, then treating blended water with the existing SJRA Surface Water Facility (SWF);
2. Blending disinfected Catahoula water with finished surface water at the existing SJRA WTP.
3. Blending disinfected Catahoula water in a GRP participant's existing storage tank.
4. Direct discharge to raw surface water by transferring Catahoula water to Lake Conroe.

Exhibit 1 is an overview map showing the general extents of the study area considered for evaluating the Catahoula aquifer supplies. *Exhibit 2* is an illustration of the generalized TDS contours in the study area. The general locations of the three strategy options considered for developing Catahoula supplies are also included in *Exhibit 1*. *Exhibits 3-7* are individual location maps for each of the four options discussed in this technical memorandum. It is assumed that SJRA can produce 10,500 ac-ft/yr from the Catahoula aquifer. This amount is the difference between an assumed total maximum Catahoula supply of 15,000 ac-ft/yr[1], and the 2016 Catahoula pumpage of 4,500 ac-ft/yr reported to the LSGCD. Different assumptions may produce a more significant potential yield but will be subject to further study of the aquifer. Supply development for each option is discussed below.

Strategy Alternative Option 1 - This option, illustrated in *Exhibit 3*, considers the development of four 2,000 gallons per minute (GPM) wells, each at a depth of 2,500 feet, to produce water from the Catahoula aquifer located beneath SJRA property at the Lake Conroe Dam. The groundwater would be treated through a separate reverse osmosis process in order to reduce TDS to an acceptable level before being blended with raw water from Lake Conroe. The combined supply stream could then be treated by the existing SJRA SWF.

Key considerations related to this option include:

- In the absence of Catahoula aquifer water quality data at the Lake Conroe dam, water quality data from nearby Catahoula aquifer wells are assumed to be representative of conditions at the proposed well sites;
- The corrosion potential for the Catahoula aquifer water is high due to very low calcium hardness and high TDS. Treatment is essential for this option in order to prevent conflict with the treatment process that is designed for the water quality of Lake Conroe;
- There is considerable amount of heat load associated with the Catahoula water; therefore, consideration of cooling towers for managing the heat load and water quality is recommended.

Strategy Alternative Option 2 - The volume of groundwater that can be produced from the Catahoula aquifer and the wellfield layout is identical to Option 1. In Option 2, groundwater is not treated

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[1] LSGCD rules do not currently (May 2017) specify the maximum total volume of Catahoula aquifer water that may be permitted. LSGCD is currently studying the effects that long-term Catahoula aquifer production has on both the Catahoula aquifer, and the Gulf Coast aquifer system. The 15,000 ac-ft/yr maximum supply is an assumed volume based on discussions with LSGCD's consultant performing the study, and may change in the future as more information is developed.

through a costly reverse osmosis treatment process but is disinfected and piped to existing clearwells for blending at the SJRA WTP. This approach parallels the current use of Catahoula by many utilities in Montgomery County that blend Catahoula water with their existing water supplies in ground storage tanks (GSTs). Option 2 is illustrated in *Exhibit 4*. Total new supply is 10,500 ac-ft/yr.

Key considerations related to this option include:

- In the absence of Catahoula aquifer water quality data at the Lake Conroe dam, water quality data from nearby Catahoula aquifer wells are assumed to be representative of conditions at the proposed well sites;
- Water quality of Lake Conroe varies with depth and location and therefore its quality is assumed as a conservative estimate;
- Corrosion parameters could be an issue – low calcium, high chloride to sulfate mass ratio;
- High alkalinity may mitigate corrosion;
- Disinfection By-Products (DBPs) – Higher TDS and bromide could increase DBPs in transmission system;
- Fluoride of Catahoula water at 2.1 mg/L is above Secondary Constituent Level of 2.0 mg/L;
- Blending with surface water will decrease TDS, Fluoride, and Chloride;
- It is recommended that the blend of groundwater to surface water never exceed 50% to maintain acceptable water quality.

<u>Strategy Alternative Option 3</u> - Many of SJRA's smaller GRP participants are spread out geographically, making it economically infeasible to serve them with treated surface water. These customers currently use Gulf Coast Aquifer groundwater, which is disinfected before entering the customers' storage tanks. Option 3 of the Catahoula aquifer supply strategy considers constructing a Catahoula aquifer well at the site of a GRP participant's existing tank and either blending the Catahoula water with Gulf Coast aquifer water in the tank or replacing the Gulf Coast aquifer supply altogether.

The existing public water supply systems that have developed Catahoula aquifer supplies in the area north and west of the 1,000 mg/L TDS contour are shown in *Exhibit 2*. For this study, only GRP participants that are north and west of this line, not near the existing GRP pipeline, and not already being supplied by Catahoula water, were considered. The average water demand of eligible customers is 0.09 million gallons per day (MGD), median demand is 0.05 MGD, and maximum demand is 0.50 MGD. These limited demands significantly reduce the potential for serving customers a reasonable blend of water from a Catahoula well without extensive, cost-prohibitive conveyance infrastructure.

Costs were developed for Montgomery County UD #2, the eligible GRP participant with the highest maximum demand, 0.50 MGD. Montgomery County UD #2 is already built out and currently has three Jasper aquifer wells with a single GST. This option considers construction of a new Catahoula aquifer well on the same site as the existing Jasper wells, a new disinfection system for the Catahoula well, and a connection to the existing GST. Option 3 is illustrated in *Exhibit 5*. TDS at Far Hills Utility District, a nearby public water system using Jasper supplies, is 416 mg/L. Assuming that TDS at Montgomery County UD #2 is similar, it is possible that the entire Jasper supply could be replaced by the Catahoula supply. A distribution line to transfer supplies to other GRP participant wells from Montgomery County UD #2, while feasible, would be costly; therefore, was not included in this analysis.

Key considerations related to this option include:

- The nearest measured TDS is at Far Hills UD, approximately 1.7 miles southeast of Montgomery County UD #2. Analysis at Far Hills UD showed a TDS of 416 mg/L. Assuming a similar TDS at Montgomery County UD #2, it may be feasible to replace their Jasper supply with the proposed Catahoula supply, pending site-specific water quality analysis;

- If TDS values increase in the future, existing Jasper wells could be used to reduce overall TDS through blending;
- Blending in the GST is preferable to blending directly in the distribution system. To aid in complete mixing, blending directly in the distribution system would have to be achieved by utilizing multiple entry points, increasing the cost and complexity of operating the system. Even with multiple entry points, there would be a risk that retail customers near each entry point would experience increased temperature and salinity in the water.
- Development of this strategy would mean the abandonment of existing groundwater infrastructure owned by Montgomery UD #2. This would have to be considered in the evaluation of costs for the project.
- This strategy could be scaled up for supplying other utilities, including other larger systems that may be developed within the zones of higher water quality as the GRP expands to include customers through the Safe Harbor GRP provision.

<u>Strategy Alternative Option 4</u> - A fourth option for implementing the Catahoula aquifer supplies strategy is to consider pumping water from the aquifer and directly discharging it into Lake Conroe. Multiple wells can be located in the Catahoula aquifer in the locations that are in close proximity to Lake Conroe near the Sam Houston National Forest area. The quality of water in the Catahoula aquifer is superior at the Sam Houston National Forest area and, therefore, provides better opportunities for discharging Catahoula supplies to Lake Conroe without significantly impacting the quality of the receiving water body. Similar to other options, approximately 10,500 acre-feet per year of supplies is assumed to be available for direct discharge into Lake Conroe.

Four wells were sited to produce the available yield of 10,500 acre-feet per year. Option 4 considers two production wells on the east side and the remaining two on the west side of Lake Conroe in the Sam Houston National Forest area. *Exhibits 6* includes the illustrations of Option 4. In this option, the wells were located in close proximity to Lake Conroe to minimize the transmission system required to discharge the aquifer supplies into the Lake. The well locations would be finalized in later phases based on accessibility and proximity to utility service. One of the biggest benefits of this option is the flexibility of the blending rate. Given that the volumes of Catahoula aquifer supplies are limited compared to the Lake Conroe volumes, the rate at which the Catahoula water is blended with the lake supplies is not a concern. Water can be directly discharged into the lake with minimal need for a transmission system. Groundwater is accessible at shallower depths in the proximity of the lake Conroe near the Sam Houston National Forest area and the aquifer is also capable of producing higher yields at this location. The groundwater produced in this location would be of superior quality compared to areas of higher development to the south and east. Discharging into the lake also helps address the issue of the heat load of the produced Catahoula water, thus precluding the need for cooling towers or any other water quality infrastructure.

The volume of water produced in this strategy will be of raw water quality as opposed to the treated water produced in other strategies. A cost estimate for the alternative discussed in this option is included below.

Key considerations related to this option include:

- SJRA will need to acquire the land for the well locations. For instance, they may be able to lease the land from the Sam Houston National Forest Service.

- Access to power supply must be ascertained for each well location and also access from the well location to Lake Conroe.
- There will be reduced pumping costs during wet periods.
- SJRA will have to develop an operations plan based on the lake level fluctuations to determine the ideal timing for pumping groundwater into the reservoir. This supply will be coordinated with other reservoir, customer, and treatment operations through supervisory control and data acquisition (SCADA).
- SJRA will have to coordinate with TCEQ on a bed and banks permit for conveying the water through the lake.
- The impact of the Catahoula water to lake levels and water quality will have to be considered and may require a diffuser system to provide localized mixing at the discharge location.
- Compared to Option 2, it has much less desirable cost.

Environmental Considerations

Following are some of the general environmental considerations associated with the distribution system identified for developing supplies in Options 1 - 4. A desktop-level survey was conducted to identify any environmental issues associated with the specific routes and sites. The details of the survey are summarized below.

1. The USFWS IPaC webservice was consulted to obtain a list of federally-listed species and designated critical habitat segments that could occur within the general project area. The federally-protected species listed below, comprised of five bird species and four flowering plant species, were identified by the IPaC query as potentially occurring within the general project area. Though some of these species have designated critical habitats, no critical habitat tracts/segments occur within the overall project area.

    - Least tern (*Sterna antillarum*)
    - Piping plover (*Charadrius melodus*)
    - Red knot (*Calidris canutus rufa*)
    - Red-cockaded woodpecker (*Picoides borealis*)
    - Whooping crane (*Grus americana*)
    - Navasota ladies' tresses (*Spiranthes parksii*)
    - Neches River rose-mallow (*Hibiscus dasycalyx*)
    - Texas prairie dawn-flower (*Hymenoxys texana*)
    - Texas trailing phlox (*Phlox nivalis* spp. *texensis*)

    Of these protected species, the following have potential to be affected by the proposed project, and would require a presence/absence survey of the selected/preferred facility locations prior to construction should the project require permitting through the USACE for anticipated impacts to regulated waters of the U.S. (WOTUS).

    - Red-cockaded woodpecker (*Picoides borealis*)
    - Navasota ladies' tresses (*Spiranthes parksii*)

- Neches River rose-mallow (*Hibiscus dasycalyx*)
- Texas prairie dawn-flower (*Hymenoxys texana*)
- Texas trailing phlox (*Phlox nivalis* spp. *texensis*)

2. Due the presence of streams, wetlands and ponds that could be deemed WOTUS and jurisdictional to Section 404 of the Clean Water Act (CWA) throughout distribution system alignments, acquiring a permit(s) through the USACE would be required prior to beginning construction activities. Pending the level of potential WOTUS impacts, project activities could likely be covered by a Nationwide Permit. Nationwide Permits are typically obtained within 45 to 60 calendar days, but acquiring an Individual Permit typically requires a minimum of 180 calendar days and a public comment period.

3. If no federal funding or assistance would be used for construction of the proposed project, the need to complete a National Environmental Policy Act (NEPA) process would not be required. However, coordination with the USACE to obtain a CWA Section 404 permit, particularly an Individual Permit, could trigger the need to comply with the NEPA review process.

Summary of desktop survey findings specific to each alternative alignment:

Table 1 below is a summary of the desktop-level environmental constraints information pertaining to the study area considered in this evaluation. Acreages listed below for ponds, prime farmland soil tracts, and wetlands are the amount of these features that are potentially present within buffered boundaries depicted by the study area.

Table 1. Summary of Desktop Environmental Constraints for Catahoula Supply Infrastructure

Transmission Route Option	Ponds/Acres	Stream Crossings	Potential Wetlands	Total Wetlands Acreage (Acres)	Prime Farmland Soil Tracts	Farmland Acreage (Acres)
Option 1	0	0	0	0	0	0
Option 2	0	0	0	0	0	0
Option 3	0	0	0	0	0	0
Option 4	0	0	0	0	0	0

Permitting and Development

To develop any of the Catahoula groundwater supply options, permits must be sought from the LSGCD to allow for drilling a test bore in the Catahoula formation, and then to permit the production from any completed wells. A Texas Commission on Environmental Quality (TCEQ) plan review would be required for Options 1 through 3. For Option 1, a permit from the Railroad Commission of Texas would be required for an injection well to dispose of RO concentrate. A bed and banks permit is needed for direct blending of Catahoula water with Lake Conroe, as described in Option 4. This option may also require a TPDES permit.

Cost Analysis

Preliminary opinions of the probable construction costs were developed based on planning-level details considered for the four alternatives evaluated in this strategy. The cost estimates were developed using the approach used for the Region H regional planning strategy evaluation and indexed to August 2017 dollars. It should be noted that these cost estimates are preliminary planning level cost estimates and cannot be used for contracting or designing purposes. Detailed cost estimates must be developed during the feasibility or design phases of the study. The required pumpage fee to LSGCD is included in the unit cost estimates. A summary of the cost estimates for the four alternatives considered in this strategy is provided in *Table 2* below. Costs for the project options are detailed below in *Tables 3* through *5*.

Table 2. Summary of Preliminary Planning Level Cost Estimates for Developing Catahoula Aquifer Supplies

Strategy Alternative	Capital Costs	Annual Costs (With Debt Service)	Annual Costs (without Debt Service)	Per Ac-Ft Cost (With Debt Service)	Per Ac-Ft Cost (Without Debt Service)
Option 1	$68,582,500	$35,129,000	$29,390,690	$3,346	$2,799
Option 2	$17,054,000	$5,458,000	$4,031,000	$520	$384
Option 3	$4,681,000	$634,100	$242,000	$1,132	$433
Option 4 [1]	$14,186,000	$5,589,000	$4,402,000	$532	$419

[1] This option provides raw water that must be treated at the SJRA SWF in order to provide treated water supply.

Table 3 – Option 1: Treated Groundwater Blended with Raw Water at Surface Water Facility

OPINION OF PROBABLE CONSTRUCTION COST					September 13, 2017
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
PROJECT CAPITAL COST SUMMARY					
1	CONSTRUCTION COST	1	LS	$49,791,098	$49,791,098
2	ENGINEERING, FINANCIAL, AND LEGAL SERVICES AND CONTINGENCIES	1	LS	$17,329,810	$17,329,810
3	LAND AND EASEMENTS	1	LS	$77,550	$77,550
4	ENVIRONMENTAL - STUDIES AND MITIGATION	1	LS	$270,845	$270,845
5	INTEREST DURING CONSTRUCTION	1	LS	$1,113,307	$1,113,307
	PROJECT CAPITAL COST				$68,582,611

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	DEBT SERVICE	$5,738,947	$5,738,947	$0	$0	$0	$0
2	OPERATION AND MAINTENANCE (O&M)	$25,482,452	$25,482,452	$25,482,452	$25,482,452	$25,482,452	$25,482,452
3	PUMPING ENERGY COSTS	$3,702,962	$3,702,962	$3,702,962	$3,702,962	$3,702,962	$3,702,962
4	PURCHASE COST OF WATER	$205,275	$205,275	$205,275	$205,275	$205,275	$205,275
	TOTAL ANNUAL COST	$35,129,637	$35,129,637	$29,390,690	$29,390,690	$29,390,690	$29,390,690

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	ANNUAL COST	$35,129,637	$35,129,637	$29,390,690	$29,390,690	$29,390,690	$29,390,690
2	YIELD	10,500	10,500	10,500	10,500	10,500	10,500
3	UNIT COST	$3,346	$3,346	$2,799	$2,799	$2,799	$2,799
	TOTAL UNIT COST						$2,981

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION COST SUMMARY					
1	PIPELINES	1	LS	$1,785,732	$1,785,732
2	PIPELINE CROSSINGS	1	LS	$155,751	$155,751
3	WATER TREATMENT PLANTS	1	LS	$37,434,614	$37,434,614
4	WELL FIELDS	1	LS	$9,415,002	$9,415,002
5	CONNECT TO EXISTING RAW SURFACE WATER SUPPLY	1	LS	$1,000,000	$1,000,000
	PROJECT COST				$49,791,098

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
OPERATION AND MAINTENANCE (O&M) COST SUMMARY					
1	PIPELINES	1.0	%	$1,785,732	$17,857
2	PIPELINE CROSSINGS	1.0	%	$155,751	$1,558
3	WATER TREATMENT PLANTS	66.7	%	$37,434,614	$24,968,887
4	WELL FIELDS	1.0	%	$9,415,002	$94,150
5	CONNECTION, ADDITION OF LIME AND CARBON DIOXIDE	40.0	%	$1,000,000	$400,000
	ANNUAL OPERATION AND MAINTENANCE COST				$25,482,452

Table 4 – Option 2: Blending with Treated Surface Water at SWF

OPINION OF PROBABLE CONSTRUCTION COST					September 13, 2017
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**TOTAL**
PROJECT CAPITAL COST SUMMARY					
1	CONSTRUCTION COST	1	LS	$12,356,484	$12,356,484
2	ENGINEERING, FINANCIAL, AND LEGAL SERVICES AND CONTINGENCIES	1	LS	$4,227,695	$4,227,695
3	LAND AND EASEMENTS	1	LS	$0	$0
4	ENVIRONMENTAL - STUDIES AND MITIGATION	1	LS	$193,295	$193,295
5	INTEREST DURING CONSTRUCTION	1	LS	$276,844	$276,844
	PROJECT CAPITAL COST				**$17,054,319**

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
1	DEBT SERVICE	$1,427,094	$1,427,094	$0	$0	$0	$0
2	OPERATION AND MAINTENANCE (O&M)	$123,565	$123,565	$123,565	$123,565	$123,565	$123,565
3	PUMPING ENERGY COSTS	$3,702,962	$3,702,962	$3,702,962	$3,702,962	$3,702,962	$3,702,962
4	PURCHASE COST OF WATER	$205,275	$205,275	$205,275	$205,275	$205,275	$205,275
	TOTAL ANNUAL COST	**$5,458,896**	**$5,458,896**	**$4,031,802**	**$4,031,802**	**$4,031,802**	**$4,031,802**

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
1	ANNUAL COST	$5,458,896	$5,458,896	$4,031,802	$4,031,802	$4,031,802	$4,031,802
2	YIELD	10,500	10,500	10,500	10,500	10,500	10,500
3	UNIT COST	$520	$520	$384	$384	$384	$384
	TOTAL UNIT COST						**$429**

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION COST SUMMARY					
1	PIPELINES	1	LS	$1,785,732	$1,785,732
2	PIPELINE CROSSINGS	1	LS	$155,751	$155,751
3	WELL FIELDS	1	LS	$9,415,002	$9,415,002
4	CONNECT TO EXISTING CLEARWELL	1	LS	$1,000,000	$1,000,000
	PROJECT COST				**$12,356,484**

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
OPERATION AND MAINTENANCE (O&M) COST SUMMARY					
1	PIPELINES	1.0	%	$1,785,732	$17,857
2	PIPELINE CROSSINGS	1.0	%	$155,751	$1,558
3	WELL FIELDS	1.0	%	$9,415,002	$94,150
4	CONNECT TO EXISTING CLEARWELL	1.0	%	$1,000,000	$10,000
	ANNUAL OPERATION AND MAINTENANCE COST				**$123,565**

Table 5 – Option 3: Blending in GRP Participant Tank

OPINION OF PROBABLE CONSTRUCTION COST					September 13, 2017
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
PROJECT CAPITAL COST SUMMARY					
1	CONSTRUCTION COST	1	LS	$3,382,705	$3,382,705
2	ENGINEERING, FINANCIAL, AND LEGAL SERVICES AND CONTINGENCIES	1	LS	$1,183,292	$1,183,292
3	LAND AND EASEMENTS	1	LS	$4,125	$4,125
4	ENVIRONMENTAL - STUDIES AND MITIGATION	1	LS	$35,716	$35,716
5	INTEREST DURING CONSTRUCTION	1	LS	$76,001	$76,001
	PROJECT CAPITAL COST				$4,681,839

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	DEBT SERVICE	$391,773	$391,773	$0	$0	$0	$0
2	OPERATION AND MAINTENANCE (O&M)	$41,532	$41,532	$41,532	$41,532	$41,532	$41,532
3	PUMPING ENERGY COSTS	$189,895	$189,895	$189,895	$189,895	$189,895	$189,895
4	PURCHASE COST OF WATER	$10,948	$10,948	$10,948	$10,948	$10,948	$10,948
	TOTAL ANNUAL COST	$634,148	$634,148	$242,375	$242,375	$242,375	$242,375

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	ANNUAL COST	$634,148	$634,148	$242,375	$242,375	$242,375	$242,375
2	YIELD	560	560	560	560	560	560
3	UNIT COST	$1,132	$1,132	$433	$433	$433	$433
	TOTAL UNIT COST						$666

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION COST SUMMARY					
1	PIPELINES	1	LS	$13,083	$13,083
2	WATER TREATMENT PLANTS	1	LS	$2,000,000	$2,000,000
3	WELL FIELDS	1	LS	$1,269,622	$1,269,622
4	CONNECTION TO EXISTING GROUND STORAGE TANK	1	LS	$100,000	$100,000
	PROJECT COST				$3,382,705

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
OPERATION AND MAINTENANCE (O&M) COST SUMMARY					
1	PIPELINES	1.0	%	$13,083	$131
2	WATER TREATMENT PLANTS	1.0	LS	$27,705	$27,705
3	WELL FIELDS	1.0	%	$1,269,622	$12,696
4	CONNECTION TO EXISTING GROUND STORAGE TANK	1.0	%	$100,000	$1,000
	ANNUAL OPERATION AND MAINTENANCE COST				$41,532

Table 6 – Option 4: Direct Discharge to Lake Conroe

OPINION OF PROBABLE CONSTRUCTION COST					September 13, 2017
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
PROJECT CAPITAL COST SUMMARY					
1	CONSTRUCTION COST	1	LS	$10,415,002	$10,415,002
2	ENGINEERING, FINANCIAL, AND LEGAL SERVICES AND CONTINGENCIES	1	LS	$3,645,251	$3,645,251
3	LAND AND EASEMENTS	1	LS	$30,000	$30,000
4	ENVIRONMENTAL - STUDIES AND MITIGATION	1	LS	$20,000	$20,000
5	INTEREST DURING CONSTRUCTION	1	LS	$76,001	$76,001
	PROJECT CAPITAL COST				$14,186,253

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	DEBT SERVICE	$1,187,096	$1,187,096	$0	$0	$0	$0
2	OPERATION AND MAINTENANCE (O&M)	$494,150	$494,150	$494,150	$494,150	$494,150	$494,150
3	PUMPING ENERGY COSTS	$3,702,962	$3,702,962	$3,702,962	$3,702,962	$3,702,962	$3,702,962
4	PURCHASE COST OF WATER	$205,275	$205,275	$205,275	$205,275	$205,275	$205,275
	TOTAL ANNUAL COST	$5,589,484	$5,589,484	$4,402,387	$4,402,387	$4,402,387	$4,402,387

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	ANNUAL COST	$5,589,484	$5,589,484	$4,402,387	$4,402,387	$4,402,387	$4,402,387
2	YIELD	10,500	10,500	10,500	10,500	10,500	10,500
3	UNIT COST	$532	$532	$419	$419	$419	$419
	TOTAL UNIT COST						$457

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION COST SUMMARY					
1	PIPELINES	1	LS	$0	$0
2	PIPELINE CROSSINGS	1	LS	$0	$0
3	WELL FIELDS	1	LS	$9,415,002	$9,415,002
4	CONNECT TO EXISTING RAW SURFACE WATER SUPPLY	1	LS	$1,000,000	$1,000,000
	PROJECT COST				$10,415,002

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
OPERATION AND MAINTENANCE (O&M) COST SUMMARY					
1	PIPELINES	1.0	%	$0	$0
2	PIPELINE CROSSINGS	1.0	%	$0	$0
3	WELL FIELDS	1.0	%	$9,415,002	$94,150
4	CONNECTION, ADDITION OF LIME AND CARBON DIOXIDE	40.0	%	$1,000,000	$400,000
	ANNUAL OPERATION AND MAINTENANCE COST				$494,150

WATER MANAGEMENT STRATEGY EVALUATION

Based on the analysis provided above, the Catahoula aquifer supplies project was evaluated across eleven different criteria for the purpose of quick comparison against alternative strategies that may be incorporated into the Raw Water Supply Master Plan. The results of this evaluation can be seen in *Table 5* shown below. Project criteria and scoring methodology are described in the technical memorandum, *Preliminary Strategy Identification and Evaluation (Task 1104)*. Higher scores relate to preferable characteristics.

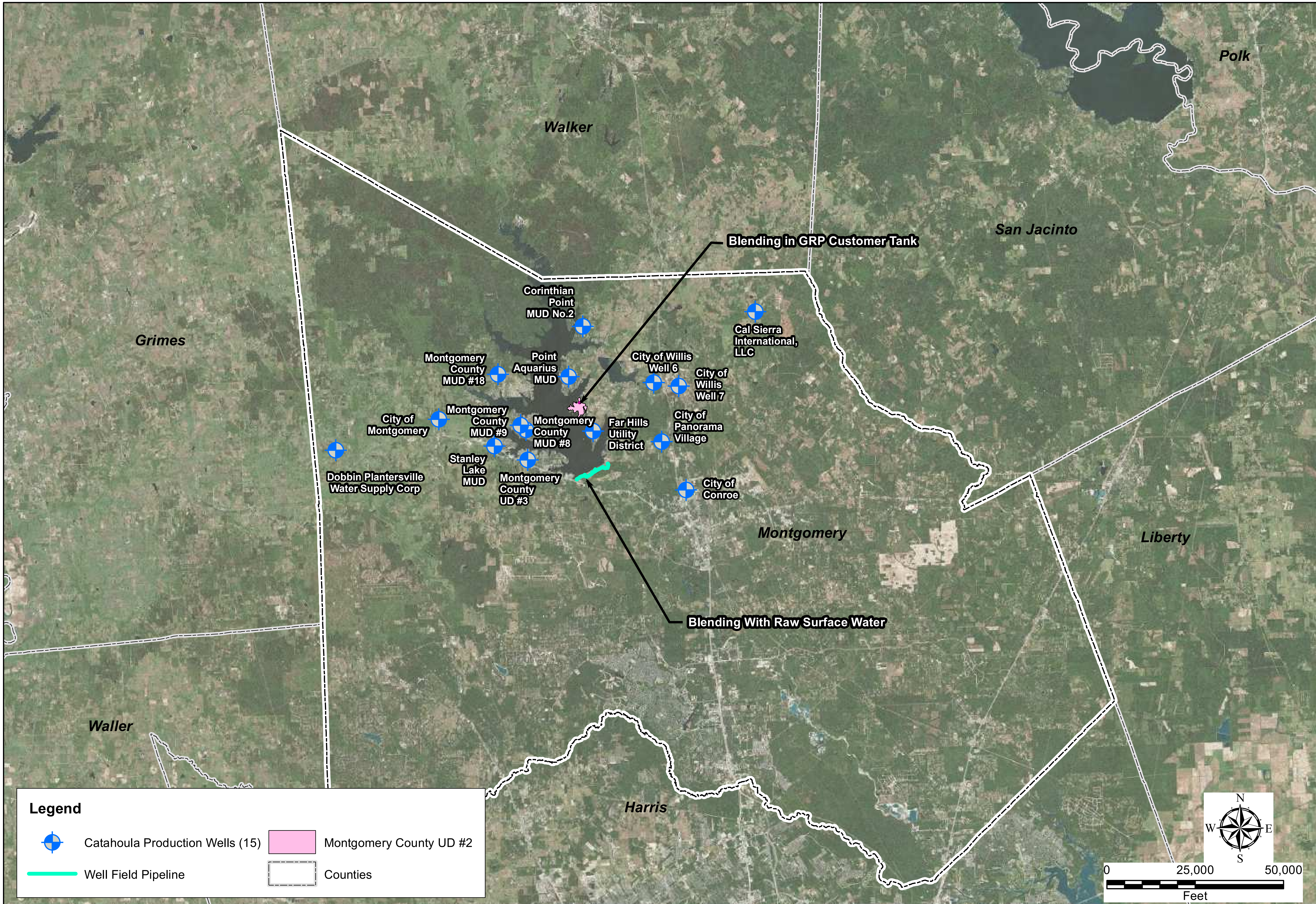
Table 5 – Screening Criteria and Scores for the Catahoula Aquifer Supply Strategy

Criteria	Rating			
	Option 1 Treated GW at SWF	Option 2 Blending with Treated SW	Option 3 Blending at GRP GSTs	Option 4 Lake Conroe Discharge
Cooperation	3	3	4	3
Cost	1	3	3	3
Diversification	4	4	4	4
Environmental	3	4	4	3
Funding	2	2	2	2
Land Acquisition	4	4	4	4
Legal	3	4	3	3
Location	3	3	4	4
Magnitude	2	2	1	2
Other Supplies	3	3	3	3
Public	3	2	2	4
Scalability	1	1	4	1
Schedule	3	4	4	3
Yield Risk	1	1	1	1
Weighted Score [1]	198	290	302	290

[1] Based on weighting methodology adopted in Preliminary Strategy Identification and Evaluation (Task 1104)

References

Freese and Nichols, Inc. 2012. Catahoula Aquifer Evaluation.
Freese and Nichols, Inc. 2015. Catahoula Aquifer Phase II Feasibility Study.
Region H Water Planning Group. 2015. 2016 Regional Water Plan.



FN PROJECT NO.	SJR15616
DATE CREATED	5/17/2017
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas South Central
FILE NAME	Exhibit_1_Overview
PREPARED BY	DML

SJRA RAW WATER SUPPLY MASTER PLAN

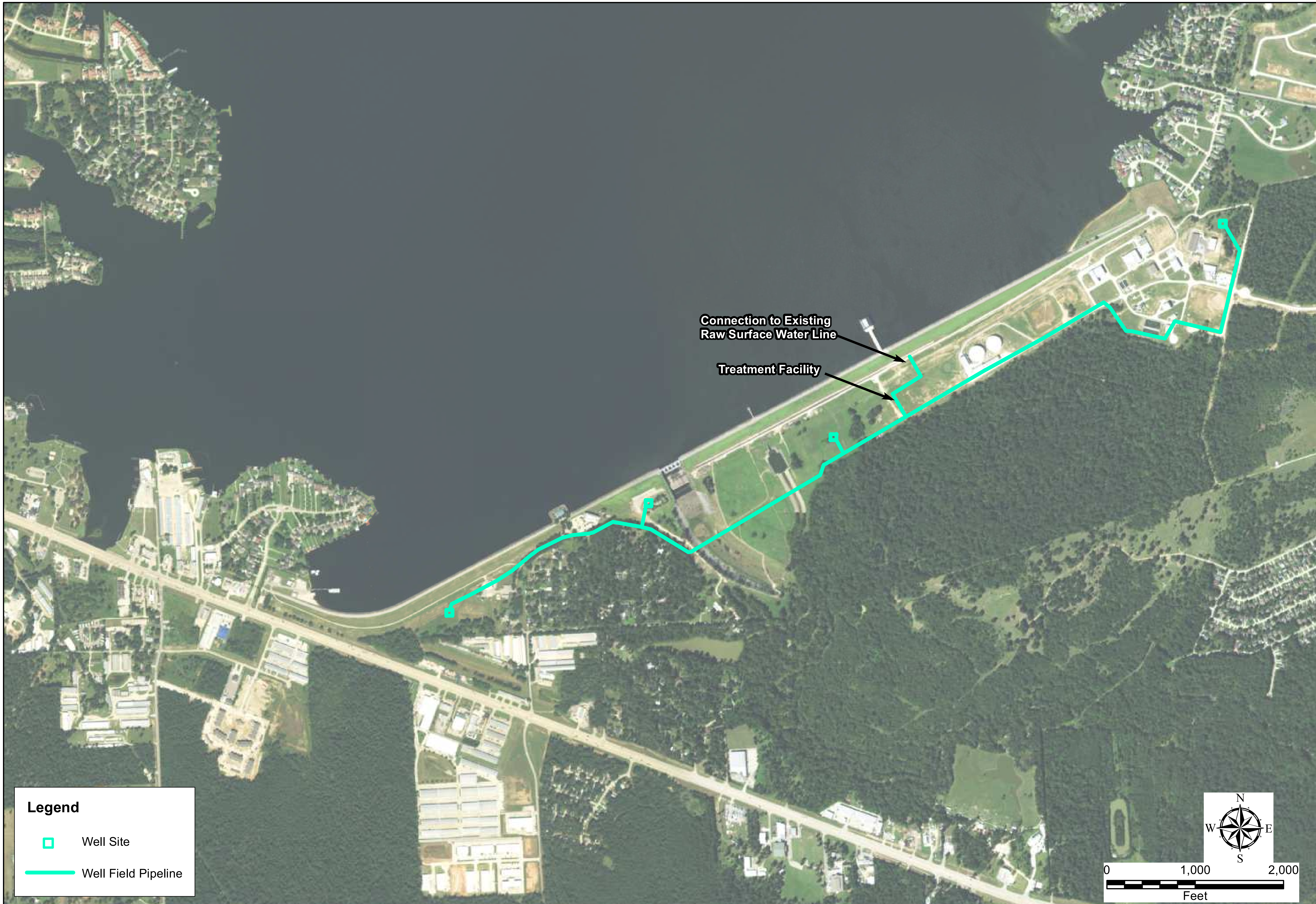
Montgomery County Service Area

Montgomery County Service Area Overview

FREESE AND NICHOLS, INC.
10497 TOWN AND
COUNTRY WAY, SUITE 600
HOUSTON, TEXAS 77024
P: (713) 600-6800
F: (713) 600-6801

EXHIBIT

1



SJRA RAW WATER SUPPLY MASTER PLAN

Montgomery County Service Area

Direct Blending in Raw Surface Water Supply

FN PROJECT NO. SJR15616
DATE CREATED 11/30/2017
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central
FILE NAME Exhibit_2_DirectBlendingRawWaterTreatment
PREPARED BY DML

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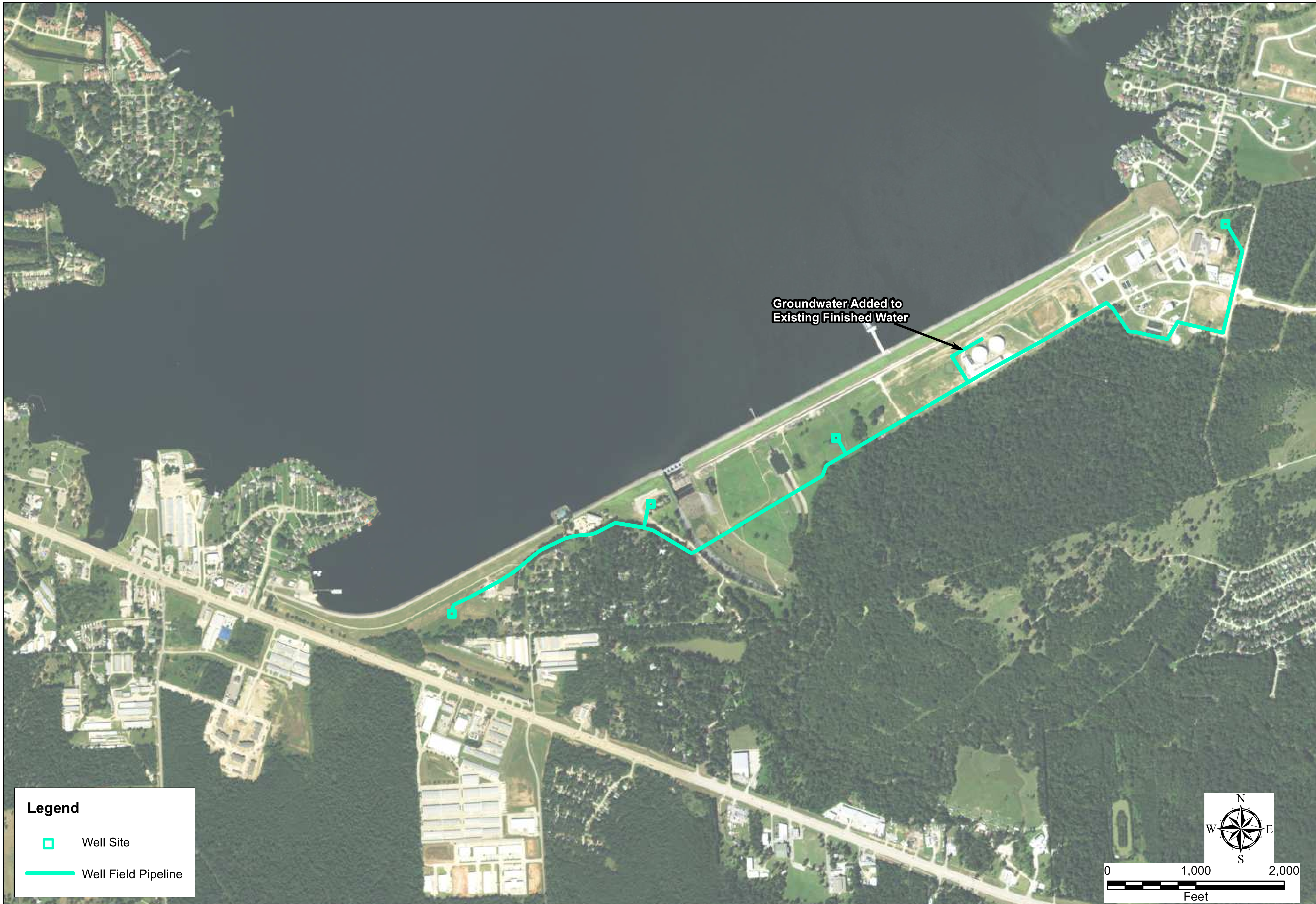
EXHIBIT

2

SJRA RAW WATER SUPPLY MASTER PLAN

Montgomery County Service Area

Disinfected Water Blended with Finished Surface Water



FN PROJECT NO. SJR15616

DATE CREATED 11/30/2017

DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central

FILE NAME Exhibit_3_BlendedWithFinishedWater

PREPARED BY DML

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HOUSTON, TEXAS 77024
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EXHIBIT

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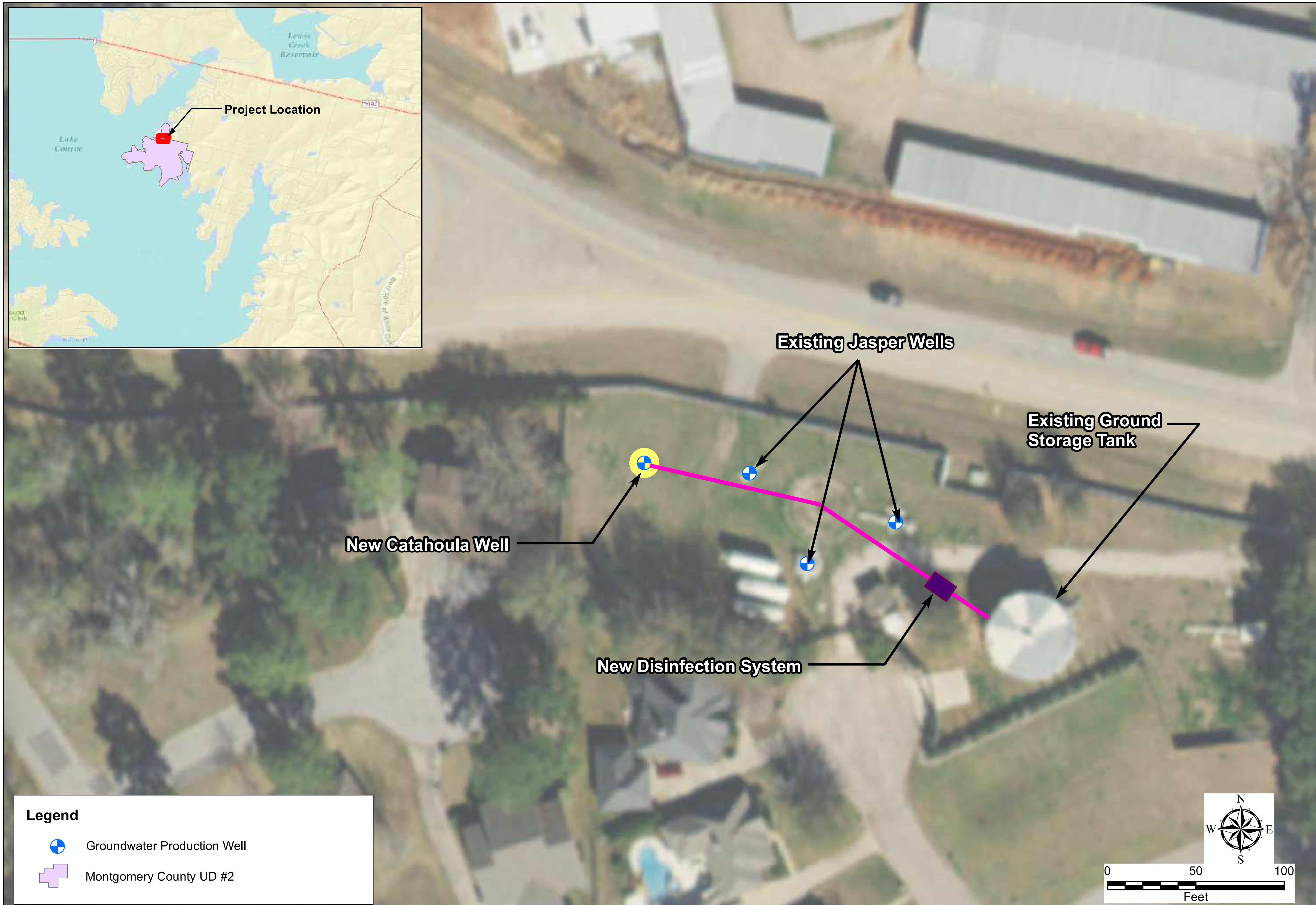

SJRA RAW WATER SUPPLY MASTER PLAN

Montgomery County Service Area

Blending in GRP Customer Tank

FN PROJECT NO. SJR15616

DATE CREATED 11/30/2017

DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central

FILE NAME Exhibit_4_BlendinginGRPCustomerTank

PREPARED BY DML

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COUNTRY WAY, SUITE 600
HOUSTON, TEXAS 77024
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EXHIBIT

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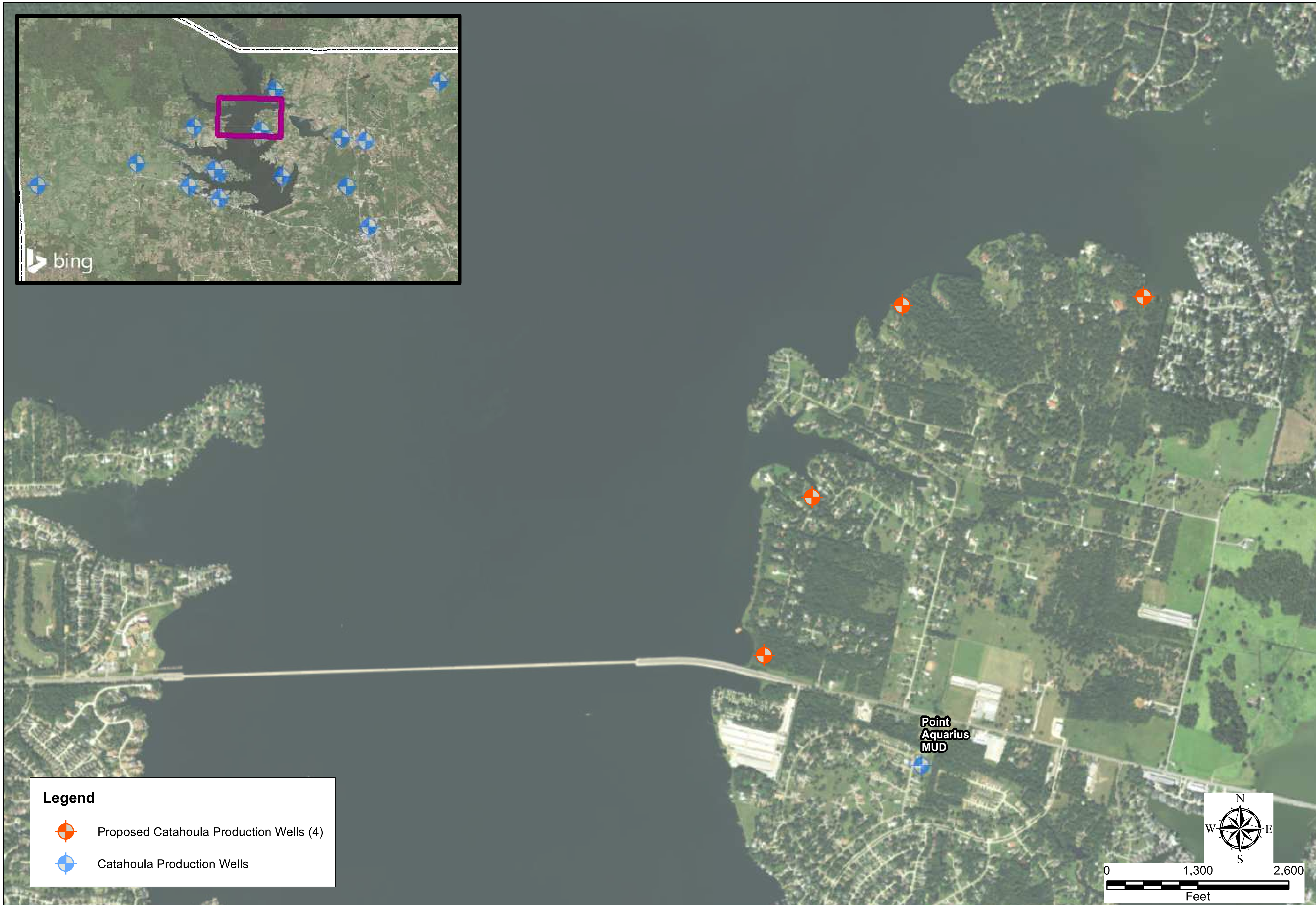

FN PROJECT NO. SJR15616
DATE CREATED 11/30/2017
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central
FILE NAME Exhibit_5_Alternative4a
PREPARED BY DML

SJRA RAW WATER SUPPLY MASTER PLAN

Montgomery County Service Area

Raw Water Transfer from Catahoula Wells to Lake Conroe (East)

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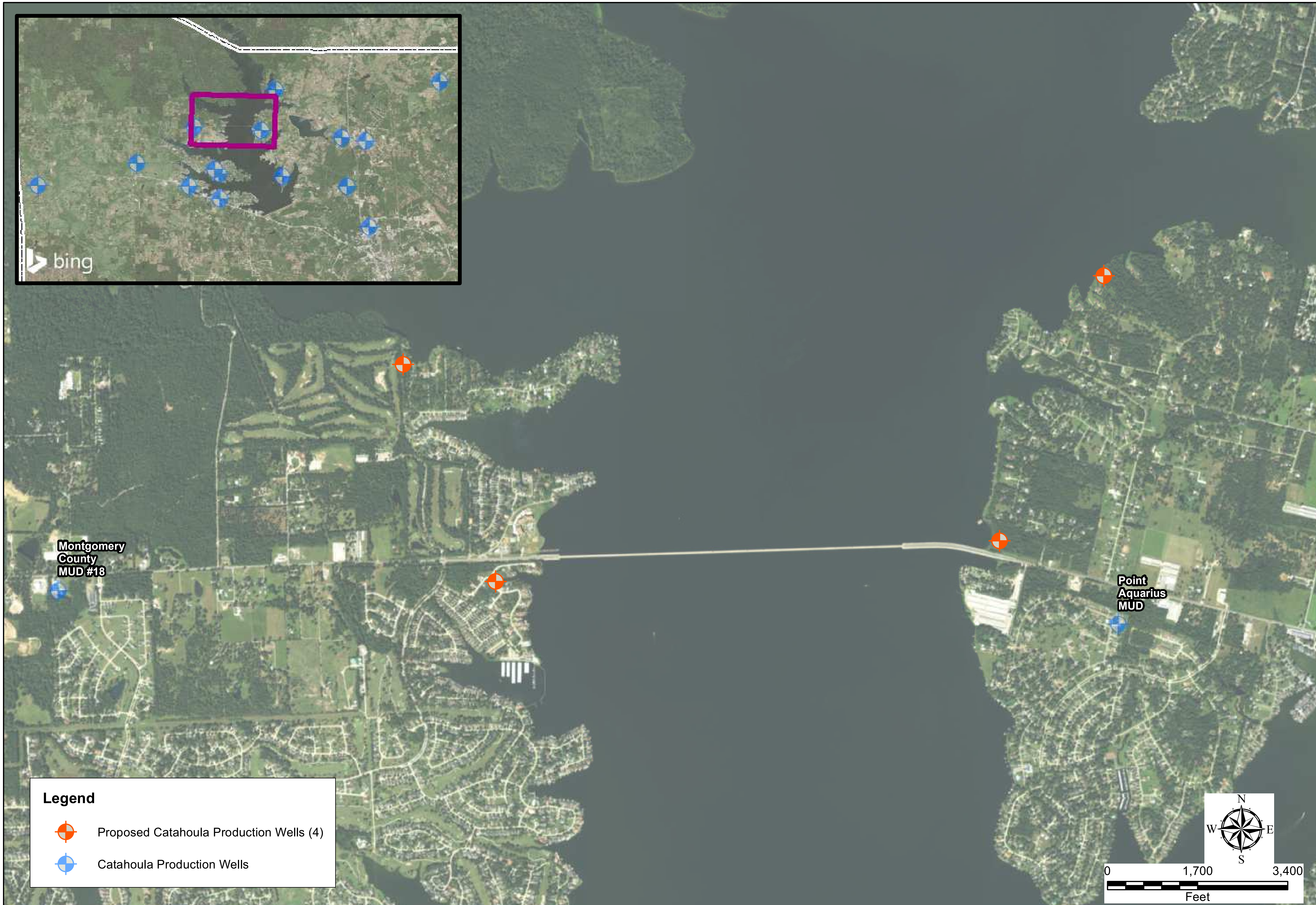
EXHIBIT

5



SJRA RAW WATER SUPPLY MASTER PLAN

Montgomery County Service Area

Raw Water Transfer from Catahoula Wells to Lake Conroe (East and West)

FN PROJECT NO.	SJR15616
DATE CREATED	11/30/2017
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas South Central
FILE NAME	Exhibit_6_Alternative4b
PREPARED BY	DML

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EXHIBIT

6

SAN JACINTO RIVER AUTHORITY RAW WATER SUPPLY MASTER PLAN DETAILED STRATEGY EVALUATION TECHNICAL MEMORANDUM

Project Name:	Return Flows in Montgomery County Service Area
Project Type:	Reuse
Potential Supply Quantity (Rounded):	Up to 26,300 acre-feet/year (23 mgd)
Development Timeline:	5 years
Project Capital Cost:	$0 - $34,059,000 (August 2017)
Unit Water Cost (Rounded):	$0 - $313 per acre-feet (during loan period) $0 - $111 per acre-feet (after loan period)

STATE OF TEXAS
SPANDANA TUMMURI
107802
LICENSED
PROFESSIONAL ENGINEER

FREESE AND NICHOLS, INC.
TEXAS REGISTERED
ENGINEERING FIRM
F-2144

STRATEGY DESCRIPTION

The San Jacinto River Authority (SJRA) is a wholesale water provider for various municipal, industrial, and irrigation retail customers in the San Jacinto River Basin. In Montgomery County, Lake Conroe is SJRA's primary source of supply. Montgomery County is currently in the process of converting excess groundwater demand to surface water and other sources. This process is being carried out by the Large Volume Groundwater Users (LVGUs) in the county and can be accomplished by individual LVGUs or collectively in a joint Groundwater Reduction Plan (GRP). SJRA represents the largest surface water provider, providing a means of conversion within the county to several LVGUs in its joint GRP. Current supplies from Lake Conroe are adequate for initial phases of conversion but future growth will require the introduction of additional options such as groundwater and treated wastewater alternatives.

Return flows are one of the various sources of supply that SJRA is considering as a potential future source. Throughout the San Jacinto River Basin, organized community development is steadily overtaking the traditional, rural pattern that has historically been present in much of the area. Over time, homes with individual wells and on-site sewage systems are being replaced with homes served by master-planned water and wastewater service from centralized utility systems. It is these latter types of development that produce opportunity for the development of return flows from wastewater treatment facilities.

Below is a description of the methodology used to compute the return flows, as presented in Task 1102. The populations contributing to return flows were taken from the 2016 Region H Regional Water Plan (RWP) and the Regional Groundwater Update Project (RGUP) developed by Harris-Galveston Subsidence District (HGSD), Fort Bend Subsidence District (FBSD), and Lone Star Groundwater Conservation District (LSGCD), where possible. These sources were also used in the development of the 2016 Region H Regional Water Plan (RWP). A detailed analysis of population density in utilities known to have a comprehensive wastewater system was conducted. The population densities for various utilities were determined and the lowest of these densities were used as a threshold for other population-bearing units; those with a density less than this threshold will be assumed to use on-site treatment and will be assumed to not generate return flows until they reach a density that surpasses the threshold. Based on the review of per-capita demands from the RGUP and Region H, the per-capita demands developed during the planning for the 2016 RWP without the application of conservation were used to develop estimates of return flows.

The return flow estimates were generated based on a return flow factor of 40% of the annual water demand. Based on real-time observations of the return flow potential in other parts of the state, it was determined that a 40% return flow factor is a reasonable assumption. In addition, the return flows in the basin that are already permitted under existing water rights were excluded from consideration.

STRATEGY ANALYSES

The project analyses for Return Flows strategy for the Montgomery County service area include evaluations of the potential supply to be created, environmental factors involved in the project, permitting and development considerations, and an analysis of potential project cost.

Supply Development

Separate return flows strategies are being developed for the Montgomery County service area and the Highlands service area. Therefore, the sub-basins contributing return flows to each one of the service areas were identified and were separated based on the service area to which they are contributing return flows. It is possible that the choice to develop certain return flows strategies may impact the potential to develop strategies downstream in the Highlands service area.

Exhibit 1, attached to this technical memorandum, includes a map of the sub-basins contributing to the Montgomery County service area. Some or all of the return flows generated in the Montgomery County service area could potentially be diverted downstream in Lake Houston to serve the Highlands service area. However, for purposes of this analysis, it was assumed that the return flows generated above Lake Conroe and in the area indicated as the Lake Creek sub-basin of the San Jacinto River will be captured and permitted as part of the Montgomery County service area strategy. Similarly, return flows generated from sub-basins below these two sub-basins were considered to be part of the Highlands service area strategy.

Two sub-basins were identified as potential sources contributing return flows to the Montgomery County service area: Lake Conroe and Lake Creek. The overall volumes of return flows generated for these sub-basins are reported in *Table 1* below.

Table 1. Summary of Return Flows generated in the Montgomery County Service Area

Service Area	Return Flows (Acre-Feet per Year) [1]					
	2020	2030	2040	2050	2060	2070
Lake Conroe	4,777	6,150	7,483	8,990	11,651	14,315
Lake Creek	6,466	8,382	10,282	12,522	15,357	17,718
TOTAL	**11,243**	**14,532**	**17,765**	**21,512**	**27,008**	**32,033**

[1] Return flow estimates in this table do not include deductions for existing authorization or channel losses.

Any return flows already permitted under the existing water rights authorizations were subtracted from these return flows. *Table 2* includes a list of existing authorizations considered in this evaluation. The return flows to be deducted were determined based on the geographical extents of the existing authorizations and the manner in which they drain to potential diversion points. In addition to this deduction, conveyance losses for the travel time from the sub-basins to the diversion points were also subtracted from the return flows listed in *Table 1* during the evaluation of supply options seen below. A channel loss factor of 5% was assumed and used for estimating these conveyance losses.

Table 2. Summary of the Currently Authorized/Negotiated Return Flows within the Montgomery County Service Area

Deduction	Return Flows (Acre-Feet per Year) [1]					
	2020	2030	2040	2050	2060	2070
Lake Conroe	540	556	572	584	595	620
Montgomery County MUDs 8 and 9 [2]	*85*	*90*	*101*	*113*	*125*	*150*
City of Huntsville [2]	*455*	*466*	*470*	*470*	*470*	*470*
Lake Creek	5,669	6,749	8,045	9,068	10,164	11,292
City of Conroe [2]	*5,577*	*6,657*	*7,953*	*8,975*	*10,072*	*11,200*
City of Panorama Village	*92*	*92*	*92*	*92*	*92*	*92*
TOTAL	**6,209**	**7,305**	**8,617**	**9,651**	**10,759**	**11,912**

[1] Return flow estimates in this table do not include deductions for existing authorization or channel losses.
[2] Include flows that may be developed by SJRA.

The options considered below use the return flows identified in *Table 1* along with the reductions indicated in *Table 2* in order to present potential scenarios in which flows may be developed for supply purposes. The options considered develop water from the flows that are currently being identified through agreement and presented in *Table 2* but also utilize resources that are not currently under consideration as presented in *Table 1*, less the volumes in negotiation/under approval in *Table 2*. Therefore, some supplies will be more readily obtainable because their permitting and contractual agreements are already materializing at the present.

Return Flow Strategy Options

In order to develop the return flows in the Lake Conroe sub-basin or the Lake Creek sub-basin, SJRA must obtain permits from the state of Texas to use these supplies. The process to accomplish this objective requires SJRA to: determine the volume of return flows available in each sub-basin in the Montgomery County service area, identify the entities that are generating those return flows, determine the pending applications for return flows to keep track of, establish agreements/contracts with entities generating return flows, and apply for TCEQ permits for the return flows. SJRA has the following potential project alternatives.

Option 1 - Existing Supplies contributing to Lake Conroe. These are the pending agreements that SJRA currently holds that require additional steps to perfect the return flows as an available supply.

Option 2 - Other Sources contributing to Lake Conroe. These sources can be GRP participants or non-GRP participants or other entities contributing return flows to the Lake Conroe sub-basin.

Option 3 - All water users (GRP participants and non-GRP participants) currently contributing return flows to Lake Creek sub-basin. For this option, SJRA must determine if an agreement can be set with those participants for acquiring the return flow permit. Some of these supplies are already in the process of being developed through permitting of the City of Conroe's return flows.

Strategy Option 1 - SJRA has pending agreements with MUDs 8 and 9 for return flows originating from MUDs 8 and 9, and from the MUDs 8 and 9 contract for reuse supplies with City of Huntsville. As per this agreement, 21% of the return flows generated from the MUDs 8 and 9 reuse contract will be available in Lake Conroe. In addition, the City of Huntsville will dedicate 21% of the supply discharged for MUDs 8 and 9 at their WWTPs for diversion downstream at Lake Conroe, less conveyance loss. About one-third of the volume available in Lake Conroe is available for SJRA to permit and the two-thirds is accounted for by the City of Houston. The one-third portion returned to the SJRA portion of Lake Conroe is readily available to SJRA and the remaining two-thirds accounted for the City of Houston portion may also be availed to SJRA but would require the negotiation of terms with the City of Houston that would parallel the existing agreement for SJRA to obtain contract supplies from the COH portion of Lake Conroe. Based on this agreement, the volumes shown in *Table 3* below are potentially available to SJRA for future permits. In this case, SJRA already has an agreement in development with MUDs 8 and 9. If they choose to develop a project for these return flows, SJRA will have to apply to TCEQ for a bed and banks transfer of the return flow volumes specified in *Table 3,* and any additional steps necessary should they pursue the City of Houston portion of supplies. The return flows from these two agreements will be available for capture at Lake Conroe.

Table 3. Option 1: Return Flow Volumes Available for SJRA Agreement with MUDs 8 and 9 and City of Huntsville

Reuse Source	Return Flows (Acre-Feet per Year) [1]					
	2020	2030	2040	2050	2060	2070
MUDs 8 and 9 returns	81	90	101	113	125	150
SJRA Portion	*28*	*30*	*34*	*38*	*42*	*50*
City of Houston Portion	*57*	*60*	*68*	*75*	*83*	*100*
City of Huntsville Contract with MUDs 8 and 9 returns	455	466	470	470	470	470
SJRA Portion	*152*	*155*	*157*	*157*	*157*	*157*
City of Houston Portion	*303*	*311*	*313*	*313*	*313*	*313*
OPTION 1 TOTAL	**540**	**556**	**572**	**584**	**595**	**620**
SJRA Portion	***180***	***185***	***191***	***195***	***198***	***207***
City of Houston Portion	***360***	***371***	***381***	***389***	***397***	***414***

[1] Return flows adjusted for channel losses.

Strategy Option 2 – This strategy option includes the permitting of the return flows generated in the Lake Conroe sub-basin by the SJRA GRP and non-GRP participants and all other sources contributing flows to Lake Conroe. In this strategy alternative, it was assumed that SJRA would apply to TCEQ for a bed and banks permit to convey the return flows generated from the sub-basin through Lake Conroe to the point of diversion. Because the return flows are naturally flowing into Lake Conroe, there is no requirement for any additional infrastructure to capture these return flows. To that end, the only cost incurred in developing this strategy is: 1) the administrative and legal fees associated with the TCEQ permitting process 2) the cost, if any, in obtaining contracts from the wastewater discharge owners for use of the return flows; and 3) if preferred, the cost for use of the City of Houston share of these supplies. It should be noted that the return flows permitted in this strategy will represent an additional source of supply and not be considered as part of SJRA's existing permit authorization for Lake Conroe.

Table 4 includes the summation of return flow volumes from entities that rely on SJRA's surface water supplies and contribute return flows to the Lake Conroe sub-basin. Also included is a summation of return flows generated by other sources. Once SJRA has coordinated with the specific entities and agreements have been secured, SJRA can apply to TCEQ for permits. It should be noted that the return flow estimates for City of Huntsville and MUDs 8 and 9 were not included in this table as SJRA is currently under contract with these two entities for return flows. The return flow estimates available for SJRA from the contracts with the two entities are reported in *Table 3*.

Table 4. Option 2: Summary of SJRA GRP Participants and Others Contributing Return Flows to the Lake Conroe Sub-Basin in Montgomery County Service Area

Reuse Source	Return Flows (Acre-Feet per Year) [1]					
	2020	2030	2040	2050	2060	2070
SJRA Surface Water	0	132	188	555	675	853
Other Sources	1,663	2,753	3,886	4,898	7,253	9,493
OPTION 2 TOTAL	**1,663**	**2,885**	**4,075**	**5,454**	**7,928**	**10,346**

[1] Return flows adjusted for channel losses

Strategy Option 3 – Another option is for SJRA to reach out to the GRP participants and non-GRP participants contributing return flows to the Lake Creek sub-basin. Significant amounts of return flows to the Lake Creek sub-basin originate from City of Conroe's wastewater discharges. These flows are currently in the process of being permitted through TCEQ by both Conroe and SJRA which will provide access to the groundwater and surface water-based return flows of these discharges, respectively. In addition to this Conroe discharge, there are other unpermitted return flows contributed by other groundwater users. *Table 5* includes a summary of the entities relying on SJRA surface water, and those that are relying on groundwater, that contribute return flows to the Lake Creek sub-basin. The most feasible course of action would be for SJRA to coordinate with the entities generating return flows starting with surface water users and other sources, in that order. Once agreements have been secured with these entities, SJRA must apply to TCEQ for a diversion permit to divert the return flows from a suitable downstream location on the West Fork San Jacinto River. For purposes of this strategy analysis, a usage site was selected near the crossing of Interstate Highway 45 and the San Jacinto river for transfer the supplies to Lake Conroe by means of a new pumped conveyance system. It should be noted that this diversion point was selected as one potential location for planning purposes only, and further study may refine this location to a more suitable site at a later time.

Since the return flows from the Lake Creek sub-basin are not naturally flowing into Lake Conroe, additional infrastructure is required to develop the supply from this strategy and use it to serve the Montgomery County service area demands. A maximum of approximately 14,085 acre-feet of supplies can be developed in this strategy. It was assumed that the return flows generated from the Lake Creek sub-basin will be captured at the intersection of the San Jacinto river and Interstate Highway 45 and transferred to the SJRA's water treatment plant near Lake Conroe by means of a transmission pipeline and pump station. In addition to the cost incurred in securing the TCEQ permit for diverting the supplies at the Interstate Highway 45 diversion point, this strategy option will include additional construction cost for the infrastructure development. The cost estimates for transferring the supplies to the treatment plant are discussed in the cost estimates section below.

Table 5. Option 3: List of Entities Contributing Return Flows to the Lake Creek Sub-Basin in Montgomery County Service Area

Reuse Source	Return Flows (Acre-Feet per Year) [1]					
	2020	2030	2040	2050	2060	2070
City of Conroe Permit	3,299	4,194	5,667	6,395	7,176	7,980
SJRA Surface Water	*3,299*	*4,194*	*5,667*	*6,395*	*7,176*	*7,980*
Unpermitted Flows	757	1,552	2,125	3,282	4,934	6,105
SJRA Surface Water	*0*	*692*	*1,012*	*1,224*	*2,121*	*2,568*
Other Sources	*757*	*860*	*1,113*	*2,058*	*2,813*	*3,537*
OPTION 3 TOTAL	**4,056**	**5,745**	**7,792**	**9,677**	**12,110**	**14,085**
SJRA Surface Water	***3,299***	***4,885***	***6,678***	***7,619***	***9,297***	***10,548***
Other Sources	***757***	***860***	***1,113***	***2,058***	***2,813***	***3,537***

[1] Return flows adjusted for channel losses

The return flows discussed in these options are available for and subject to the granting of a TCEQ permit by any party pursuing this opportunity. Therefore, the amount available may vary as additional permits are obtained by other entities. The current evaluation of these strategy options accounted for all the known existing authorizations. The future analyses of this strategy must take into consideration any additional return flow authorizations secured or applied for with TCEQ. It should be noted that the City of Conroe permit supplies are developed as an alternative strategy for the Highlands service area. If the supplies are not captured in the Montgomery County service area strategy, they can be developed for the Highlands service area or vice versa.

Another possibility for developing return flows would be to consider the development of a new water treatment plant at the southern boundary of the Montgomery County service area to treat all the return flows generated and captured in the service area. This option would include return flows originating from sub-basins below the Lake Conroe and Upper West Fork sub-basins and therefore create additional return flow supply over that provided in Table 5. This option would require a TCEQ permit for diverting the return flows at a location closer to the southern boundary of the service area, a conveyance system (pipelines and pump station) to transfer the supplies to the new treatment plant, and the construction of the new treatment plant. If the return flows generated in the service area justified the investment in a conveyance and treatment system in the southern portion of the service area, this strategy would be a meaningful one. However, at this time, the return flow volumes in the service area are low in magnitude and this option was considered cost prohibitive and not feasible for the near term. If any of the assumptions or variables considered in this study change in the future, thus making this option more viable, this strategy should be considered for further evaluation at that point in time.

Environmental Considerations

Environmental considerations associated with reuse are largely associated with the reduction of instream flows. This consideration must be included as part of the permitting process for any indirect reuse project. More specific issues also arise from the development of infrastructure intended to facilitate the use of reclaimed water. The following are some of the general environmental considerations associated with this strategy, including the transmission facilities identified for developing return flows strategy option 3 for the Montgomery County service area. A desktop-level survey was conducted to identify these environmental issues associated with the specific route selected for this study. The details of the survey are summarized below.

1. The diversion of the effluent source supply would be expected to reduce instream flows downstream of the diversion point for any portion of the source supply originating from current

levels of return flow. A more detailed analysis of environmental impacts and legal constraints would be considered during the permit application and review process. Any impacts would be anticipated to occur from reuse of effluent generated from current levels of discharge; diversion of the portion attributable to future growth would not be expected to cause additional impact. It should also be noted that the proposed diversions would occur upstream of the monitoring points for Senate Bill 3 environmental flow standards and could potentially be subject to associated restrictions.

2. Due the presence of streams, wetlands and ponds that could be deemed Waters of the United States (WOTUS) and jurisdictional to Section 404 of the Clean Water Act (CWA) throughout the alignment considered for option 3, acquiring a permit(s) through the USACE would be required prior to beginning construction activities. Pending the level of potential WOTUS impacts, project activities could likely be covered by a Nationwide Permit. Nationwide Permits are typically obtained within 45 to 60 calendar days, but acquiring an Individual Permit typically requires a minimum of 180 days and a public comment period.

3. If no Federal funding or assistance would be used for construction of the proposed project, the need to complete the National Environmental Policy Act (NEPA) process would not be required. However, coordination with the USACE to obtain a CWA Section 404 permit, particularly an Individual Permit, could trigger the need to comply with the NEPA review process.

4. *Table 6* provides a synopsis of potential archaeological/historical resources present within the alternative alignment.

5. *Table 7* includes a summary of the desktop environmental constraints information pertaining to the transmission route considered for alternative Option 3 in this evaluation.

Table 6. Summary of Desktop Archaeological/Historical Constraints for the Transmission Route for Transferring Return Flows from Lake Creek Sub-Basin to Lake Conroe

Option	Archaeological Sites within 1-mile buffer	Cemetery	Historic Places Listed	Texas Historic Landmark
3	36	0	0	0

Table 7. Summary of Desktop Environmental Constraints for the Transmission Route for Transferring Return Flows from Lake Creek Sub-Basin to Lake Conroe

Option	Ponds/Pond Acreage (acre)	Stream and Canal Crossings/Length (miles)	Potential Wetlands	Total Wetland Acreage (Acres)	Prime Farmland Soil Tracts	Farmland Acreage (Acres)
3	1.0/0.14	10/5	20	29.02	9.0	167.5

All environmental constraints must be addressed during the permitting and detailed feasibility study phases of the project development. At this stage, the environmental considerations are merely provided as a guide for selecting the appropriate route for future evaluation.

Permitting and Development

SJRA will have to coordinate with TCEQ for a bed and banks permit to convey the return flows developed in all strategy alternative options. For Options 1 and 2, SJRA must apply for authorization to use the bed and banks of Lake Conroe and upstream tributaries to convey reuse supplies for subsequent diversion. For option 3, SJRA must apply for a permit to convey water through the bed and banks of Lake Creek and divert supplies at the Interstate Highway 45 intersection with the West Fork of San Jacinto River. Owing to the pre-existing contractual relations that SJRA has with its GRP participants, it may be procedurally easier to develop the return flows with GRP participants than it is to develop the projects with non-GRP participants.

Cost Analysis

There will be some cost incurred for implementing Options 1 and 2, and these costs may include permitting fees, legal fees, and contract fees with various entities. However, it is difficult to provide an estimate for these costs as each strategy cost will be different and varied on a case-by-case basis. Preliminary opinions of probable construction cost estimates were developed based on planning-level details considered for alternative Option 3. The cost estimates were developed using a similar approach used for the Region H regional planning strategy evaluation. The cost estimates were indexed to August 2017 dollars. *Table 8* includes the overall preliminary opinion of probable cost for Option 3. It should be noted that these estimates are preliminary planning-level costs intended as a means to compare and evaluate alternatives and are not intended for contracting or designing purposes. Detailed cost estimates should be developed during subsequent feasibility and design phases.

Table 8– Cost Estimate for Return Flows Alternative Option 3 - Transfer of Return Flows from Lake Creek Sub-Basin to SJRA Water Treatment Plant

OPINION OF PROBABLE CONSTRUCTION COST					September 14, 2017
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
PROJECT COST SUMMARY					
1	CONSTRUCTION (CAPITAL) COST	1	LS	$23,651,700	$23,651,700
2	ENGINEERING, FINANCIAL, AND LEGAL SERVICES AND CONTINGENCIES	1	LS	$7,611,840	$7,611,840
3	LAND AND EASEMENTS	1	LS	$732,689	$732,689
4	ENVIRONMENTAL - STUDIES AND MITIGATION	1	LS	$1,018,674	$1,018,674.24
5	INTEREST DURING CONSTRUCTION	1	LS	$544,777	$544,777
6	OTHER (LEGAL FEES)	1	LS	$0	$500,000
	PROJECT COST				$34,059,680

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	DEBT SERVICE	$2,850,091	$2,850,091	$0	$0	$0	$0
2	OPERATION AND MAINTENANCE (O&M)	$386,416	$386,416	$386,416	$386,416	$386,416	$386,416
3	PUMPING ENERGY COSTS	$1,175,820	$1,175,820	$1,175,820	$1,175,820	$1,175,820	$1,175,820
4	PURCHASE COST OF WATER	$0	$0	$0	$0	$0	$0
	TOTAL ANNUAL COST	$4,412,327	$4,412,327	$1,562,236	$1,562,236	$1,562,236	$1,562,236

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	ANNUAL COST	$4,412,327	$4,412,327	$1,562,236	$1,562,236	$1,562,236	$1,562,236
2	YIELD	14,085	14,085	14,085	14,085	14,085	14,085
3	UNIT COST	$313	$313	$111	$111	$111	$111
	TOTAL UNIT COST						$178

CONSTRUCTION COST SUMMARY					
1	PUMP STATIONS	1	LS	$9,826,600	$9,826,600
2	PIPELINES	1	LS	$11,858,429	$11,858,429
3	PIPELINE CROSSINGS	1	LS	$1,466,671	$1,466,671
4	DAMS AND RESERVOIRS	1	LS	$500,000	$500,000
	PROJECT COST				$23,651,700

OPERATION AND MINTENANCE (O&M) COST SUMMARY					
1	PUMP STATIONS	2.5	%	$9,826,600	$245,665
2	PIPELINES	1.0	%	$11,858,429	$118,584
3	PIPELINE CROSSINGS	1.0	%	$1,466,671	$14,667
4	DAMS AND RESERVOIRS	1.5	%	$500,000	$7,500
	ANNUAL OPERATION AND MAINTENANCE COST				$386,416

PUMP STATION CONSTRUCTION COSTS					
1	2000 HP Pump Station with Intake	1.0	LS	$9,826,600	$9,826,600
	PUMP STATIONS TOTAL COST				$9,826,600

PIPELINE CONSTRUCTION COSTS					
1	30'' Diameter Pipeline (Rural Soil) Lake Creek to Lake Conroe	83,975.0	LF	$141	$11,858,429
	PIPELINES TOTAL COST				$11,858,429

PIPELINE CROSSING CONSTRUCTION COST					
1	30'' Diameter Pipeline Crossing (Boring) SH 105	250.0	LF	$793	$198,199
2	30'' Diameter Pipeline Crossing (Boring) Spillway and ROW	800.0	LF	$793	$634,236
3	30'' Diameter Pipeline Crossing (Boring) I45 Intersection	800.0	LF	$793	$634,236
	PIPELINE CROSSINGS TOTAL COSTS				$1,466,671

DAMS AND RESERVOIRS CONSTRUCTION COST					
1	On-Channel Dam for Diversion	1.0	LS	$500,000	$500,000
	DAM AND RESERVOIR TOTAL COSTS				$500,000

WATER MANAGEMENT STRATEGY EVALUATION

Based on the analysis provided above, the Return Flows in Montgomery County Service Area strategy was evaluated across eleven different criteria for the purpose of quick comparison against alternative projects that may be incorporated into the Regional Water Plan. The results of this evaluation can be seen in *Table 9* below. Project criteria and scoring methodology are described in the technical memorandum, *Preliminary Strategy Identification and Evaluation (Task 1104)*. Higher scores relate to preferable characteristics.

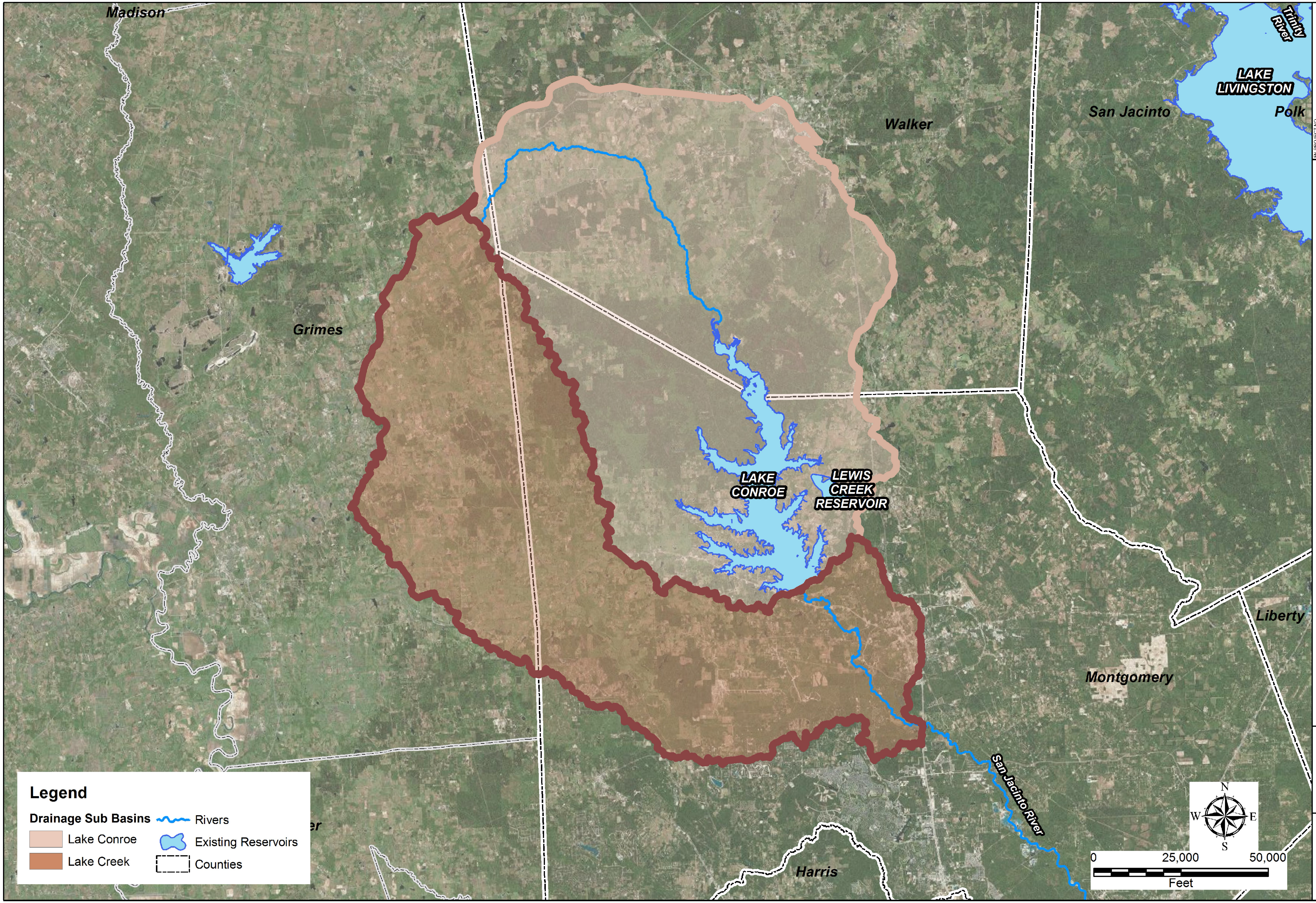
Table 9 - Screening Criteria and Scores for Return Flows in Montgomery County Service Area Strategy

Criteria	Rating Option 1 MUDs 8 and 9 and City of Huntsville	Rating Option 2 Other Lake Conroe Flows	Rating Option 3 Lake Creek Diversion
Cooperation	3	2	2
Cost	4	4	2
Diversification	3	3	3
Environmental	3	3	2
Funding	4	4	4
Land Acquisition	4	4	3
Legal	2	2	1
Location	4	4	2
Magnitude	1	2	2
Other Supplies	3	3	2
Public	3	3	2
Scalability	1	1	1
Schedule	4	3	3
Yield Risk	2	2	2
Weighted Score [1]	332	326	210

[1] Based on weighting methodology adopted in Preliminary Strategy Identification and Evaluation (Task 1104)

REFERENCES

Region H Water Planning Group. 2015. 2016 Regional Water Plan.



FN PROJECT NO. SJR15616
DATE CREATED 9/7/2017
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central
FILE NAME Exhibit_1_MontgomerySA_ReturnFlows
PREPARED BY DML

SJRA RAW WATER SUPPLY MASTER PLAN

Montgomery County Service Area

Sub-Basins Contributing Return Flows

FREESE AND NICHOLS, INC.
10497 TOWN AND
COUNTRY WAY, SUITE 600
HOUSTON, TEXAS 77024
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EXHIBIT
1

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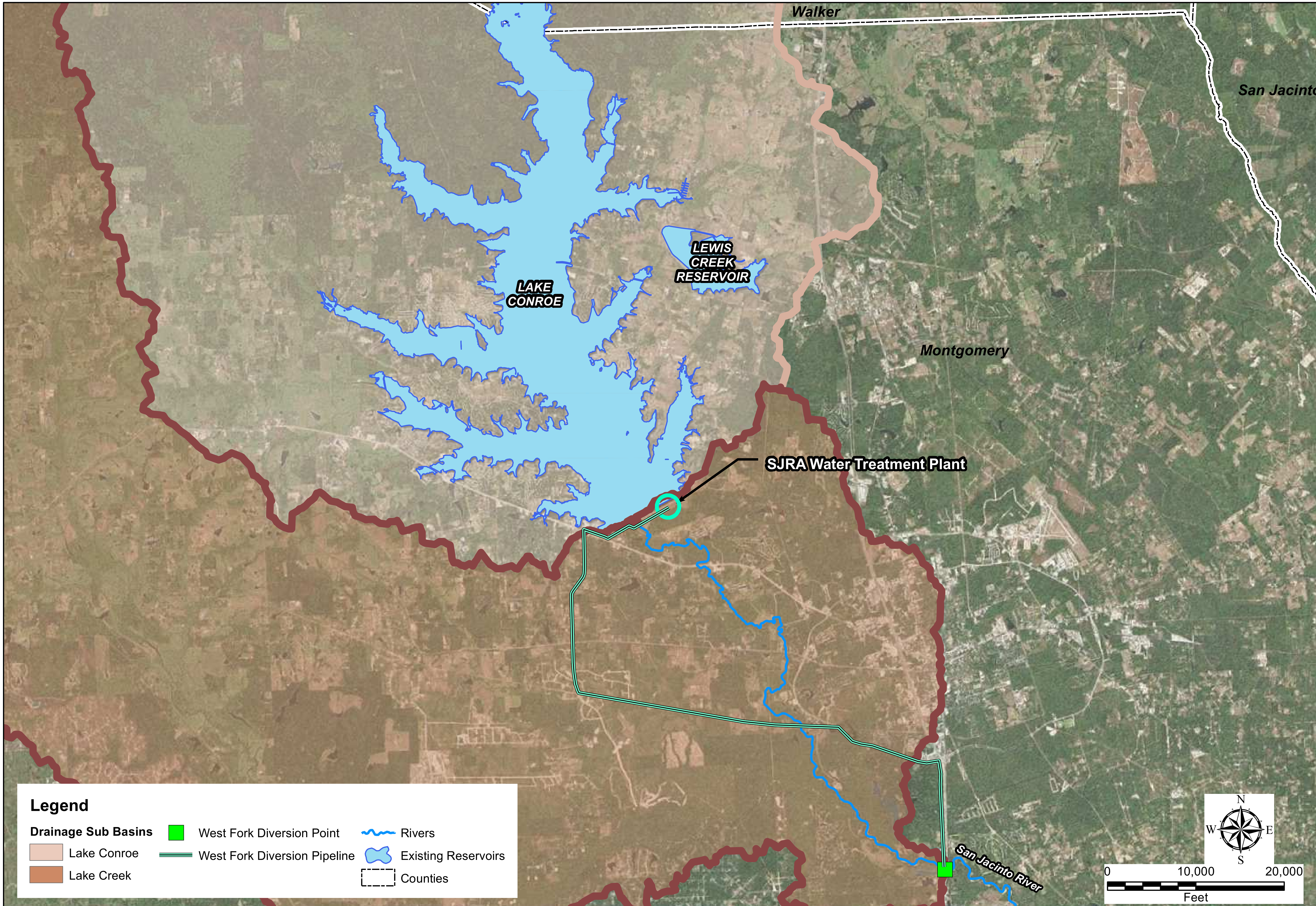

SJRA RAW WATER SUPPLY MASTER PLAN

Montgomery County Service Area

Alternative Option 2 - Transfer Of Return Flows From West Fork to SJRA Water Treatment Plant

FN PROJECT NO.	SJR15616
DATE CREATED	9/7/2017
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas South Central
FILE NAME	Exhibit_2_ReturnFlow_Alternative2
PREPARED BY	DML

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EXHIBIT

2

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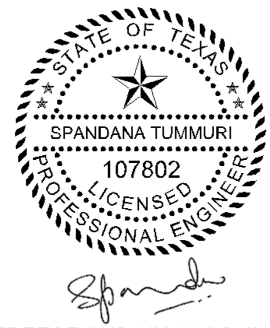
SAN JACINTO RIVER AUTHORITY RAW WATER SUPPLY MASTER PLAN DETAILED STRATEGY EVALUATION TECHNICAL MEMORANDUM

Project Name:	Municipal Water Conservation
Project Type:	Conservation
Potential Supply Quantity (Rounded):	2020: 8,576 ac-ft/year (7.7 MGD) 2070: 43,588 ac-ft/year (38.9 MGD)
Development Timeline:	Escalating throughout the planning horizon
Project Capital Cost:	NA
Unit Water Cost (Rounded):	2020: $0-$209 per ac-ft ($0.00-$0.64 per 1,000 gallons) 2070: $0-$92 per ac-ft ($0.00-$0.28 per 1,000 gallons)



FREESE AND NICHOLS, INC.
TEXAS REGISTERED
ENGINEERING FIRM
F-2144

STRATEGY DESCRIPTION

Water Conservation involves the use of various methods to increase the efficiency of water use for a particular demand category. Conservation may include practices to reduce water consumption for industrial, irrigation, or municipal uses. However, this proposed strategy focuses on the application of efficient water use methods for municipal water demand which includes water used to serve residential, commercial, and light industrial demands as well as any landscape irrigation associated with these customers, which may include golf courses or other landscape areas irrigated by public water systems or private wells.

Unlike other strategies which typically involve potential activities by the SJRA to either acquire new water supplies or relocate existing supplies to address future identified shortages, this detailed strategy evaluation instead addresses the potential for the SJRA to permanently reduce demands that would otherwise occur by promoting proven water conservation practices. Therefore, instead of creating a “project”, this strategy considers how SJRA might develop programs to promote specific water conservation activities within the various utilities in Montgomery County that would directly benefit those utilities and result in a permanent reduction of raw water demands for those entities and to a lower-cost water supply overall for the region.

The 2016 Region H Regional Water Plan (RWP) included up to a regional average 16.8 percent in conservation savings over baseline demands by the year 2070. This conservation savings came from a combination of baseline conservation applied by the Texas Water Development Board (TWDB) in the development of water demands, water loss reduction, and advanced conservation through methods applied by the Region H Water Planning Group (RHWPG).

The strategies proposed for the San Jacinto River Authority (SJRA) service area in Montgomery County consists of the following:

- Option 1: TWDB baseline conservation.
- Option 2: Recommendations adapted from the 2016 Region H RWP development process.
    - Advanced conservation adapted from the Goldwater Study by Averitt & Associates and the Texas Water Foundation.
    - Additional recommendations made by Averitt & Associates and the Texas Water Foundation but not incorporated into the RWP.
    - Water savings related to water loss reduction.

Previous Planning Activities

In each round of regional water planning, TWDB has prepared estimates of water demands that include projected reductions in per-capita municipal water use based on various trends. Historically, these projections have included the adoption of efficient plumbing codes with higher standards for water efficiency and the replacement of legacy plumbing fixtures over time as new development occurs. In the 2016 RWPs, projections also included provisions for high-efficiency appliances and other water savings that are expected to occur passively. Because of the passive nature of implementation, it can be assumed that these reductions in demand will occur over time without formal implementation or encouragement by a project sponsor, such as SJRA or a private utility.

The RHWPG also included certain recommendations from the Goldwater Project conducted by Averitt & Associates and the Texas Water Foundation. The project aimed to quantify and measure ongoing water conservation efforts in Region H and to work with stakeholders to identify gaps in attaining the desired results and recommend projects for meeting the recommended conservation goals in the 2011 RWP. These additional practices include the use of:

- Efficient residential irrigation controllers,
- Efficient meter installations,
- Tank-type ultra-low-flow toilet rebates,
- Efficient commercial dishwashers,
- Efficient commercial spray-rinse valves,
- Efficient commercial steamers,
- Efficient commercial cooling towers,
- Large landscape surveys for single-family residences,
- Large landscape water budgets for single-family residences,
- Large landscape irrigation controllers for single-family residences.

The RHWPG also investigated the reduction of water loss within the region as a means of reducing overall water demand. Information from the 2010 Water Loss Audit Report was used to identify water loss experienced by various utilities and associated these with the Water User Groups (WUGs) throughout Region H. Any WUGs with water loss levels greater than 10 percent were assumed to reduce their water loss at a rate of one percent annually until losses were limited to a target of 10 percent. Although losses could be reduced below this level, 10 percent was identified as a reasonable target that would provide the greatest benefit per unit cost. These loss reductions would be conducted through a process of system auditing and leak detection and repair.

Results from the study of current and required practices for meeting the goals in the 2011 RWP were adapted into potential projects for all Region H counties in the 2016 RWP with the exception of those that could conserve a considerable amount of water (approaching the level recommended for projects in the 2011 RWP) through water loss reduction alone. This list of practices and recommended strategies listed above is not intended to be exhaustive of all practices that may be employed to reduce municipal water use.

While the 2016 RWP was under development, the Goldwater Project continued gathering information from stakeholders and identifying opportunities for additional conservation savings. One such opportunity was identified from the report, *Water Conservation by the Yard* by the Texas Living Waters Project. The study investigated the potential for reducing water use through the implementation of mandatory restriction on outside landscape irrigation to no more than twice-per-week watering. The results of this study suggested that water savings of four percent could be achieved by water users within Region H as a result of these restrictions. This recommendation was made too late to be incorporated into the 2016 RWP but was contained in the final Goldwater Study report.

Basic Approach

This memorandum categorizes two primary mechanisms for incorporating conservation into the SJRA Raw Water Supply Master Plan (RWSMP). The first mechanism provides for the reduction in demand according to the passive measures identified by TWDB. These practices are expected to occur over time without an active conservation program. Including these measures within the RWSMP will help prevent over-planning that can occur when long-term trends in water demand reduction are not adequately identified during planning. The second mechanism is the use of the active measures prescribed in the Region H and Goldwater studies. These reductions will require an active conservation sponsor, such as SJRA or one or more of its customers, in order to implement further reductions in demand. A combination of these strategies (both passive and active measures) could be used to achieve the five- and ten-year goals set forth in the SJRA water conservation plans. The most recent plans for all SJRA divisions were adopted March 27, 2014, and contain a recommendation of a one percent annual reduction in water use over the five- and ten-year target periods.

STRATEGY ANALYSES

The strategy analyses for Water Conservation include evaluations of the potential supply to be created through demand reduction, environmental factors to be considered with this strategy, implementation considerations, and an analysis of potential cost.

Supply Development

Unlike other strategies, the potential amount of demand reductions in municipal use are typically evaluated as being achieved under a programmatic effort within each specific utility. Based on the previous planning efforts for this region, four categories of activities were identified as the most appropriate areas for focus by the SJRA.

- Option 1 – Passive Measures
    - TWDB Baseline Conservation - passive reduction expected to be achieved due to fundamental changes to plumbing codes and to improved appliance efficiencies.
- Option 2 – Active Measures
    - Advanced Conservation Programs - RHWPG estimates from Goldwater Study based on ongoing active water conservation programs throughout the region designed to encourage various best management practices for municipal utilities.
    - Water Loss Reduction - additional demand reductions for specific utilities due to savings in water loss through infrastructure improvements.
    - Outdoor Landscape Watering Programs - potential savings from implementing irrigation schedules that limit outdoor watering to two occurrences weekly.

Baseline per capita demand reductions identified by TWDB for the 2016 Region H Regional Water Plan were calculated for each demand unit identified during Task 1102 of the RWSMP, Demand Scenario Evaluation. For this analysis, each unit was assigned a representative WUG from the Region H RWP with a corresponding per capita demand as the demand units did not necessarily align with Region H-designated WUGs. The differences between the initial per capita used by TWDB to generate WUG demands and the per capita demand adjusted by TWDB for each decade represent the adjustment made for baseline conservation. Therefore, finding the difference between demands developed with each per capita basis represents the intended reduction in demand associated with the TWDB baseline savings. Finally, demand reduction for the SJRA service area was developed based on the same delineation of the SJRA GRP customers used for demand development. It should be noted that the Woodlands has already adopted a twice per week watering schedule and should already benefit from the associated savings. However, this adoption occurred after the development of the baseline per capita demand used in the demand and strategy analyses and, therefore, the identified savings may still be applied as a strategy within the master plan.

During the development of the 2016 RWP, the Goldwater Study was able to identify high level savings from the programs recommended for each county but applying these on a WUG level was recognized as a much less certain exercise. At the time, a methodology was adopted to distribute identified conservation savings across WUGs within a county based on the distribution of demand. Therefore, WUGs with higher levels of water use were assumed to have greater potential in reducing demand and, therefore, received a higher allocation of water demand reduction through conservation. A similar methodology was employed in this study and the county-wide advanced conservation goals in the Region H RWP were allocated across the demand units in Montgomery County based on their demand after the application of baseline conservation, as was calculated in the RWP. Again, demand reduction for the SJRA service area was developed based on the same delineation of the SJRA GRP customers used for demand development.

In the 2016 Region H RWP, water loss calculations were developed for each WUG based on data presented for the utilities in the *2010 Water Audit Loss Report* where possible. In cases where direct data was not available, such as for County Other WUGs, data on real losses were derived from an aggregation of utilities representing portions of the WUG. Since the demand units evaluated in the Demand Scenario Evaluation of the RWSMP were already associated with Region H WUGs, the water loss savings in the Region H RWP were distributed across the matching demand units in the RWSMP.

Once this distribution was made, water loss reductions associated with demand units within the SJRA GRP were summarized to determine the overall potential for use of this strategy.

The Texas Living Waters Project produced a report, *Water Conservation by the Yard*, which examined outdoor water use in both Region H and Region C. Specifically, the study examined the largely untapped potential of implementing irrigation schedules that limit outdoor watering to two occurrences weekly. The Region H results predicted as much as a four percent reduction in water demand with the implementation of ordinances restricting watering schedules. Water demands for all demand units, after application of baseline conservation, were reduced by four percent and the conservation potential summarized for the SJRA GRP service area. As mentioned previously, uncertainty is an element of all conservation studies and this is especially true for ongoing watering restrictions which will reduce demand more in dry years than wet years and which are also highly variable based on enforcement and compliance.

The combined, projected conservation savings for the SJRA GRP service area in Montgomery County by decade are shown below in *Figure 1*. The passive savings projected from Option 1 are shown in blue while all other approaches associated with Option 2 are shown in green. A considerable volume of savings can be anticipated through only passive measures captured in the TWDB baseline conservation. Further conservation requires the implementation of active measures in Option 2 including advanced conservation, water loss reduction, and twice per week watering. Adopting the Goldwater recommendations identified in the 2016 Region H RWP also provides a significant level of savings which only increase with the addition of the recommended twice per peek watering schedule. Only limited savings can be obtained from water loss reduction. Since the largest demand units within the SJRA GRP, The Woodlands and the City of Conroe, are already good performers in terms of water loss. Their reported losses are less than 10 percent, thus limiting potential water loss reductions to other smaller users with limited opportunity to provide benefit to the overall water supply.

The RWSMP has been conducted in a way which provides for water needs to be identified and addressed on a monthly basis. Therefore, it is important to consider the efficacy of various conservation programs throughout the year. Conservation practices such as the use of more efficient indoor fixtures will generally produce a fairly constant benefit throughout the year. In contrast, modified outdoor watering schedules will demonstrate their greatest benefits at peak watering periods. For the purpose of this analysis, TWDB baseline and advanced conservation programs recommended in the Goldwater Study for the 2016 RWP were assumed to reduce demands evenly throughout the year. Benefits from water loss reduction and outdoor twice-per-week watering were assumed to provide benefits distributed throughout the year in proportion to the overall demand curve. The resulting monthly benefits by month for each decade of Option 2 are shown below in *Figure 2*. It is assumed that Option 1 benefits will occur throughout the year at a constant rate.

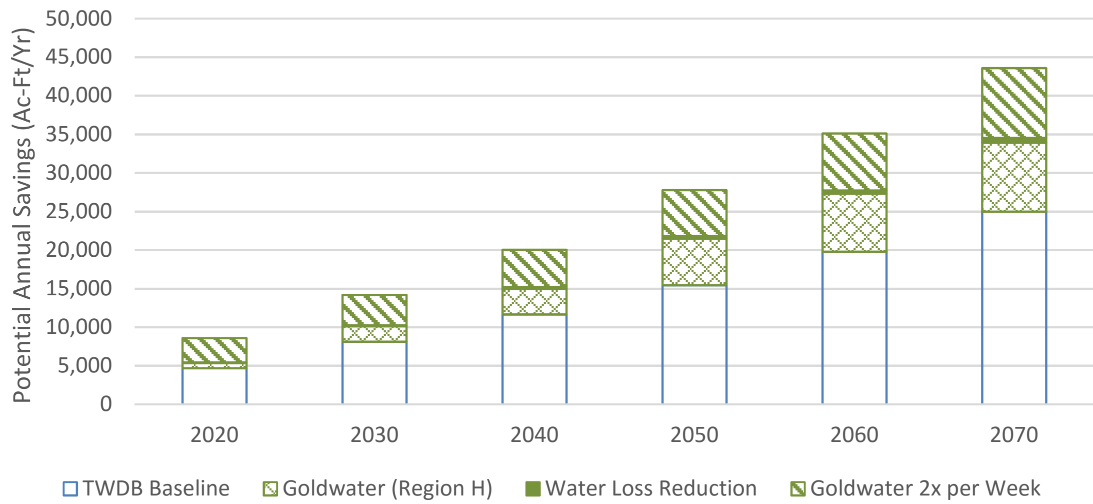


Figure 1 – Potential Water Savings for the SJRA GRP by Program (Options 1 and 2)

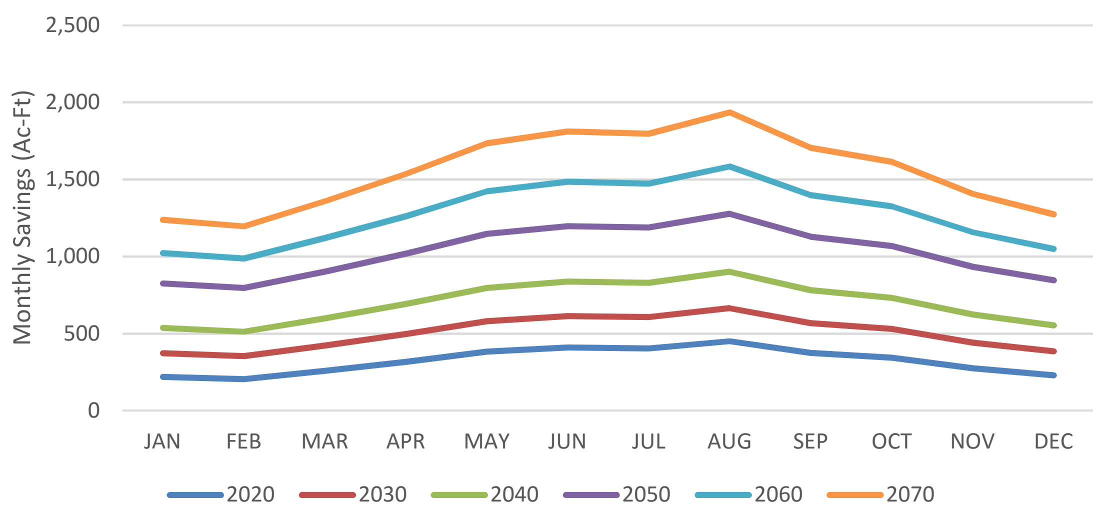


Figure 2 – Monthly Projected Active Conservation Savings for the SJRA GRP under Option 2

Environmental Considerations

Generally, there are no significant negative environmental impacts associated with the conservation programs outlined herein or that may result from implementation of any specific conservation management project. Large-scale structural modifications (constructing physical facilities) are not necessary to implement the water conservation management program. Improvements required for most water loss programs often require water main replacement within existing streets or rights-of-way. Therefore, construction impacts are not anticipated as with other strategies. However, improved conservation may create various types of social impacts and will be subject to varying degrees of acceptance throughout the community. It is noteworthy that conservation measures do sometimes change the pattern of return flows introduced to streams. Municipal effluent is a critical and substantial component to baseflows in the San Jacinto River basin and conservation measures, particularly those associated with in-house methods, will reduce these flows below the level that would occur without conservation in place. However, the reduction in return flows in the demand basin due to conservation would, theoretically, be more than offset by the reduced diversions of water from the source basins or development of other, less environmentally friendly alternatives.

Permitting and Development

Accomplishing the water conservation demand reductions, as described herein, requires proactive implementation. Identification of an appropriate utility or political subdivision to manage or legislate implementation of the conservation measures to the municipal users is one of the critical issues facing the success of this strategy. Development of any conservation program for the SJRA GRP will inevitably require a high degree of coordination across the GRP division's customer base. Individual systems will have varying attitudes toward conservation and SJRA efforts will have to be implemented to demonstrate the value of conservation to the GRP participants as well as their retail customers.

Option 1 will require no effort by SJRA since these savings rely on the natural adoption of water-efficient fixtures and appliances over time. Incorporation of these savings into the RWSMP will represent the acceptance of this assumption rather than the deliberate development of a conservation program by SJRA. Option 2, in contrast, will require an active initiative by SJRA or other parties in order to realize the potential savings estimated in this analysis. One fundamental requirement for SJRA will be the development of staff resources dedicated to the implementation of conservation programs, including the shared purposing of at least one staff member who can focus on these responsibilities in addition to other tasks. Although this staff member or members may be employed at a number of levels, including the SJRA customer level, a dedicated staff member employed by SJRA will have the greatest latitude in promoting conservation initiatives throughout the organization. While direct conservation savings are not associated with this position, SJRA will likely have the greatest success in driving down the conservation strategies to all SJRA customers as appropriate and the assumed water savings from Option 2 are dependent on active implementation through such a position. The primary costs for this position includes the salary and overhead expenses for the SJRA which can range from $135,000 to $165,000 depending on qualifications and level of experience. For the purpose of this analysis the high end of the salary range was added to the annual cost for Option 2.

Other requirements for the implementation of Option 2 will include the planning and funding of specific initiatives intended to promote the advanced conservation, water loss reduction, and twice per week watering approaches described here. These include the following for each approach:

- Advanced Conservation
    - Assess current conservation practices employed by SJRA divisions and major retail customers.

  - Adopt the Alliance for Water Efficiency (AWE) tool for representing water systems served by SJRA.
  - Utilize the AWE tool to estimate the efficacy of current programs.
  - Identify future conservation goals and use the AWE tool to select conservation strategies, including those identified in the Goldwater Study, that may be most appropriately implemented within the SJRA service area.
  - Evaluate and select detailed actions desired to promote prescribed conservation practices through SJRA divisions and customers.
- Water Loss Reduction
  - Determine existing water loss estimates associated with and reduction efforts by SJRA divisions and customers.
  - Identify qualified contractors to provide services in locating sources of water loss through desktop and field analyses.
  - Work with customers experiencing high levels of water loss along with qualified contractor to select measures to increase accountability.
- Twice per Week Watering
  - Review current customer policies encouraging twice per week watering and identify those that can benefit from enacting more appropriate policies or enhancing existing water ordinances.
  - Develop model ordinances, public relations materials, and recommended enforcement approach to promote more efficient outdoor water use including restrictions on watering more frequently than twice per week.
  - Work with SJRA divisions and customers to promote adoption of efficient outdoor watering ordinances.

Cost Analysis

Costs for the conservation measures adapted from the 2016 Region H RWP were developed based on information in that document. Since TWDB baseline conservation relies on passive measures to achieve conservation, no cost has been allocated for this practice.

Costs in the 2016 Region H RWP for advanced conservation programs were developed as part of the Goldwater Study and originated from information included in the AWE Water Conservation Tool. Due to the uncertainties in the actual implementation of these programs, costs developed on a WUG-level in the RWP were summarized and distributed across all WUGs after the initial estimates were developed in order to provide a uniform cost across the region. In a similar manner, the Region H conservation costs for Montgomery County were distributed across the various demand units in the RWSMP study, after which the portion associated with the SJRA GRP was identified separately. Water loss reduction was similarly calculated for the SJRA service area. Costs identified for Montgomery County in the 2016 RWP were allocated across demand units based on the projected savings for each with data for the SJRA service area being compiled separately. It was assumed that twice-per-week watering would cost each entity $0.07 per thousand gallons (Fort Worth Water Conservation Plan, April 2014). It is assumed that any coordination and enforcement of this policy would require part-time or full-time staff which would be funded within SJRA and the GRP customer systems.

Costs for all conservation practices derived from Region H are shown below in *Table 1*.

Table 1 – Estimated Annual Program Costs for Conservation in SJRA GRP by Approach

Approach	Estimated Annual Program Cost					
	2020	2030	2040	2050	2060	2070
Option 1: TWDB Baseline	$0	$0	$0	$0	$0	$0
Option 2: Active Measures	$808,620	$931,328	$1,069,261	$1,394,182	$1,532,648	$1,716,145
Total	**$808,620**	**$931,328**	**$1,069,261**	**$1,394,182**	**$1,532,648**	**$1,716,145**

Table 2 shows the unit costs for active measures based on the estimated annual cost for Option 2 compared against the estimated savings from the active measures. The cost per acre foot ranges from $209 in 2020 to $92 by 2070 with the cost per 1,000 gallons ranging from $0.64 in 2020 to $0.28 by 2070. It is often said that conservation is one of the most cost-effective strategies, which is shown in this cost analysis. It is notable that the effective benefit of conservation is the reduction of water demand at the point of use. Many other comparable strategies may produce water at a lower cost, but must be coupled with treatment and transmission projects in order to satisfy demands. These additional projects are not necessary with a conservation approach, making conservation programs extremely cost-competitive if the efficacy of the programs can be realized.

Table 2 – Estimated Units Costs by Decade for Conservation in SJRA GRP for Option 2 (Active Conservation)

Decade	Active Water Savings (Ac-Ft/Yr)	Annual Cost	Cost per Ac-Ft	Cost per 1,000 gallons
2020	3,872	$808,620	$209	$0.64
2030	6,037	$931,328	$154	$0.47
2040	8,394	$1,069,261	$127	$0.39
2050	12,327	$1,394,182	$113	$0.35
2060	15,287	$1,532,648	$100	$0.31
2070	18,607	$1,716,145	$92	$0.28

WATER MANAGEMENT STRATEGY EVALUATION

Based on the analysis provided above, the Water Conservation project was evaluated across the eleven different criteria for the purpose of a quick comparison against other alternative strategies that are under consideration within this Raw Water Supply Master Plan. The results of this evaluation are shown in *Table 3* below. Project criteria and scoring methodology are described in the technical memorandum, *Preliminary Strategy Identification and Evaluation (Task 1104)*. Higher scores relate to more preferable characteristics.

Baseline conservation or passive measures expected to occur over time ranked higher than active measures due to the cost of those active measures. Potential application of these conservation strategies assume that the baseline conservation goals will be achieved organically over time. SJRA may further choose to implement the effective, yet more costly, active measures in order to achieve 5- and 10-year conservation goals and further reduce identified water needs.

Table 3 – Screening Criteria and Scores of the Water Conservation Strategy

Criteria	Rating	
	Option 1 Passive Measures	Option 2 Active Measures
Cooperation	3	3
Cost	4	4
Diversification	3	3
Environmental	4	4
Funding	4	4
Land Acquisition	4	4
Legal	3	3
Location	4	4
Magnitude	2	2
Other Supplies	2	2
Public	4	4
Scalability	4	4
Schedule	3	3
Yield Risk	3	3
Weighted Score [1]	364	364

[1] Based on weighting methodology adopted in Preliminary Strategy Identification and Evaluation (Task 1104)

REFERENCES

2010 Water Loss Audit Dataset. Texas Water Development Board.

2016 Regional Water Plan. Region H Water Planning Group, 2015.

Goldwater Project Region H Report. Averitt & Associates and Texas Water Foundation. October 2015.

Water Conservation Implementation Task Force Report to the 79th Legislature. November 2004. Published by the Texas Water Development Board.

Water Conservation Plan. City of Fort Worth, 2014.

SAN JACINTO RIVER AUTHORITY RAW WATER SUPPLY MASTER PLAN
DETAILED STRATEGY EVALUATION TECHNICAL MEMORANDUM

Project Name:	Trinity Supplies Transfer to Highlands Service Area
Project Type:	Existing Surface Water Source
Potential Supply Quantity (Rounded):	50,000 acre-feet/year (45 MGD)
Development Timeline:	10 years
Project Capital Cost:	$0 - $109,681,000 (August 2017)
Unit Water Cost (Rounded):	$5 - $549 per acre-feet (during loan period) $5 - $77 per acre-feet (after loan period)

FREESE AND NICHOLS, INC.
TEXAS REGISTERED
ENGINEERING FIRM
F-2144

STRATEGY DESCRIPTION

The San Jacinto River Authority (SJRA) is a wholesale water provider for various municipal, industrial, and irrigation retail customers in the San Jacinto River Basin. SJRA serves a substantial demand center of largely industrial water needs from its Highlands System. In the Highlands service area, Lake Houston is SJRA's primary source of supply; however, SJRA also has water rights in the Trinity River Basin that are used as a source of supply to meet the Highlands service area demands. In terms of conveyance capacity, SJRA delivers all the Highlands supplies by means of an extensive canal system. In addition to water rights diverted at Lake Houston, SJRA also contracts with Coastal Water Authority (CWA) to convey SJRA water rights from the lower Trinity River Basin to its Highlands service area.

SJRA's current supplies in the Trinity basin were acquired several decades ago from a portion of the Devers and Chambers-Liberty Counties Navigation District (CLCND) water rights. The Devers water right (COA-5271C, as amended in 2006) provides access to 56,000 acre-feet per year of supplies and the CLCND water right (COA-4279A as amended in 2008) provides access to 30,000 acre-feet per year of supplies. It should be noted that the Devers water right has a firm yield of 56,000 acre-feet per year when it is backed up through agreement with the City of Houston (COH). SJRA's current contracted capacity in the CWA canal allows them to transfer up to 56,000 acre-feet per year (50 MGD) of supplies from the Trinity basin. As long as the demand in the Highlands service area on the Trinity Basin is approximately 56,000 acre-feet per year, SJRA has both the infrastructure canal capacity and the yield available to meet the Highlands demands using Trinity supplies. However, when the Highlands demands on Trinity supplies exceed 56,000 acre-feet per year, SJRA must increase infrastructure capacity to tap into the additional 30,000 acre-feet per year supplies from the CLCND water rights. In the eventuality that the Highlands demands on the Trinity system exceed the total 86,000 acre-feet per year, SJRA may contract for additional supplies from TRA's Lake Livingston. In addition to the availability of contractual capacity in the CWA system, capacity is also limited by the physical constraints imposed by COH in their own use of the canal system and transfer pumping facilities.

In April 2013, SJRA secured an option agreement with the Trinity River Authority (TRA) for the purchase of up to 50,000 acre-feet of water per year from Lake Livingston. Currently, this water supply is permitted by TCEQ for use within the Trinity River Basin and adjoining coastal basins; however, it can be permitted in the future for transfer out of the Trinity Basin to either the Montgomery County or the Highlands service area. As part of this feasibility study, strategies to deliver Lake Livingston water were developed both for the Montgomery County and the Highlands service areas for the full amount of the water available under this option agreement with TRA.

The current options agreement essentially provides SJRA a "right-of-first-refusal" to enter into a Water Supply Contract with TRA for an initial contract term of not less than 50 years, with provisions in the contract to reserve water at a reservation fee rate for up to 20 years or until water supply is actually used, when at such time the full take-or-pay system rate would go into effect. The options agreement requires SJRA and TRA to enter into a Service Area Agreement by April 2023 and a Water Supply Contract by April 2028.

It should be noted that the 50,000 acre-feet per year of water purchased from TRA may potentially be used to serve any location of the SJRA service area. When comparing the strategies for future selection, it should be noted that the Highlands and the Montgomery County strategies for delivering Livingston water must be treated as mutually exclusive or it should be considered that any of the TRA option amount dedicated to supply in one service area effectively reduces the potential strategy supply available in the other service area. Any volume in excess of this amount would require additional contracting with TRA or other parties.

STRATEGY ANALYSES

The project analyses for supplies from TRA's Trinity supplies conveyed to the Highlands service area include evaluations of the potential amount of supply to be created, environmental factors involved in the project, permitting and development considerations, and an analysis of project cost.

Supply Development

This strategy considers the use of both existing CLCND water right (after exhausting the usage of the Devers water right backed up by COH) and the potential use of the TRA's Livingston supplies to meet the demand in the Highlands service area. The available supply for this strategy includes the 30,000 acre-feet per year from CLCND water right and the additional contracted supplies of 50,000 acre-feet per year from TRA's Lake Livingston.

The identified supply of 50,000 acre-feet per year is allocated out of TRA's existing rights associated with Lake Livingston and the Wallisville Saltwater Barrier. This total supply of 403,200 acre-feet per year was determined to be firm and available for use by TRA in the 2016 Region H Regional Water Plan (RWP). The water right allowing access for the Livingston supply transfer to Highlands is COA 08-4248 and is stored water in Lake Livingston, permitted to be diverted anywhere downstream. It is assumed that the TRA supplies, when contracted, will be apportioned from TRA's Lake Livingston right and diverted at the CWA Main Canal along with SJRA's CLCND and Devers water rights. Only a minor amendment process will be required to utilize this water in the adjoining Trinity-San Jacinto coastal basin that the Highlands System serves.

A review of the demands identified in Task 1102 of this study for the Highlands service area indicated that SJRA's current supplies in the Trinity basin are sufficient to meet the currently identified future demand. It was noted in the supply availability analysis that the occasional lack of availability of the existing Devers and CLCND water rights to meet the identified future demand coincided with hydrological dry conditions, but this issue is addressed by the COH back up for Devers water rights during dry conditions. The assumption considered for the supply availability evaluation was that SJRA will use the contracted capacity of 50 MGD (approximately 56,000 acre-feet per year) in the CWA canal to transfer the supplies from the Devers water right diversion point (when it is backed up by the COH) to the Highlands service area. After using all of the Devers water right (backed up by the COH), the maximum shortage identified in the supply availability analysis was approximately 3,000 acre-feet per year. This amount was rounded up to 5,000 acre-feet per year for long-term strategy planning purposes. A shortage of 5,000 acre-feet per year over the entire planning horizon (2020-2070) is not a significant shortage and mostly arises from a lack of infrastructure capacity to transfer existing CLCND supplies from the Trinity basin.

There may be a future time when SJRA will be required to meet demands greater than the demands considered in this study. The demands in the Highlands service area could grow exponentially due to a new industrial customer locating to this area or due to exponential growth beyond what was projected in Task 1102. While it is uncertain who this potential customer and what the requested demand would be, the Strategy Options presented in this technical memorandum consider the possibility of meeting both the projected demand from Task 1102 and a future unknown demand. For the purposes of defining an upper bound on the potential demand increase, it is assumed that the maximum demand increase in the Highlands service area would be up to 50,000 acre-feet per year. SJRA can meet the demand increases ranging from 5,000 acre-feet per year (based on Task 1102) to 50,000 acre-feet per year by increasing the conveyance capacity to tap into the CLCND rights, exhaust the 30,000 acre-feet per year of CLCND water rights, and ultimately contract with TRA for an additional 20,000 acre-feet per year and also increase conveyance capacity commensurately. It should be noted that the 30,000 acre-feet per year of CLCND water rights does not reflect a firm supply and is also not backed up by any other water rights or contracts. To that end, there is some yield risk associated with SJRA's ability to access the CLCND supplies in the full amount for the 30,000 and 50,000 acre-feet per year options. There is no such yield risk associated with the 5,000 acre-feet per year option due to the anticipated firm yield of this right.

Two different strategy options were identified for transferring Trinity supplies to SJRA's East and South Canals in the Highlands service area. Since most of the high-demand customers are located on the downstream ends of SJRA's East and South Canals, conveyance of Trinity supplies to these canals was determined as the most feasible delivery approach in the Highlands service area.

Strategy Option 1 is based on contracting for additional capacity in the CWA canal to transfer supplies ranging from 5,000 to 50,000 acre-feet per year. Use of this water by SJRA requires various approaches to delivering the supply to meet demands within SJRA's Highlands service area. This additional capacity will provide SJRA access to their CLCND water rights so they can transfer the supplies to the Highlands service area to meet the long-term system shortages. Once the CLCND water rights are exhausted, SJRA can contract with TRA for additional supplies of 20,000 acre-feet per year from Lake Livingston. The cost incurred in this Strategy Option development is the purchase cost of additional capacity in the CWA canal to convey the CLCND water rights and purchase cost to contract for additional supply from TRA, if the shortages are greater than 30,000 acre-feet per year. *Table 1* includes a preliminary cost estimate for Strategy Option 1 for contracting additional conveyance capacity to deliver three different supply volumes, 5,000, 30,000, and 50,000 acre-feet per year.

The acquisition of additional capacity in the CWA Main Canal is subject to negotiations with COH and CWA. Strategy Option 2 is proposed as a way of approximating the maximum cost of conveyance for supplies greater than the current SJRA use within the CWA Main Canal. This strategy proposes a 21-mile long pipeline that parallels the current CWA Main Canal. The analysis of this hypothetical Strategy Option 2 can help SJRA determine the potential benefits when contracting for additional CWA Main Canal capacity. In this hypothetical option, it was assumed that the contracted supplies of 5,000, 30,000, and 50,000 acre-feet per year will be transferred from the Trinity basin to the Highlands service area by means of a hypothetical transmission system potentially owned and operated by SJRA. In any event, SJRA can use Strategy Option 1 as their first go-to option. However, the terms of such an agreement are uncertain at this time and this approximation serves as a means of evaluating the maximum anticipated project cost.

A hypothetical pipeline route was identified along the same easements as the CWA canal location. It was assumed that the transmission system will be owned and operated by SJRA. It was also assumed that the necessary upgrades will be made to the pump stations at SJRA's East and South Canal transfer location to accommodate the additional volumes of 5,000 30,000, and 50,000 acre-feet per year (these costs were not included in the cost estimate for the strategies discussed in this tech memo). In addition to the purchase cost of water from TRA, SJRA will have a significant investment in infrastructure for this option. *Table 2* includes a cost estimate for this hypothetical strategy option.

Exhibit 1 illustrates the overall study area including the general confines of the transmission route considered for transferring supplies from TRA's Trinity diversion point to SJRA's East and South Canals in the Highlands service area. *Exhibit 1* also shows the CWA canal that is currently used to transfer the CLCND and Devers supplies to SJRA's South and East Canals. *Exhibit 2* includes the hydraulic grade lines for the pipeline route and the infrastructure details specific to the transmission route such as the length of the pipeline route and the pipe diameter required to transfer the supplies. The transmission route assumed for this analysis was considered viable at this stage of the feasibility evaluation. Therefore, the environmental considerations, the permitting requirements, and cost details for the alternatives are discussed in this technical memorandum. The strategy evaluation matrix was developed for the various options and capacities considered.

Environmental Considerations

Following are some of the general environmental considerations associated with the transmission alignment identified for transferring supplies from Lake Livingston to Highlands service area in Option 2. A desktop-level survey was conducted to identify any environmental issues associated with the specific route. The details of the survey are summarized below.

1. Permitting coordination with the USACE, TPWD, and other natural resource agencies that may be required to construct the project could encounter obstacles pertaining to potential of the water supply pipeline to serve as a conduit for transferring the exotic invasive mollusk species *Dreissena polymorpha* (zebra mussel). The TPWD confirmed a population of zebra mussels residing within Lake Livingston during June 2016.

2. The USFWS IPaC webservice was consulted to obtain a list of federally-listed species and designated critical habitat segments that could occur within the general project area. The

federally-protected species listed below, comprised of five bird species and four flowering plant species, were identified by the IPaC query as potentially occurring within the general project area. Though some of these species have designated critical habitats, no critical habitat tracts/segments occur within the overall project area.

I. Least tern (Sterna antillarum)
II. Piping plover (Charadrius melodus)
III. Red knot (Calidris canutus rufa)
IV. Red-cockaded woodpecker (Picoides borealis)
V. Whooping crane (Grus americana)
VI. Navasota ladies' tresses (Spiranthes parksii)
VII. Neches River rose-mallow (Hibiscus dasycalyx)
VIII. Texas prairie dawn-flower (Hymenoxys texana)
IX. Texas trailing phlox (Phlox nivalis spp. texensis)

Of these protected species, the following have potential to be affected by the proposed project, and would require a presence/absence survey of the selected/preferred pipeline alignment prior to construction should the project require permitting through the USACE for anticipated impacts to regulated waters of the U.S. (WOTUS).

I. Red-cockaded woodpecker (*Picoides borealis*)
II. Navasota ladies' tresses (*Spiranthes parksii*)
III. Neches River rose-mallow (*Hibiscus dasycalyx*)
IV. Texas prairie dawn-flower (*Hymenoxys texana*)
V. Texas trailing phlox (*Phlox nivalis* spp. *texensis*)

3. Due the presence of streams, wetlands and ponds that could be deemed WOTUS and jurisdictional to Section 404 of the Clean Water Act (CWA) throughout the proposed alignment, acquiring a permit(s) through the USACE would be required prior to beginning construction activities. Pending the level of potential WOTUS impacts, project activities could likely be covered by a Nationwide Permit. The presence of zebra mussels within the Trinity River/Lake Livingston watershed could require that project activities obtain an Individual Permit. Nationwide Permits are typically obtained within 45 to 60 calendar days, but acquiring an Individual Permit typically requires a minimum of 180 days and a public comment period.

4. If no Federal funding or assistance would be used for construction of the proposed project, the need to complete the National Environmental Policy Act (NEPA) process would not be required. However, coordination with the USACE to obtain a CWA Section 404 permit, particularly an Individual Permit, could trigger the need to comply with the NEPA review process.

5. No potential archaeological/historical resources were impacted by this alignment.

All the environmental constraints must be addressed during the permitting and detailed feasibility study phases of the project development. At this stage, the environmental considerations are merely provided as a guide to understanding the potential issues associated with the alignment, and would require a thorough evaluation in the feasibility phase. Detailed environmental evaluation was not conducted for this hypothetical alignment.

Permitting and Development

Although a water right permit exists for the development of the TRA supply, additional permitting will be required to divert TRA's Lake Livingston supplies at the CWA Main Canal pump station. The project will potentially reduce water within the Trinity River Basin below the pump station by as much as 50,000 acre-feet/year. This volume of water is already permitted for full consumptive use within the basin but this strategy considers the transmission of the supplies from the Trinity to the Trinity-San Jacinto River basin. This transmission can be accomplished under the current permitting guidelines established in the Lake Livingston permit and may require a minor amendment or an inter-basin transfer. The project may result in as much as 50,000 acre-feet per year of additional flow in the receiving basins assuming 50 percent return flows through municipal effluent.

Cost Analysis

Preliminary opinions of probable construction costs were developed based on planning-level details considered for the two options evaluated. Cost estimates were indexed to August 2017 dollars and the contract cost of water was included in these estimates to provide a more realistic comparison to other strategies. *Tables 1* and *2* below include a summary of the overall preliminary opinions of probable cost estimates. *Tables 3* through *8* include the detailed cost estimates for various supply volumes evaluated for each of the options. It should be noted that these cost estimates are preliminary planning level cost estimates and cannot be used for contracting or designing purposes. Detailed cost estimates must be developed during the feasibility or design phases of the study.

Table 1. Summary of Preliminary Planning Level Cost Estimates for Transferring Trinity Supplies to Highlands using the Additional Capacity in the CWA Canal (Option 1)

Strategy Option 1 Volumes (Acre-Feet per Year)	Capital Costs	Annual Costs (With Debt Service)	Annual Costs (Without Debt Service)	Unit Cost ($/AF) (With Debt Service)	Unit Cost ($/AF) (Without Debt Service)
5,000	-	$24,000	$24,000	$5	$5
30,000	-	$142,000	$142,000	$5	$5
50,000	-	$2,136,000	$2.136,000	$43	$43

Table 2. Summary of Preliminary Planning Level Cost Estimates for Transferring Trinity Supplies to Highlands using a Hypothetical Potential Pipeline (Option 2)

Strategy Option 2 Volumes (Acre-Feet per Year)	Capital Costs	Annual Costs (With Debt Service)	Annual Costs (Without Debt Service)	Unit Cost ($/AF) (With Debt Service)	Unit Cost ($/AF) (Without Debt Service)
5,000	$28,797,000	$2,745,000	$335,000	$549	$67
30,000	$83,994,000	$8,218,000	$1,189,000	$274	$40
50,000	$109,681,000	$13,013,000	$3,835,000	$260	$77

Table 3 – TRA's Trinity Run-of-River Supplies Transfer to Highlands Service Area Cost Estimate for Option 1 Using Additional CWA Canal Capacity (5,000 acre-feet per year)

OPINION OF PROBABLE CONSTRUCTION COST					September 18, 2017
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
PROJECT CAPITAL COST SUMMARY					
1	CONSTRUCTION COST	1	LS	$0	$0
2	ENGINEERING, FINANCIAL, AND LEGAL SERVICES AND CONTINGENCIES	1	LS	$0	$0
3	LAND AND EASEMENTS	1	LS	$0	$0
4	ENVIRONMENTAL - STUDIES AND MITIGATION	1	LS	$0	$0
5	INTEREST DURING CONSTRUCTION	1	LS	$0	$0
	PROJECT CAPITAL COST				$0

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	DEBT SERVICE	$0	$0	$0	$0	$0	$0
2	OPERATION AND MAINTENANCE (O&M)	$0	$0	$0	$0	$0	$0
3	PUMPING ENERGY COSTS	$0	$0	$0	$0	$0	$0
4	PURCHASE COST OF WATER	$0	$0	$0	$0	$0	$0
5	ADDITIONAL CWA CAPACITY	$23,627	$23,627	$23,627	$23,627	$23,627	$23,627
	TOTAL ANNUAL COST	$23,627	$23,627	$23,627	$23,627	$23,627	$23,627

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	ANNUAL COST	$23,627	$23,627	$23,627	$23,627	$23,627	$23,627
2	YIELD	5,000	5,000	5,000	5,000	5,000	5,000
3	UNIT COST	$5	$5	$5	$5	$5	$5
	TOTAL UNIT COST						$5

Table 4 – TRA's Trinity Run-of-River Supplies Transfer to Highlands Service Area Cost Estimate for Option 1 Using Additional CWA Canal Capacity (30,000 acre-feet per year)

OPINION OF PROBABLE CONSTRUCTION COST					September 18, 2017
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
PROJECT CAPITAL COST SUMMARY					
1	CONSTRUCTION COST	1	LS	$0	$0
2	ENGINEERING, FINANCIAL, AND LEGAL SERVICES AND CONTINGENCIES	1	LS	$0	$0
3	LAND AND EASEMENTS	1	LS	$0	$0
4	ENVIRONMENTAL - STUDIES AND MITIGATION	1	LS	$0	$0
5	INTEREST DURING CONSTRUCTION	1	LS	$0	$0
	PROJECT CAPITAL COST				$0

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	DEBT SERVICE	$0	$0	$0	$0	$0	$0
2	OPERATION AND MAINTENANCE (O&M)	$0	$0	$0	$0	$0	$0
3	PUMPING ENERGY COSTS	$0	$0	$0	$0	$0	$0
4	PURCHASE COST OF WATER	$0	$0	$0	$0	$0	$0
5	ADDITIONAL CWA CAPACITY	$141,763	$141,763	$141,763	$141,763	$141,763	$141,763
	TOTAL ANNUAL COST	$141,763	$141,763	$141,763	$141,763	$141,763	$141,763

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	ANNUAL COST	$141,763	$141,763	$141,763	$141,763	$141,763	$141,763
2	YIELD	30,000	30,000	30,000	30,000	30,000	30,000
3	UNIT COST	$5	$5	$5	$5	$5	$5
	TOTAL UNIT COST						$5

Table 5 – TRA's Trinity Run-of-River Supplies Transfer to Highlands Service Area Cost Estimate for Option 1 Using Additional CWA Canal Capacity (50,000 acre-feet per year)

OPINION OF PROBABLE CONSTRUCTION COST					September 18, 2017
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
PROJECT CAPITAL COST SUMMARY					
1	CONSTRUCTION COST	1	LS	$0	$0
2	ENGINEERING, FINANCIAL, AND LEGAL SERVICES AND CONTINGENCIES	1	LS	$0	$0
3	LAND AND EASEMENTS	1	LS	$0	$0
4	ENVIRONMENTAL - STUDIES AND MITIGATION	1	LS	$0	$0
5	INTEREST DURING CONSTRUCTION	1	LS	$0	$0
	PROJECT CAPITAL COST				$0

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	DEBT SERVICE	$0	$0	$0	$0	$0	$0
2	OPERATION AND MAINTENANCE (O&M)	$0	$0	$0	$0	$0	$0
3	PUMPING ENERGY COSTS	$0	$0	$0	$0	$0	$0
4	PURCHASE COST OF WATER	$1,900,000	$1,900,000	$1,900,000	$1,900,000	$1,900,000	$1,900,000
5	ADDITIONAL CWA CAPACITY	$236,272	$236,272	$236,272	$236,272	$236,272	$236,272
	TOTAL ANNUAL COST	$2,136,272	$2,136,272	$2,136,272	$2,136,272	$2,136,272	$2,136,272

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	ANNUAL COST	$2,136,272	$2,136,272	$2,136,272	$2,136,272	$2,136,272	$2,136,272
2	YIELD	50,000	50,000	50,000	50,000	50,000	50,000
3	UNIT COST	$43	$43	$43	$43	$43	$43
	TOTAL UNIT COST						$43

Table 6 – TRA's Trinity Run-of-River Supplies Transfer to Highlands Service Area Cost Estimate for Option 2 Using a Hypothetical Pipeline (5,000 acre-feet per year)

OPINION OF PROBABLE CONSTRUCTION COST						October 31, 2017
ITEM	DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	TOTAL
PROJECT CAPITAL COST SUMMARY						
1	CONSTRUCTION COST		1	LS	$18,058,809	$18,058,809
2	ENGINEERING, FINANCIAL, AND LEGAL SERVICES AND CONTINGENCIES		1	LS	$5,597,910	$5,597,910
3	LAND AND EASEMENTS		1	LS	$3,216,667	$3,216,667
4	ENVIRONMENTAL - STUDIES AND MITIGATION		1	LS	$1,030,924	$1,030,924
5	INTEREST DURING CONSTRUCTION		1	LS	$892,642	$892,642
	PROJECT CAPITAL COST					$28,796,952

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	DEBT SERVICE	$2,409,710	$2,409,710	$0	$0	$0	$0
2	OPERATION AND MAINTENANCE (O&M)	$234,668	$234,668	$234,668	$234,668	$234,668	$234,668
3	PUMPING ENERGY COSTS	$100,533	$100,533	$100,533	$100,533	$100,533	$100,533
4	PURCHASE COST OF WATER	$0	$0	$0	$0	$0	$0
	TOTAL ANNUAL COST	$2,744,911	$2,744,911	$335,201	$335,201	$335,201	$335,201
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	ANNUAL COST	$2,744,911	$2,744,911	$335,201	$335,201	$335,201	$335,201
2	YIELD	5,000	5,000	5,000	5,000	5,000	5,000
3	UNIT COST	$549	$549	$67	$67	$67	$67
	TOTAL UNIT COST						$228

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION COST SUMMARY					
1	PUMP STATIONS	1	LS	$3,605,350	$3,605,350
2	PIPELINES	1	LS	$14,297,709	$14,297,709
3	PIPELINE CROSSINGS	1	LS	$155,751	$155,751
	PROJECT COST				$18,058,809
OPERATION AND MAINTENANCE (O&M) COST SUMMARY					
1	PUMP STATIONS	2.5	%	$3,605,350	$90,134
2	PIPELINES	1.0	%	$14,297,709	$142,977
3	PIPELINE CROSSINGS	1.0	%	$155,751	$1,558
	ANNUAL OPERATION AND MAINTENANCE COST				$234,668
PUMP STATION CONSTRUCTION COSTS					
1	412 HP Pump Station with Intake	1.0	LS	$3,605,350	$3,605,350
	PUMP STATIONS TOTAL COST				$3,605,350
PIPELINE CONSTRUCTION COSTS					
1	24'' Diameter Pipeline (Rural Soil)	101,331.0	LF	$125	$12,625,883
2	24'' Diameter Pipeline (Urban Soil)	7,031.0	LF	$238	$1,671,826
	PIPELINES TOTAL COST				$14,297,709
PIPELINE CROSSING CONSTRUCTION COST					
1	24'' Diameter Pipeline Crossing (Directional, Rock)	500.0	LF	$312	$155,751
	PIPELINE CROSSINGS TOTAL COSTS				$155,751

Table 7 – TRA's Trinity Run-of-River Supplies Transfer to Highlands Service Area Cost Estimate for Option 2 Using a Hypothetical Pipeline (30,000 acre-feet per year)

OPINION OF PROBABLE CONSTRUCTION COST					October 31, 2017
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**TOTAL**
PROJECT CAPITAL COST SUMMARY					
1	CONSTRUCTION COST	1	LS	$58,894,797	$58,894,797
2	ENGINEERING, FINANCIAL, AND LEGAL SERVICES AND CONTINGENCIES	1	LS	$18,175,309	$18,175,309
3	LAND AND EASEMENTS	1	LS	$3,239,394	$3,239,394
4	ENVIRONMENTAL - STUDIES AND MITIGATION	1	LS	$1,080,924	$1,080,924
5	INTEREST DURING CONSTRUCTION	1	LS	$2,603,630	$2,603,630
	PROJECT CAPITAL COST				**$83,994,055**

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
1	DEBT SERVICE	$7,028,566	$7,028,566	$0	$0	$0	$0
2	OPERATION AND MAINTENANCE (O&M)	$741,009	$741,009	$741,009	$741,009	$741,009	$741,009
3	PUMPING ENERGY COSTS	$447,987	$447,987	$447,987	$447,987	$447,987	$447,987
4	PURCHASE COST OF WATER	$0	$0	$0	$0	$0	$0
	TOTAL ANNUAL COST	**$8,217,563**	**$8,217,563**	**$1,188,996**	**$1,188,996**	**$1,188,996**	**$1,188,996**
ANNUAL COST SUMMARY		**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
1	ANNUAL COST	$8,217,563	$8,217,563	$1,188,996	$1,188,996	$1,188,996	$1,188,996
2	YIELD	30,000	30,000	30,000	30,000	30,000	30,000
3	UNIT COST	$274	$274	$40	$40	$40	$40
	TOTAL UNIT COST						**$118**

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION COST SUMMARY					
1	PUMP STATIONS	1	LS	$10,137,400	$10,137,400
2	PIPELINES	1	LS	$47,926,728	$47,926,728
3	PIPELINE CROSSINGS	1	LS	$830,670	$830,670
	PROJECT COST				**$58,894,797**
OPERATION AND MAINTENANCE (O&M) COST SUMMARY					
1	PUMP STATIONS	2.5	%	$10,137,400	$253,435
2	PIPELINES	1.0	%	$47,926,728	$479,267
3	PIPELINE CROSSINGS	1.0	%	$830,670	$8,307
	ANNUAL OPERATION AND MAINTENANCE COST				**$741,009**
PUMP STATION CONSTRUCTION COSTS					
1	1642 HP Pump Station with Intake	1.0	LS	$10,137,400	$10,137,400
	PUMP STATIONS TOTAL COST				**$10,137,400**
PIPELINE CONSTRUCTION COSTS					
1	54'' Diameter Pipeline (Rural Soil)	101,331.0	LF	$415	$42,086,291
2	54'' Diameter Pipeline (Urban Soil)	7,031.0	LF	$831	$5,840,437
	PIPELINES TOTAL COST				**$47,926,728**
PIPELINE CROSSING CONSTRUCTION COST					
1	54'' Diameter Pipeline Crossing (Directional, Rock)	500.0	LF	$1,661	$830,670
	PIPELINE CROSSINGS TOTAL COSTS				**$830,670**

Table 8 – TRA's Trinity Run-of-River Supplies Transfer to Highlands Service Area Cost Estimate for Option 2 Using a Hypothetical Pipeline (50,000 acre-feet per year)

OPINION OF PROBABLE CONSTRUCTION COST					October 31, 2017
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
PROJECT CAPITAL COST SUMMARY					
1	CONSTRUCTION COST	1	LS	$77,765,797	$77,765,797
2	ENGINEERING, FINANCIAL, AND LEGAL SERVICES AND CONTINGENCIES	1	LS	$24,170,692	$24,170,692
3	LAND AND EASEMENTS	1	LS	$3,214,141	$3,214,141
4	ENVIRONMENTAL - STUDIES AND MITIGATION	1	LS	$1,130,924	$1,130,924
5	INTEREST DURING CONSTRUCTION	1	LS	$3,399,882	$3,399,882
	PROJECT CAPITAL COST				$109,681,437

ITEM	DESCRIPTION	ANNUAL TOTAL					
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	DEBT SERVICE	$9,178,069	$9,178,069	$0	$0	$0	$0
2	OPERATION AND MAINTENANCE (O&M)	$1,029,944	$1,029,944	$1,029,944	$1,029,944	$1,029,944	$1,029,944
3	PUMPING ENERGY COSTS	$904,793	$904,793	$904,793	$904,793	$904,793	$904,793
4	PURCHASE COST OF WATER	$1,900,000	$1,900,000	$1,900,000	$1,900,000	$1,900,000	$1,900,000
	TOTAL ANNUAL COST	$13,012,806	$13,012,806	$3,834,737	$3,834,737	$3,834,737	$3,834,737
ANNUAL COST SUMMARY		2020	2030	2040	2050	2060	2070
1	ANNUAL COST	$13,012,806	$13,012,806	$3,834,737	$3,834,737	$3,834,737	$3,834,737
2	YIELD	50,000	50,000	50,000	50,000	50,000	50,000
3	UNIT COST	$260	$260	$77	$77	$77	$77
	TOTAL UNIT COST						$138

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION COST SUMMARY					
1	PUMP STATIONS	1	LS	$16,819,050	$16,819,050
2	PIPELINES	1	LS	$59,908,410	$59,908,410
3	PIPELINE CROSSINGS	1	LS	$1,038,337	$1,038,337
	PROJECT COST				$77,765,797
OPERATION AND MAINTENANCE (O&M) COST SUMMARY					
1	PUMP STATIONS	2.5	%	$16,819,050	$420,476
2	PIPELINES	1.0	%	$59,908,410	$599,084
3	PIPELINE CROSSINGS	1.0	%	$1,038,337	$10,383
	ANNUAL OPERATION AND MAINTENANCE COST				$1,029,944
PUMP STATION CONSTRUCTION COSTS					
1	3590 HP Pump Station with Intake	1.0	LS	$16,819,050	$16,819,050
	PUMP STATIONS TOTAL COST				$16,819,050
PIPELINE CONSTRUCTION COSTS					
1	60'' Diameter Pipeline (Rural Soil)	101,331.0	LF	$519	$52,607,863
2	60'' Diameter Pipeline (Urban Soil)	7,031.0	LF	$1,038	$7,300,547
	PIPELINES TOTAL COST				$59,908,410
PIPELINE CROSSING CONSTRUCTION COST					
1	60'' Diameter Pipeline Crossing (Directional, Rock)	500.0	LF	$2,077	$1,038,337
	PIPELINE CROSSINGS TOTAL COSTS				$1,038,337

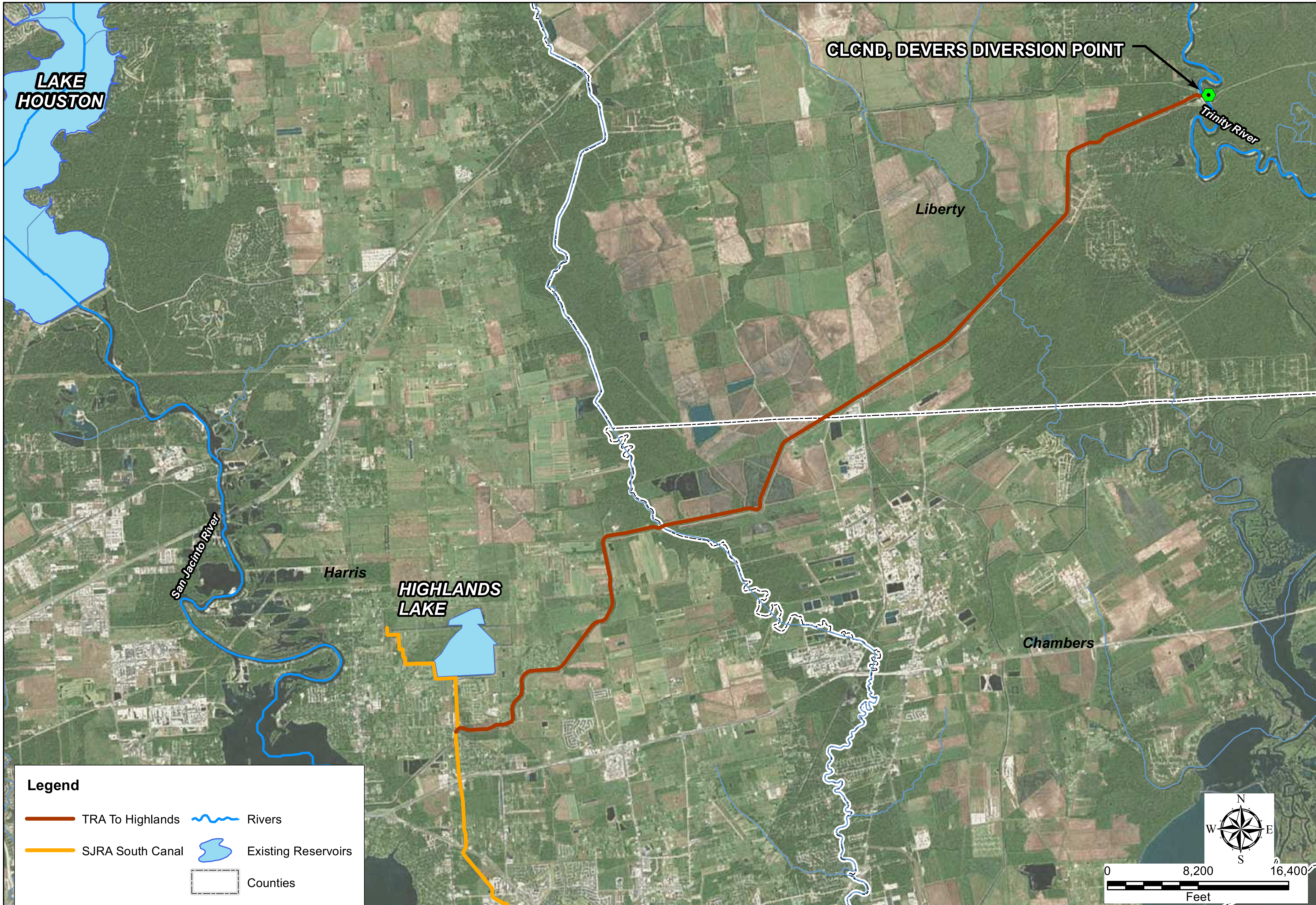
WATER MANAGEMENT STRATEGY EVALUATION

Based on the analysis provided above, the Trinity supplies transfer to Highlands project was evaluated across eleven different criteria for the purpose of quick comparison against alternative projects that may be incorporated into the Regional Water Plan. The results of this evaluation can be seen in *Table 9* below.

Table 9 - Screening Criteria and Scores for Trinity Supplies Transfer to Highlands Strategy

Criteria	Rating					
	Conveyance for 3,000 ac-ft/yr Option 1a	Conveyance for 30,000 ac-ft/yr Option 1b	Conveyance for 50,000 ac-ft/yr Option 1c	New Transmission for 3,000 ac-ft/yr Option 2a	New Transmission for 30,000 ac-ft/yr Option 2b	New Transmission for 50,000 ac-ft/yr Option 2c
Cooperation	3	3	3	4	4	4
Cost	4	4	4	3	3	3
Diversification	3	3	3	3	3	3
Environmental	3	3	3	3	3	3
Funding	2	2	2	2	2	2
Land Acquisition	4	4	4	3	3	3
Legal	3	3	3	3	3	3
Location	1	3	3	1	3	3
Magnitude	3	3	3	3	3	3
Other Supplies	4	4	4	3	3	3
Public	4	4	4	3	3	3
Scalability	1	1	1	1	1	1
Schedule	4	4	4	3	3	3
Yield Risk	4	2	3	4	2	3
Weighted Score*	**340**	**340**	**346**	**286**	**286**	**292**

*Based on weighting methodology adopted in Preliminary Strategy Identification and Evaluation (Task 1104



SJRA RAW WATER SUPPLY MASTER PLAN

Highlands Service Area

TRA's Trinity Run-of-River Supplies Transfer to Highlands Strategy

FN PROJECT NO.	SJR15616
DATE CREATED	5/17/2017
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas South Central
FILE NAME	Exhibit_1_LakeLivingstonToHighlands
PREPARED BY	DML

FREESE AND NICHOLS, INC.
10497 TOWN AND
COUNTRY WAY, SUITE 600
HOUSTON, TEXAS 77024
P: (713) 600-6800
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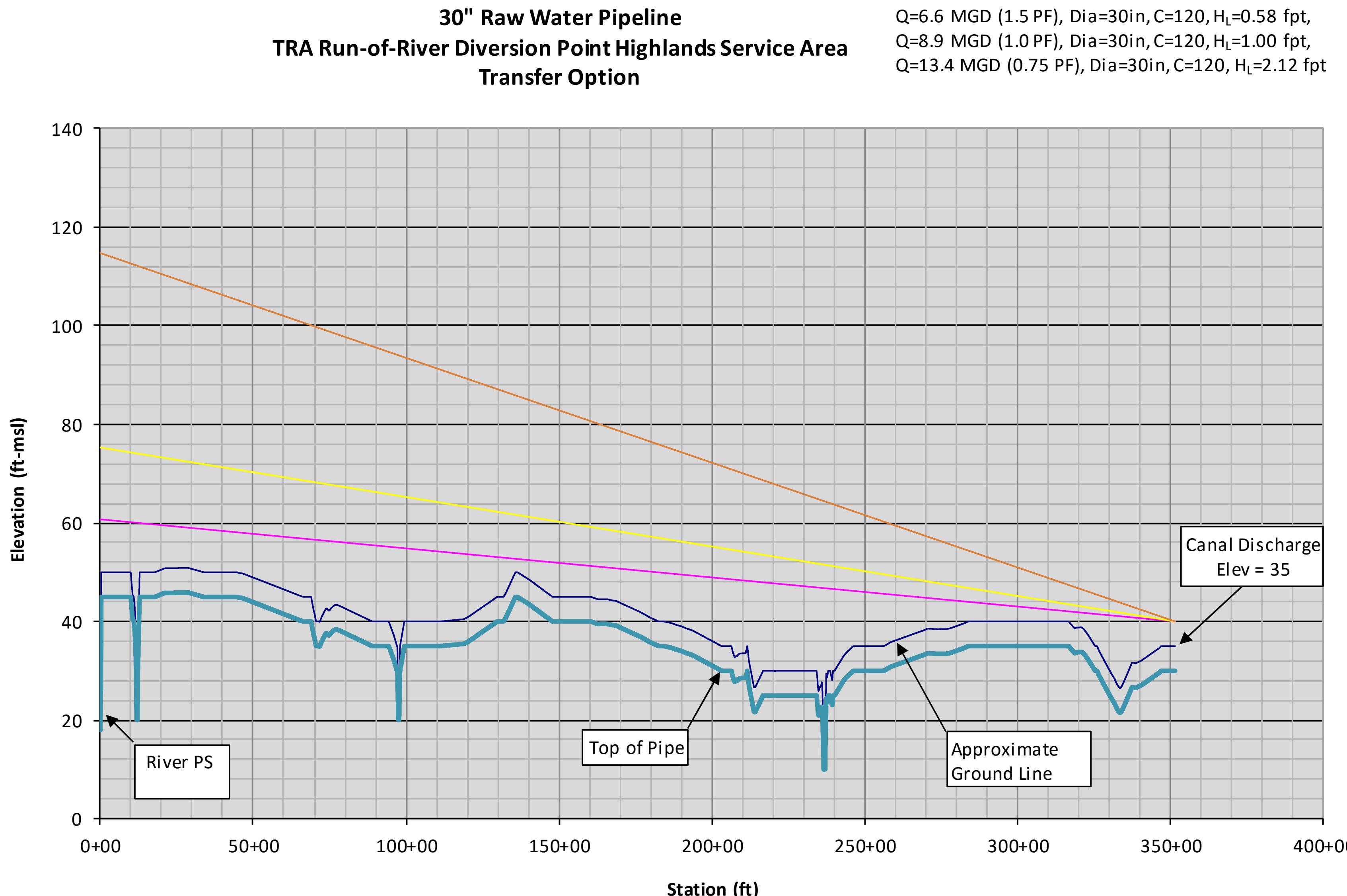
EXHIBIT

1

Date Saved: 5/17/2017 2:45:18 PM

Path: H:\WR_PLANNING\Working\SJRA_RWSMP\Exhibit_1_LakeLivingstonToHighlands.mxd



Note: Ground line obtained from 5' contours.

Exhibit 2. TRA's Trinity Run-of-River Diversion Point to Highlands Service Area Transfer Strategy Hydraulic Grade Line

SAN JACINTO RIVER AUTHORITY RAW WATER SUPPLY MASTER PLAN
DETAILED STRATEGY EVALUATION TECHNICAL MEMORANDUM

Project Name:	Return Flows in Highlands Service Area
Project Type:	Reuse
Potential Supply Quantity (Rounded):	135,146 acre-feet/year (120 MGD)
Development Timeline:	5 years
Project Capital Cost:	NA
Unit Water Cost (Rounded):	NA

STATE OF TEXAS
SPANDANA TUMMURI
107802
LICENSED
PROFESSIONAL ENGINEER

FREESE AND NICHOLS, INC.
TEXAS REGISTERED
ENGINEERING FIRM
F-2144

STRATEGY DESCRIPTION

The San Jacinto River Authority (SJRA) is a wholesale raw water provider for various municipal retail, industrial, and irrigation customers in the San Jacinto River Basin. SJRA serves a substantial demand center of largely industrial water needs from its Highlands System. In the Highlands service area, water rights diverted at Lake Houston are SJRA's original and primary source of supply. SJRA also has water rights in the Trinity River Basin that were acquired from CLCND and the Devers Canal Company (approximately 20 – 30 years ago) to be used as a source of supply to meet the Highlands service area demands. In terms of conveyance capacity, SJRA delivers the Lake Houston supplies by means of an extensive canal system. In addition to water rights and return flows diverted at Lake Houston, SJRA also contracts with Coastal Water Authority (CWA) to convey the water rights it owns in the lower Trinity River Basin to its Highland system. While the existing supplies are adequate to meet most of the current demand projections in the Highlands service area, there is also potential for exponential demand increases owing to the potential for rapid growth and industrialization. SJRA desires to plan and prepare for such eventuality by developing water supply strategies that help them serve the potential growth, if needed.

Return flows are one of the various sources of supply that SJRA is considering as a potential future source. Throughout the San Jacinto River Basin, organized development is steadily overtaking the traditional, rural development that has historically been present in much of the area. Over time, homes with individual wells and on-site septic systems are being replaced with master-planned water and wastewater service. It is this urbanized housing development that produce opportunities for the use of return flows as a future water supply.

Below is a description of the methodology used to compute the return flows, as presented in Task 1102. The populations contributing to return flows were taken from the 2016 RWP and the Regional Groundwater Update Project (RGUP) developed by Houston Galveston Subsidence District (HGSD), Fort Bend Subsidence District (FBSD), and Lone Star Groundwater Conservation District (LSGCD), where possible. A detailed analysis of population density in utilities known to have a comprehensive wastewater system was conducted. The population densities for various utilities were determined and the lowest of these densities were used as a threshold for other population-bearing units; those with a density less than that will be assumed to utilize on-site treatment and will not generate return flow until they reach a density that surpasses the threshold. Based on review of per-capita demands from the RGUP and Region H, the per-capita demands developed during the development of the 2016 Regional Water Plan (RWP) without the application of conservation were used to develop estimates of return flows. The return flow estimates were generated based on a return flow factor of 40% of the annual water demand. In addition, the return flows in the basin that are permitted under existing water rights were removed from consideration.

STRATEGY ANALYSES

The project analyses for Return Flows strategy for SJRA's Highlands service area include evaluations of the potential supply to be created, environmental factors involved in the project, permitting and development considerations, and an analysis of project cost.

Supply Development

Separate return flows strategies are being developed for the Montgomery County service area and the Highlands service area. Therefore, the sub-basins contributing return flows to each one of the service areas were identified and separated based on the service area to which they are contributing return flows. It is possible that the choice to develop certain return flows strategies may impact the potential to develop strategies downstream in the Highlands service area.

Exhibit 1 includes a map of the sub-basins contributing to the Highlands service area. Some or all of the return flows generated in the Montgomery County service area could potentially be diverted downstream to Lake Houston to serve the Highlands service area. This memorandum considers potential supplies discharged from the City of Conroe that may be captured upstream at the Lake Creek diversion point and used within Montgomery County, as described in the corresponding Montgomery County strategy. Other supplies included in this analysis are below this diversion point and are not readily developed for use in Montgomery County without additional considerations.

The overall potential volumes of return flows generated for the Highlands service area are reported in *Table 1* below.

Table 1. Summary of Return Flows Generated in the Highlands Service Area

Service Area	Return Flows (Acre-Feet per Year) [1]					
	2020	2030	2040	2050	2060	2070
Lake Houston	78,371	96,595	109,076	124,742	143,361	162,622
TOTAL	**78,371**	**96,595**	**109,076**	**124,742**	**143,361**	**162,622**

[1] Return flow estimates in this table do not include deductions for existing authorization or channel losses.

Any return flows already permitted under existing authorizations were subtracted from these return flows. *Table 2* includes a list of existing authorizations considered in this evaluation. The return flows to be deducted were determined based on the geographical extents of the existing authorizations and the manner in which they drain to potential diversion points. In addition to these existing authorizations, conveyance losses for the travel from the sub-basins to the diversion points were also subtracted from the return flows listed in *Table 1*. A channel loss factor of 5% was assumed and used for estimating these conveyance losses.

Table 2. Summary of Currently Authorized Return Flows Deducted from Highlands Service Area

Deduction	Return Flows (Acre-Feet per Year)[1]					
	2020	2030	2040	2050	2060	2070
City of Houston Permit 5827	5,254	5,576	5,896	6,188	6,459	6,594
River Plantation MUD	215	229	284	307	307	307
SJRA Permits 3960 and 5809[2]	9,593	10,178	10,723	11,364	12,303	13,463
TOTAL	**15,062**	**15,983**	**16,903**	**17,859**	**19,069**	**20,364**

[1] Return flow estimates in this table do not include channel losses.
[2] Include flows that are utilized by SJRA as existing supplies.

The options considered below will use the return flows identified in *Table 1* along with the deductions indicated in *Table 2* in order to present potential scenarios in which flows may be developed for supply purposes. The options considered will develop water from resources that are not currently under consideration as presented in *Table 1*, less the volumes in negotiation/authorized in *Table 2*. Upstream options in the Lake Creek watershed will also be considered, should that strategy not be implemented for use in Montgomery County.

Return Flow Strategy Options

In order to develop the return flows in the Highlands service area, SJRA must determine the volume of return flows available in the Highlands service area, identify the entities that are generating those return flows, determine the pending applications for return flows to keep track of, establish agreements/contracts with entities generating the return flows, and apply for TCEQ permit(s) for those return flows. SJRA has the following potential project alternatives.

1) Pending return flow permit applications. Evaluate the volume of return flows that would be available to the Highlands service area from those pending applications.

2) Return flows originating in Montgomery County that flow to Lake Houston. This option will include entering into contractual agreements with dischargers in Montgomery County for the use of treated effluent and the permitting of those return flows. In some cases, this will be a continuation of the existing terms between SJRA and its GRP participants that make surface water-based return flows available. In other cases, SJRA will have to contract with parties in order to obtain rights to the reuse supply.

3) Other return flows to Lake Houston. SJRA can potentially expand beyond Montgomery County to partner with others in developing reclaimed water supplies from municipal treated effluent.

Strategy Alternative Option 1 - The first return flow scenario would require SJRA to simply track the pending return flow permit for the City of Conroe return flows already submitted to TCEQ by SJRA. The permit application was submitted for 11,200 acre-feet. It is assumed that a percentage of this requested amount up to a maximum of 11,200 acre-feet will be available to SJRA to serve the Highlands service area, based on the availability of surface water-based return flows discharged by the Conroe facility. The projected volumes of return flows available from this pending application are listed in *Table 3* below, based on the assumption that SJRA's permitted return flows would not be diverted for use in Montgomery County but would pass to Lake Houston.

Table 3. Option 1: Return Flows Available in Highlands Service Area from Pending Applications

Reuse Source	Return Flows (Acre-Feet per Year) [1]					
	2020	2030	2040	2050	2060	2070
City of Conroe Permit	3,473	4,414	5,965	6,732	7,554	8,400
SJRA Surface Water	*3,473*	*4,414*	*5,965*	*6,732*	*7,554*	*8,400*
OPTION 1 TOTAL	**3,473**	**4,414**	**5,965**	**6,732**	**7,554**	**8,400**

[1] Return flows adjusted for channel losses.

Strategy Alternative Option 2 – Another return flow scenario for SJRA would be to permit all available flows originating in Montgomery County. This will involve coordinating with GRP participants relying on surface water and establishing an agreement with those dischargers to permit for the return flows associated with them. This may involve contracts with parties who are not currently within the SJRA GRP and may belong to other GRPs within the county. It is also noteworthy that this may include the inclusion of parties who are not currently part of SJRA's GRP but may be added at a later point under the Safe Harbor GRP provision. *Table 4* includes a summary of the return flow volumes available to SJRA by coordinating with GRP participants relying on surface water in Montgomery County.

Table 4. Option 2: Return Flows Available in Highlands Service Area from Montgomery

Reuse Source	Return Flows (Acre-Feet per Year) [1]					
	2020	2030	2040	2050	2060	2070
SJRA Surface Water	774	1,766	5,261	13,442	24,807	37,781
Other Sources	10,941	19,063	23,592	27,196	30,737	33,382
TOTAL	**11,715**	**20,830**	**28,853**	**40,637**	**55,544**	**71,164**

[1] Return flows adjusted for channel losses.

Strategy Alternative Option 3 – The final strategy option for SJRA would be to coordinate with the other Harris County water users, which release available return flows into Lake Houston. This includes coordination with other regional water providers such as City of Houston, NHCRWA, and WHCRWA, and also water users in Liberty, San Jacinto, and Waller counties. Upon determining the available volume of return flows contributed by each entity, SJRA can establish an agreement with these entities to permit for the return flows generated by them. *Table 5* includes a summary of the return flows anticipated to e available from these entities.

Table 5. Option 3: Return Flows Available in Highlands Service Area from GRP Participants using Groundwater

Reuse Source	Return Flows (Acre-Feet per Year) [1]					
	2020	2030	2040	2050	2060	2070
Harris County	50,511	58,662	62,166	65,056	67,523	69,835
COH	*3,416*	*3,462*	*3,478*	*3,463*	*3,427*	*3,497*
NHCRWA	*43,735*	*47,254*	*50,143*	*52,578*	*54,706*	*56,640*
WHCRWA	*2,791*	*5,433*	*5,654*	*5,822*	*5,949*	*6,048*
Other	*570*	*2,514*	*2,891*	*3,193*	*3,441*	*3,651*
Other Counties	1,083	1,121	1,155	1,191	1,225	1,259
TOTAL	**51,594**	**59,783**	**63,321**	**66,247**	**68,748**	**71,095**

[1] Return flows adjusted for channel losses.

Because the return flows are naturally flowing into Lake Houston, there is no need for any additional infrastructure to capture any of the return flows discussed in the strategies above. To that end, the only cost incurred in developing these strategies is the administrative and legal fees associated with the TCEQ permitting process. SJRA must coordinate with the entities generating the return flows to determine the timing for developing the return flows over the planning horizon. It should be noted that the return flows permitted in the strategy will represent an additional source of supply and will not be considered by TCEQ as part of SJRA's existing permit authorization for Lake Houston. These return flows are available to any entity that desires to permit the supplies. Therefore, the amount available may vary as additional permits are applied for by other entities. In addition to this TCEQ permit, SJRA will have to coordinate with City of Houston for the bed and banks transfer of the return flows through Lake Houston. The current evaluation of this strategy accounted for all the known existing authorizations. The future analyses of this strategy must take into consideration any additional return flow authorizations secured or applied for with TCEQ up to the date of the analyses.

Lastly, the delivery capacity of the Highlands conveyance system must be considered depending on the location of the proposed demands. The potential volume of available supplies under this option exceeds the current capacity of this system.

Environmental Considerations

Environmental considerations associated with reuse are largely associated with the reduction of instream flows. This consideration will be included as part of the permitting process for any indirect reuse project. More specific issues arise from the development of infrastructure intended to facilitate the use of reclaimed water. The following are some of the general environmental considerations associated with the development of the return flows strategy in the Highlands service area.

The diversion of the effluent source supply would be expected to have some degree of impact in terms of reduction of instream flows downstream of the diversion point for any portion of the source supply originating from current levels of return flow. A more detailed analysis of environmental impacts and legal constraints would be considered during the permit application and review process, which has been initiated. Any impacts would be anticipated to occur from reuse of effluent generated from current levels of discharge; diversion of the portion attributable to future growth would not be expected to cause additional impact. It should also be noted that the proposed diversions would occur upstream of the monitoring points for Senate Bill 3 environmental flow standards and could potentially be subject to associated restrictions.

All environmental constraints can be addressed during the permitting and detailed feasibility study phases of the project development. At this stage, the environmental considerations are merely provided as a guide for selecting the appropriate route for future evaluation.

Permitting and Development

SJRA will have to coordinate with TCEQ for a bed and banks permit to convey the return flows developed in this strategy. SJRA will have to apply for authorization to use the bed and banks of Lake Houston to convey reuse supplies for subsequent diversion. SJRA will have to work with the entities generating return flows to negotiate contracts to capture and divert the return flows generated by these entities. It should be noted that the unpermitted return flows are currently contributing to City of Houston's Lake Houston and enhancing the lake yield during dry periods. SJRA will have to deal with the issues associated with the impact on the lake yield when some of these return flows are permitted. It is also understood that there is a potential shortage in the San Jacinto River Basin which is being fulfilled and managed through the return flows contributing to the water bodies in the basin. When these return flows are permitted, the shortages that were managed by means of the return flows should be addressed.

Cost Analysis

The primary costs incurred in developing this strategy are the administrative and legal/engineering fees associated with the procurement of the return flow permits. There will be some contractual costs incurred for implementing all the strategy options and these costs may include permitting fees, legal fees, and contract fees with various entities. However, it is difficult to provide an estimate for these costs as each strategy cost will be different and varied on a case-to-case basis. Therefore, a cost estimate was not developed for this strategy. Although these costs cannot be determined at this time, there is likely some cost, arrangement, or legal fees inherent to contractual agreements with the multiple parties involved for several of the options described in this technical memorandum. The GRP Participants relying on surface water are one of the few with minimal issues since SJRA already has contractual relationships in place.

WATER MANAGEMENT STRATEGY EVALUATION

Based on the analysis provided above, the Return Flows in Highlands Service Area strategy was evaluated across eleven different criteria for the purpose of quick comparison against alternative projects that may be incorporated into the Regional Water Plan. The results of this evaluation can be seen in *Table 6* below. Project criteria and scoring methodology are described in the technical memorandum *Preliminary Strategy Identification and Evaluation (Task 1104)*. Higher scores relate to preferable characteristics.

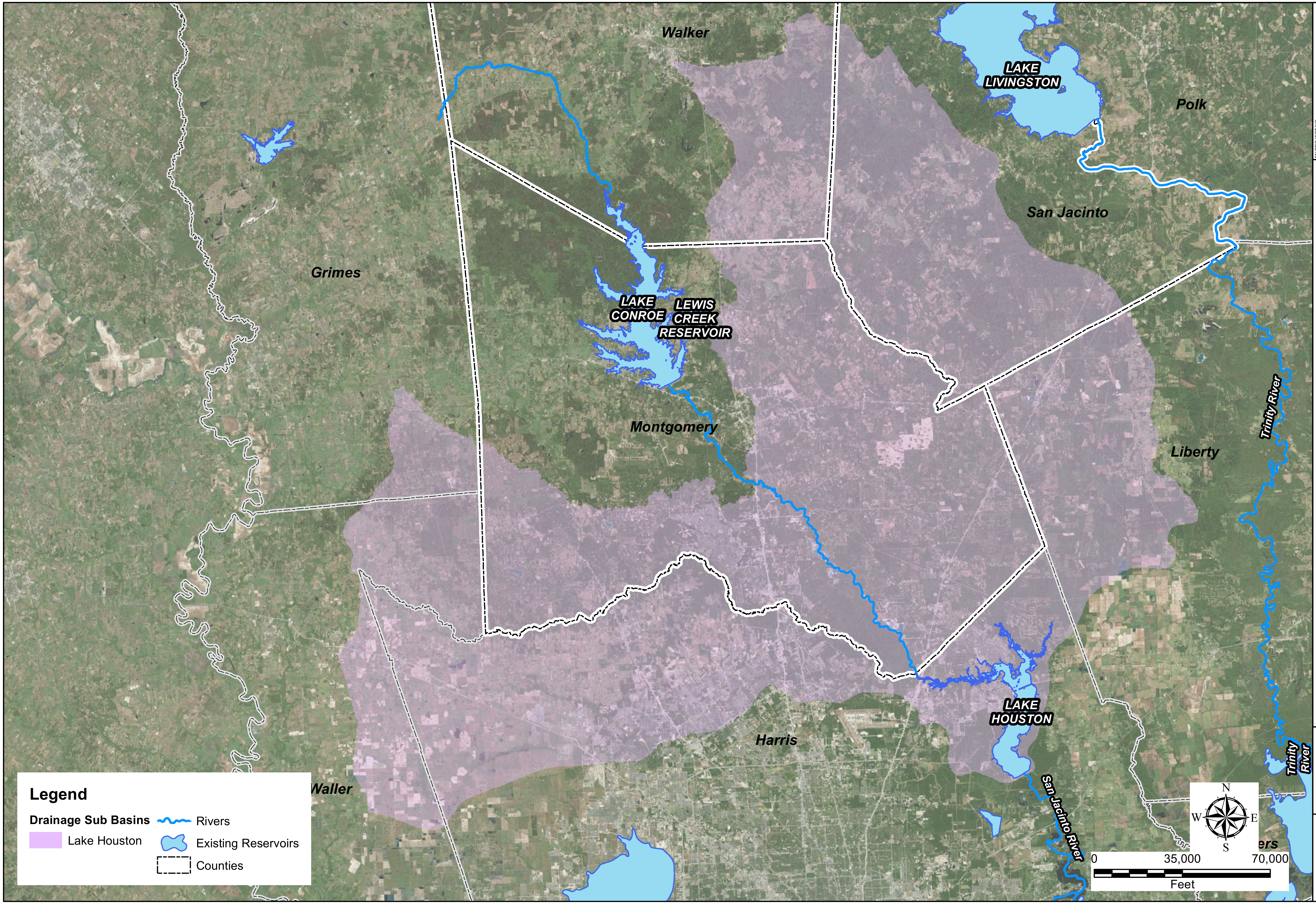
Table 6 - Screening Criteria and Scores for Return Flows in Highlands Service Area Strategy

Criteria	Rating		
	Option 1 Conroe Return Flows Permit	Option 2 Montgomery County Flows	Option 3 Other San Jacinto Flows
Cooperation	3	2	1
Cost	4	4	4
Diversification	3	3	3
Environmental	3	3	3
Funding	4	4	4
Land Acquisition	4	4	4
Legal	2	2	1
Location	4	4	4
Magnitude	2	4	4
Other Supplies	3	3	3
Public	3	3	3
Scalability	1	1	1
Schedule	4	3	3
Yield Risk	2	2	2
Weighted Score [1]	336	334	324

[1] Based on weighting methodology adopted in Preliminary Strategy Identification and Evaluation (Task 1104)

REFERENCES

Region H Water Planning Group. 2015. 2016 Regional Water Plan.



FN PROJECT NO.	SJR15616
DATE CREATED	2017-09-15
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas South Central
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PREPARED BY	DML

SJRA RAW WATER SUPPLY MASTER PLAN

Highlands Service Area

Sub-Basins Contributing Return Flows

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EXHIBIT

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