# Section 5A
# Identification, Evaluation, and Selection of Water Management Strategies

## 5A.1 Water Management Strategies

Title 31 TAC 357.7(a)(6) requires that the regional water planning group evaluate all water management strategies determined to be potentially feasible, including 15 named strategies.[1] At the beginning of the planning effort, the Brazos G Regional Water Planning Group (RWPG) determined 19 water management strategies to be potentially feasible. The Brazos G RWPG also determined that two strategies were not feasible. Those two strategies are dredging of reservoirs to enhance yield and cancellation of water rights. Potential water supply strategies examined during the course of this study are listed in Table 5A.1-1. This section describes methods and procedures utilized to evaluate water management strategies considered for inclusion in the water plan for the Brazos G region.

Within some of the 19 types of water management strategies listed in Table 5A.1-1 there are a number of sub-options. For instance, in the section on New Reservoirs (Section 5A.14), six potential reservoir sites are evaluated. Likewise, other sections, including Expanded Use of Existing Supplies (5A.4), Enhancement of Reservoir Yields (5A.7), Control of Naturally Occurring Chlorides (5A.8), Desalination (5A.11), Off-Channel Reservoirs (5A.15), Regional Surface Water Systems (5A.16), Carrizo-Wilcox Aquifer Development (5A.17), and Interconnection of Regional and Community Systems (5A.20) each contain a number of options within that type of management strategy.

### 5A.1.1 Evaluation of Strategies

The following chapters contain an evaluation of each of the potential water management strategies. Each section is typically divided into five subsections: (1) Description of Option; (2) Yield Available; (3) Environmental Issues; (4) Engineering and Costing; and (5) Implementation Issues. Information in these sections was presented to the RWPG and was used in evaluating strategies to meet water needs in the region.

---

[1] Title 31 TAC 357.7(a)(6) lists 15 potential strategies: conservation; wastewater reuse; expanded use of existing supplies; reallocation of reservoir storage; voluntary redistribution; enhancement of existing sources; chloride control; interbasin transfers; new supplies; strategies from past State water plans; brush control; weather modification; desalination; cancellation of water rights; and aquifer storage and recovery

**Table 5A.1-1.**
**Water Management Strategies Evaluated for the Brazos G Region**

| Section No. (Located in Volume 2) | Title |
|---|---|
| 5A.1.5 (Vol. I) | Agricultural Water Management Strategies |
| 5A.2 (Vol. II) | Water Conservation |
| 5A.3 (Vol. II) | Wastewater Reuse |
| 5A.4 (Vol. II) | Expanded Use of Existing Supplies |
| 5A.5 (Vol. II) | Reallocation of Reservoir Storage |
| 5A.6 (Vol. II) | Voluntary Redistribution |
| 5A.7 (Vol. II) | Enhancement of Reservoir Yields |
| 5A.8 (Vol. II) | Control of Naturally Occurring Chlorides |
| 5A.9 (Vol. II) | Brush Control and Range Management |
| 5A.10 (Vol. II) | Weather Modification |
| 5A.11 (Vol. II) | Desalination |
| 5A.12 (Vol. II) | Aquifer Storage and Recovery |
| 5A.13 (Vol. II) | Cancellation of Water Rights |
| 5A.14 (Vol. II) | New Reservoirs |
| 5A.15 (Vol. II) | Off-Channel Reservoirs |
| 5A.16 (Vol. II) | Regional Surface Water Systems to Augment Declining Groundwater Supplies |
| 5A.17 (Vol. II) | Carrizo-Wilcox Aquifer Development |
| 5A.18 (Vol. II) | Water Trades in the Brazos River Basin |
| 5A.19 (Vol. II) | Conjunctive Use in the Brazos River Alluvium |
| 5A.20 (Vol. II) | Interconnection of Regional and Community Water Systems |

### 5A.1.2 Plan Development Criteria

It is the goal of the RWPG to develop a plan to meet projected water needs within the region. The RWPG has adopted a set of Plan Development Criteria that was used to evaluate whether a given strategy should be used to meet a projected shortage and ultimately be included in the Brazos G Water Supply Plan. The proposed plans were developed by evaluating the water management strategies using the RWPG criteria and then matching strategies to meet projected shortages. This section discusses the evaluation criteria adopted by the planning group during plan development, and criteria to be met in formulation of the plan. The adopted plan elements will meet these criteria:

- Water Supply – Water supply must be evaluated with respect to quantity, reliability, and cost. The criteria for quantity is that the plan must be sufficient to meet all projected needs in the planning period. The criteria for reliability is that it meet municipal and industrial needs 100 percent of the time, and agricultural needs 75 percent of the time. The criteria for cost is that the projected cost be reasonable to meet the projected needs.
- Environmental Issues – Environmental considerations must be examined with respect to environmental water needs, wildlife habitat, cultural resources, and bays and estuaries. The criteria for environmental water flows and wildlife habitat is that stream conditions must meet permit requirements for diversions that currently have permits. For projects that require permit acquisition the project will provide adequate environmental instream flows for aquatic habitat. Projects should be sited to avoid known cultural resources, if possible. Flows to bays and estuaries should meet expected permit conditions. (It should be noted that the Brazos River does not have an estuary, so bay and estuary inflow requirements are expected to be low).
- Impacts on Other State Water Resources – The criteria recommends a follow-up study by the RWPG if any significant impacts are anticipated on other state water resources.
- Threats to Agriculture and Natural Resources – The criteria requires that the planning group identify any potential impact, compare the impact to the proposed benefit of the plan, and make recommendations.
- Equitable Comparison of Feasible Strategies – This is achieved by the equal application of criteria across different water development plans.
- Interbasin Transfers – The planning group may consider interbasin transfers as a supply option. The criteria require that the participating entities recognize and follow Texas Water Code requirements for expected permitting requirements.
- Impacts from Voluntary Redistribution – The criteria requires that any potential third party social or economic impacts from voluntary redistribution of water rights be identified and described.
- Other Criteria – Texas Water Development Board (TWDB) allows the RWPG to adopt other criteria. As of June 2000, no other criteria have been adopted by the Brazos G RWPG.

The following sections discuss the methods and procedures used to develop the information needed to evaluate the strategies and compare them to the criteria.

### *5A.1.3 Engineering*

A procedure was developed to maintain equal and consistent consideration of various design and cost variables across differing management options. These were planning level estimates only, and did not reflect detailed site-specific design work, nor any extensive optimization and selection of design variables. These procedures standardized the consideration of the following design and costing issues as closely as possible, given the varying scope and magnitude of differing projects. For each option, major cost components were determined at the outset. Estimates of volume of water and rate of delivery needed were developed from the supply-demand comparisons presented in Section 4, if directly applicable. Volumes necessary to meet shortages were estimated, and both average annual and peak rates of projected delivery were calculated. Average annual rates were adjusted to reflect pump station downtime due to maintenance activities. Transmission and treatment facilities were sized based on peak rates of delivery. Water source and delivery locations were determined, considering source and destination elevations, surrounding land use, and other geographic considerations. Further details on engineering factors considered are presented in Volume II of this report, Section 5A.1.

### *5A.1.4 Cost Estimates*

The cost estimates of this study are expressed in three major categories: (1) construction costs or capital (structural) costs, (2) other (non-structural) project costs, and (3) annual costs. Construction costs are the direct costs incurred in constructing facilities, such as those for materials, labor, and equipment. “Other” project costs include expenses not directly associated with construction activities of the project, such as costs for engineering, legal counsel, land acquisition, contingencies, environmental studies and mitigation, and interest during construction. Capital costs and other project costs comprise the total project cost. Operation and maintenance, energy costs, and debt service payments are examples of annual costs. Major components that may be part of a preliminary cost estimate are listed in Table 5A.1-2. Details regarding all cost components are presented in Volume II of this report, Section 5A.

To estimate capital costs, tables of unit costs for each major component in the capital costs were developed through an internal review of bid documents and project cost audits of projects that HDR has implemented in the past. The cost tables report all-inclusive costs to construct, including the construction, infrastructure and control equipment, and all other materials, labor, and installation costs. Unit costs were developed for pump stations, intake structures, pipelines, wells, reservoir structures, channel dams and any other structural component called for in a water supply option.

**Table 5A.1-2.**
**Major Project Cost Categories**

| ***Capital Costs (Structural Costs)*** | ***Other Project Costs (Non-Structural Costs)*** |
|---|---|
| 1. Pump Stations<br>2. Pipelines<br>3. Water Treatment Plants<br>4. Water Storage Tanks<br>5. Off-Channel Reservoirs<br>6. Well Fields<br>a. Injection<br>b. Recovery<br>c. ASR Wells<br>7. Dams and Reservoirs<br>8. Relocations<br>9. Water Distribution<br>10. Other Items | 1. Engineering (Design, Bidding and Construction Phase Services, Geotechnical, Legal, Financing, and Contingencies)<br>2. Land and Easements<br>3. Environmental - Studies and Mitigation<br>4. Interest During Construction<br><br>***Annual Project Costs***<br>1. Debt Service<br>2. Operation and Maintenance (excluding pumping energy)<br>3. Pumping Energy Costs<br>4. Purchase Water Cost (if applicable) |

As previously mentioned, "other" (non-structural) project costs are costs incurred in a project that are not directly associated with construction activities. These include costs for engineering, legal counsel, financing, contingencies, land, easements, surveying and legal fees for land acquisition, environmental and archaeology studies, permitting, mitigation, and interest during construction. These costs are added to the capital costs to obtain the total project cost. A standard percentage applied to the capital costs is used to calculate a combined cost that includes engineering, financial, legal services, and contingencies. Details are presented in Volume II.

Annual costs are those that the project owner can expect to incur if the project is implemented. These costs include repayment of borrowed funds (debt service), operation and maintenance costs of the project facilities, pumping power costs, and water purchase costs, when applicable.

Debt service is the estimated annual payment that can be expected for repayment of borrowed funds based on the total project cost, an assumed finance rate, and the finance period in years. As specified in TWDB Exhibit B, Section 1.71, debt service for all projects was calculated assuming an annual interest rate of 6 percent and a repayment period of 40 years for reservoir projects and 30 years for all other projects. The debt service factor of 0.06646 or 0.07265 for 40- or 30-year repayment periods is applied, respectively, to the total estimated project costs.

Operation and maintenance costs for dams, pump stations, pipelines, and well fields (excluding pumping power costs) include labor and materials required to operate the facilities and provide for regular repair and/or replacement of equipment. In accordance with TWDB guidelines, operation and maintenance costs are calculated at 1 percent of the total estimated construction costs for pipelines, distribution, facilities, tanks and wells, at 1.5 percent of the total estimated construction costs for dams and reservoirs, and at 2.5 percent for intake and pump stations. Water treatment plant operation and maintenance costs were based on treatment level and plant capacity. The operation and maintenance costs include labor, materials, replacement of equipment, process energy, building energy, chemicals, and pumping energy.

In accordance with TWDB guidelines, power costs are calculated on an annual basis using the appropriate calculated power load and a power rate of $0.06 per kWh. The amount of energy consumed is based upon the pumping horsepower required.

The raw water purchase cost, if applicable, is included if the water supply option involves purchase of raw or treated water from an entity. This cost varies by source.

A cost estimate summary for each individual option is presented with total capital costs, total project costs, and total annual costs. The level of detail is dependent upon the characteristics of each option. Additionally, the cost per unit of water involved in the option is reported as costs per acft and cost per 1,000 gallons of water developed. The individual option cost tables specify the point within the region at which the cost applies (e.g., raw water at the lake, treated water at the municipal and industrial demand center, or elsewhere as appropriate).

### *5A.1.5 Methods Used to Investigate Environmental Effects of Proposed Regional Water Management Strategies*

The Regional Water Planning Guidelines (31 TAC 357.7) require that each regional water management strategy includes an evaluation of environmental factors, specifically effects on environmental water needs, natural resources, wildlife habitat, cultural resources, and upstream development on bays, estuaries, and arms of the Gulf of Mexico. These factors were evaluated for each of the proposed water management strategies according to the level of description and engineering design information provided. Details regarding the methodology to investigate environmental water needs, instream flow needs, impact on bays and estuaries, and fish and wildlife habitat are detailed in Volume II of this report.

### *5A.1.6 Agricultural Water Management Strategies*

New firm water supplies cannot be developed for irrigated agriculture, because the cost of development far exceeds the value of the water in irrigated production. The assumption is made that the available groundwater resources are already fully exploited. Cloud seeding and brush control for water yield are the only potential new supplies of water for irrigated agriculture, but a firm yield cannot be assigned to these practices. Without any firm supply of water, agricultural producers will have to reduce the irrigation and confined livestock demands through a variety of conservation and other management practices.

#### *5A.1.6.1 Water Conservation and Irrigation System Conversion*

Water conservation is the most practical and feasible option, and increasing the efficiency of the irrigation systems is the strategy that offers the most practical and feasible solution with any certainty. To conserve water in irrigated agriculture, the assumption is made that the crop is fully irrigated, so that the water conserved remains in the aquifer or surface source and is available to meet other agricultural needs. The cost of water conservation per acft has to be within the production value range when it is used to meet a shortage. For example, a producer will not incur a conservation cost of $50/acft unless the production value of the water on another field with a shortage is less than $50/acft. The additional cost of delivery of the conserved irrigation water has to be taken into account. The producer will be most likely to adopt water conservation practices when a positive return will result, as with lower energy and labor costs. The tradeoff is with the higher cost of a more efficient irrigation system.

The efficiency of irrigation systems is dependent on the individual producer operation and on the inherent nature of the type of irrigation. The efficiency of irrigation is measured as the ratio of the water actually used by the crop to the total water delivered from the source. The major water losses are to deep percolation below the effective root zone of the crop (over-irrigation), water runoff from the field, and evaporation of the water to the atmosphere. As an extreme example, only 30 percent of the water applied from a high-pressure sprinkler on a very hot, very windy afternoon may ever reach the surface for infiltration. In general, gated pipe surface irrigation is 40 to 70 percent efficient, side roll sprinkler irrigation is 50 to 75 percent efficient, and a low-pressure center pivot with drop nozzles is about 90 percent efficient. The various forms of microirrigation (drip tape, microsprinklers, drip emitters, etc) are 90 to 95 percent efficient. Good management and ideal conditions will increase the efficiency.

Three scenarios were considered for an economic analysis of conversion of irrigation systems for water conservation. One scenario was conversion of a system that is 75 percent efficient to a system that is 90 percent efficient, such as conversion of a side roll system to an efficient center pivot or the renozzling of a center pivot with impact sprinkers to low-pressure drop nozzles. The second scenario was the conversion of a system that is 50 percent efficient to a system that is 75 percent efficient. This could be the conversion from a gated pipe to a side roll or adoption of cutback or surge irrigation with the gated pipe. The third scenario was the conversion of a 50 percent efficient system to a 90 percent efficient system.

Several assumptions were made for simplicity. A 25-year economic analysis period was selected, which is in the range for wells, pumps, pipelines, and the major equipment. Two interest rates were used—10 percent for conventional loan and 2 percent for a low-interest loan. Constant dollars (no inflation) were used. A linear series of annual values was used for the analysis. A capital recovery factor was calculated for the capital investment and operating (variable) costs for taxes, insurance, repair, and maintenance were calculated based on typical values. Water conservation results in lower energy costs for pumping and pressurization, and decreased labor is typically results from conversion of gated pipe and side roll irrigation to center pivot irrigation. Decreased energy and labor costs were taken into account.

For purposes of illustration, 130 acres were converted from one system to another in the scenarios. The cost of meeting the water shortage is expressed in dollars per acft of conserved water. Peanuts and cotton are the target crops for the analysis, although high-value horticultural crops and high-quality forage crops would also fit the scenarios. The crop requires 15-acre inches per acre to meet the yield objective. At 50 percent efficiency, 30 inches of water will be delivered from the source to the crop; at 75 percent efficiency, 20 inches of water will be delivered; and at 90 percent efficiency, 16.67 inches of water will be delivered. For a full season of irrigation, plus limited rainfall and carryover soil moisture reserve, the water conserved by conversion to more efficient irrigation is calculated. Conversion from 75 to 90 percent efficiency conserves 36.08 acft for the 130 acres, conversion from 50 to 75 percent conserves 108.33 acft, and conversion from 50 to 90 percent conserves 144.41 acft.

Three levels of cost for conversion of irrigation systems were selected: $300/acre, $500/acre, and $700/acre. The actual costs for a field will depend on proximity to water supply, existence or absence of pipelines, field layout, "farmability," and other factors. Taxes and insurance were calculated at 2 percent and repair and maintenance were calculated at 5 percent. The water was available at no cost. The annual cost of labor saved was estimated at $6545 for conversion to a center pivot from gated pipe or side roll system. The energy cost was calculated as $2.00 per acre-inch, based on typical values for pressure requirements, flow requirements, and electricity cost. Other costs were neglected.

The results of the cost analysis are shown in Table 4-81. As shown in the table, at conventional financing, the economically feasible options are limited. The options are for a low investment cost ($300/acre) or conversion to a 90 percent efficient irrigation system. With low interest financing, the options are more economically feasible, and include all three low investment cost scenarios and conversion of 50 percent efficient irrigation systems to 70 or 90 percent efficient systems, although an increased cost of production will be incurred by the producer.

For planning purposes, the amount of water conserved will be 0.23 acft/acre for conversion of a system that is 75 percent efficient to one that is 90 percent efficient; 0.83 for conversion from 50 percent efficient to 75 percent efficient, and 1.11 for conversion from 50 percent efficient to 90 percent efficient.

**Table 5A.1-3.**
**Cost/Value of Irrigation Water Conservation**
**from Increasing the Efficiency of Irrigation Systems**
**(130 acre system)**

| Investment Cost (dollars/acre) | Water Conserved (acft) | Cost | |
|---|---|---|---|
| | | 10% finance ($/acft) | 2% finance ($/acft) |
| 300 | 30.48 | 10.65 | 20.65 |
| | 108.33 | -40.86 | 33.98 |
| | 144.41 | 20.66 | 40.65 |
| 500 | 30.48 | -119.18 | -53.94 |
| | 108.33 | -84.1 | -40.6 |
| | 144.41 | -11.77 | -33.94 |
| 700 | 30.48 | -249.02 | -27.83 |
| | 108.33 | -127.35 | -14.27 |
| | 144.41 | -44.21 | -7.83 |

#### *5A.1.6.2 Strategies for Meeting Irrigation Shortages*

As stated previously, there are no new economically feasible water supply options for irrigated and confined animal production. Shortages must be met through agricultural management strategies detailed in the following section. Following are general water conservation strategies for irrigation.

- Plant crops that require less water and/or decrease yield objective. The cost is variable, depending on current markets. Irrigated wheat requires irrigation in winter and spring, but may have very little economic return unless wheat is used for stocker pasture in fall and mid-winter. Sorghum requires less water than cotton, but the economic return is typically much less. Peanuts require water over a 120 to 150 day growing period, but the economic return is significant. Silage corn may requires only one or two irrigations and is harvested in early July, but requires a nearby market and a compatible irrigation system. Plant populations may be decreased to make maximum use of rainfall during the growing season, but the anticipated economic benefit is usually less. An economic analysis of these strategies is very region specific, and probably specific to individual agricultural producers.
- Convert to more efficient irrigation systems for delivery and application efficiency (up to $1000/acre to convert from gated pipe to center pivot; $500/acre to convert side roll to center pivot; about $1000/acre to install drip irrigation;
- Use soil moisture and potential evapotranspiration irrigation scheduling (cost of about $3.50/acre, but significant technology transfer will be required)
- Convert to dryland production or reduce the number and amount of irrigation (deficit irrigation). Water production functions (relationship between yield and water applied) are poorly known and are not generally used for major crops in Brazos G. With water production functions, producers select the optimum timing and amount of irrigation water to apply to achieve the maximum yield for a unit of water. In general terms, this strategy allows moisture stress, but the stress is managed to have the least impact on the final yield or quality. Incorporation of deficit irrigation strategies based on plant and soil measurements will require additional research and technology transfer for each crop in each cropping region.
- Develop new crops and crop varieties. Plants that are able to perform with less water are essential. Possibilities include earlier maturing crops, crops with a higher ratio of yield to non-yield components (harvest index), crops that can be planted earlier in the growing season to take advantage of stored soil moisture and spring rains, crops with improved rooting characteristics, new crops for an area, and varieties that simply perform better than similar varieties under dry conditions. Significant research and technology transfer will be required on a regional basis.
- Use cultural practices that suppress evaporation. Mulches are effective in reducing evaporation from the soil surface. Plastic mulches may be used in vegetable production and dust mulches formed with cultivation are used extensively in row crop production.
- Increase infiltration. Off-season cultural practices that increase infiltration (i.e., reduce runoff) of winter precipitation are very effective. For many crops, half of the total water requirements may be available from a full soil moisture profile in the upper meter or so of root zone.

### *5A.1.7 Funding and Permitting by State Agencies of Projects Not in the Regional Water Plan*

Senate Bill 1 requires water supply projects be consistent with approved regional water plans to be eligible for TWDB funding and to obtain TNRCC permits. Regarding TNRCC permitting, the Texas Water Code[2] provides that the TNRCC shall grant an application to appropriate surface water, including amendments to existing permits, only if the proposed action addresses a water supply need in a manner that is consistent with an approved regional water plan. TNRCC may waive this requirement if conditions warrant.

For TWDB funding, the Texas Water Code[3] states that the TWDB may provide financial assistance to a water supply project only after TWDB determines that the needs to be met by the project will be addressed in a manner that is consistent with the appropriate regional water plan. The TWDB may waive this provision if conditions warrant.

The Brazos G Regional Water Planning Group has considered the variety of actions and permit applications that may come before the TNRCC and the TWDB and does not want to unduly constrain projects or applications for small amounts of water that may not be specifically included in the adopted regional water plan. “Small amounts of water” is defined as involving no more than 1,000 acft/yr, regardless of whether the action is for a temporary or long term action. The Brazos G RWPG provides direction to TNRCC and TWDB regarding appropriations, permit amendments, and projects involving small amounts of water that will not have a significant impact on the region’s water supply as follows: such projects are consistent with the regional water plan, even though not specifically recommended in the plan.

The Brazos G RWPG also provides direction to the TWDB regarding financial assistance for repair and replacement of existing facilities. Water supply projects not involving the development of or connection to a new water source are consistent with the regional water plan, even though not specifically mentioned in the adopted plan.

[2] Texas Water Code, Section 11.134

[3] Texas Water Code, Section 16.053(j)

(This page intentionally left blank.)