The Future of Desalination in Texas

2020 Biennial Report on Seawater and Brackish Groundwater Desalination in Texas

87th Texas Legislative Session

Texas Water Development Board

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Jeff Walker, Executive Administrator

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Texas Water Development Board

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Executive summary

Desalination is the process of removing dissolved solids and other minerals from saline water sources, which can include brackish groundwater and seawater. This important technology is used all around the world to produce new water supplies. As of 2019, there were over 20,000 desalination plants (brackish groundwater and seawater) worldwide, with an equivalent online capacity of 28.2 billion gallons per day (25.6 million acre-feet per year) (Global Water Intelligence, 2019).

In the past decade, seawater desalination has become more prevalent in the United States. On the east and west coasts of the country, there are two large (capacity >25 million gallons per day or >28,000 acre-feet per year) operational seawater desalination facilities for municipal use: the Claude "Bud" Lewis Carlsbad Desalination Plant located in Carlsbad, California, and the Tampa Bay Seawater Desalination Plant located in Tampa Bay, Florida. While Texas does not have an operational seawater desalination facility, the City of Corpus Christi and Port of Corpus Christi Authority have initiated the permitting process and applied for permits from the Texas Commission on Environmental Quality. Additionally, the City of Corpus Christi obtained a $222 million loan from the Texas Water Development Board (TWDB) to build a 30-million-gallon-per-day (33,600 acre-feet-per-year) seawater desalination plant for municipal use in the future.

Brackish groundwater is also an important water source that can provide new water supplies and help reduce the demand on freshwater supplies. For the purpose of this report, brackish groundwater is considered groundwater that contains dissolved salts with total dissolved solid concentration ranging from 1,000 to 10,000 milligrams per liter. In the United States, there are 406 municipal brackish groundwater desalination plants—with the majority located in Florida (40 percent), California (14 percent), and Texas (13 percent) (Mickley, 2018).

Texas is estimated to have more than 2.7 billion acre-feet (880 trillion gallons) of brackish groundwater available in 26 of its major and minor aquifers (LBG-Guyton Associates, 2003). In summer 2020, the TWDB updated the desalination plant database that was developed to track the growth of desalination across the state. As of August 2020, Texas has 53 municipal desalination plants that treat either brackish groundwater, surface water, or reclaimed water and have a total design capacity of approximately 157 million gallons per day (176,013 acre-feet per year). Of these 53 facilities, 36 desalinate brackish groundwater and have a total design capacity of 90 million gallons per day (100,769 acre-feet per year).

While the *2020 Biennial Report on Seawater and Brackish Groundwater Desalination* is the ninth report in the series, marking the completion of 18 years of advancing seawater desalination in

Texas, it is the third report with an expanded scope. Since 2016, the report has included progress made in furthering brackish groundwater desalination and in identifying and designating brackish groundwater production zones that meet the statutory requirements and exclusion criteria.

Primary findings of the report are as follows:

1. Brackish groundwater desalination capacity and the number of desalination plants in the state continue to increase. There is still no seawater desalination plant in Texas, but the City of Corpus Christi and the Port of Corpus Christi Authority are both pursuing intake and discharge permits for seawater desalination plants.
2. In July 2020, the City of Corpus Christi received an additional $222 million loan from the TWDB through the State Water Implementation Fund for Texas to obtain permits for two sites and design and build a 30-million-gallon-per-day seawater desalination plant for municipal use at one of the two sites. Previously, the City had received a $2.75 million loan from TWDB in July 2017 for planning tasks.
3. In August 2020, the City of Alice announced they will design and build a 3-million-gallon-per-day brackish groundwater desalination plant within 18 months through a public-private partnership. Seven Seas Water has been selected to build, own, and operate the desalination plant and will sell the water to the city for 15 years before transferring ownership to them.
4. The 86th Texas Legislature appropriated funds to support the mapping and characterization of brackish aquifers and granted the TWDB a 10-year extension to complete zone designations when the legislative deadline was changed from December 1, 2022 to December 1, 2032.
5. On March 28, 2019, the TWDB designated a total of 23 brackish groundwater production zones including 3 zones in the Blossom Aquifer, 5 zones in the Nacatoch Aquifer, and 15 zones in the Northern Trinity Aquifer. Although we studied the Lipan Aquifer, the TWDB did not designate any production zones there. As a result, the total number of designated brackish groundwater production zones increased from 8 to 31 zones.
6. In the future, the TWDB will evaluate 14 aquifers or portions of aquifers and apply statutory requirements and exclusion criteria for potential brackish groundwater production zones. These outstanding areas include two aquifers with studies completed prior to House Bill 30, 84th Texas Legislature, five ongoing aquifer studies, and seven future aquifer studies.
7. From August 2018 to August 2020, the TWDB provided $290 million in loan assistance and $200,000 in grant assistance to 10 public entities for one seawater desalination project and nine brackish groundwater desalination projects.

Results of the TWDB's studies and activities in desalination

The TWDB has a standalone Desalination Program under the Innovative Water Technologies Department. The Desalination Program was initially created in 2002 to cover activities for seawater desalination and two years later added brackish groundwater desalination activities.

For the Desalination Program, the TWDB has not had recent appropriations dedicated to support research, feasibility studies, or demonstration projects to advance seawater and brackish groundwater desalination in Texas. The Texas Legislature last appropriated funding for seawater desalination in 2005 and for brackish groundwater desalination in 2009. Between 2003 and 2006, the TWDB funded $3.2 million for seawater desalination studies through the Desalination Program, including three feasibility studies, two pilot-plant projects, and several guidance and research studies. Between 2004 and 2010, the TWDB funded 11 brackish groundwater desalination projects and studies totaling $2.1 million through the Desalination Program, which included implementing demonstration projects, preparing guidance manuals, and completing research studies.

Through the agency's financial programs, the TWDB increased the number of loans provided to public entities from three to 10 in the past biennium. The number of loans for seawater desalination projects stayed the same, but loans for brackish groundwater projects increased from two to nine. From August 2018 to August 2020, the TWDB provided $290 million in loan assistance to 10 public entities for one seawater desalination project and eight brackish groundwater desalination projects and $200,000 in grant assistance for one brackish groundwater desalination project.

Other desalination activities include TWDB staff serving on the boards of the South Central Membrane Association and the Multi-State Salinity Coalition to stay informed and aware of ongoing desalination activities.

Designation of brackish groundwater production zones

The Brackish Resources Aquifer Characterization System (BRACS) is a separate program from the Desalination Program, though it is also part of the Innovative Water Technologies Department. BRACS was created in 2009 to map and characterize in detail the brackish aquifers of the state. The 81st Texas Legislature appropriated funding in 2009 to implement the program, hire two staff members, and fund research projects.

In total, the TWDB has funded 10 contracts through the BRACS program. The TWDB funded three research projects totaling $449,500 in 2010 to support the initiation of the program. With the passing of House Bill 30 in 2015, the 84th Texas Legislature appropriated resources that funded seven contracts for eight aquifers or portions of aquifers, totaling about $1.7 million, to identify and designate brackish groundwater production zones. House Bill 30 required the TWDB to designate brackish groundwater production zones in four aquifers by the statutory deadline of December 1, 2016, determine the volumes of water that a brackish groundwater production zone could produce over 30- and 50-year periods, and make recommendations on reasonable monitoring to observe the effects of brackish groundwater production within the zone.

To date, the TWDB has designated a total of 31 brackish groundwater production zones in the state with moderate to high availability and productivity of brackish groundwater that meet these statutory requirements and exclusion criteria. On October 20, 2016, the TWDB designated eight brackish groundwater production zones including one zone in the Carrizo-Wilcox Aquifer south of the Colorado River, four zones in the Gulf Coast Aquifer and bordering sediments, and three zones in the Rustler Aquifer. Although we studied the Blaine Aquifer, we determined the aquifer had no zones that met statutory and exclusion criteria. On March 28, 2019, the TWDB designated an additional 23 brackish groundwater production zones, including 3 zones in the Blossom Aquifer 5 zones in the Nacatoch Aquifer, and 15 zones in the Northern Trinity Aquifer. We did not designate any zones in the Lipan Aquifer. As with the Blaine Aquifer, the Lipan Aquifer did not have any zones that qualified.

In the 2018–2019 biennium, the TWDB did not receive appropriations to continue implementing the statutory requirements. As a result, the TWDB would not have been able to map brackish groundwater resources and designate zones in the remaining aquifers by the statutory deadline of December 1, 2022, even with future restoration of funds. The TWDB continued mapping brackish aquifers with existing resources at a slower pace and requested $2 million for the 2020–2021 biennium.

In 2019, the 86th Texas Legislature restored and appropriated funding to the TWDB for contract and administrative costs to support designation of brackish groundwater production zones in aquifers of the state, excluding the Dockum Aquifer. The legislature also passed Senate Bill 1041, which extended the deadline to complete zone designations from December 1, 2022, to December 1, 2032, and House Bill 722, which established a permitting framework for developing water supplies from TWDB-designated brackish groundwater productions zones. Additionally, the legislature appropriated funding for one full-time equivalent staff member to support technical reviews associated with brackish groundwater production zone operating permits.

Research, regulatory, technical, and financial impediments to implementation

Over the last decade, the impediment to desalination research and pilot-scale testing has been the lack of state funding. The Texas Legislature last appropriated funds to the TWDB to advance seawater and brackish groundwater desalination in Texas in 2009. The regulatory impediment for seawater desalination is that, while the permitting requirements are in place, they will not be refined by practice until a few seawater desalination plants have undergone the required permitting cycles. The City of Corpus and the Port of Corpus Christi Authority are the first to initiate the permitting process and will be a learning opportunity for Texas. Another factor that can affect seawater desalination permitting is public opposition due to environmental concerns, as encountered in the Corpus Christi area. The relatively high cost and site specificity of desalination compared to the cost of developing conventional freshwater supplies continue to be technical and financial impediments to advancing desalination in Texas. Other factors that affect the cost of desalination include permitting, treatment, brine disposal, and transmission pipelines. In general, the feasibility of desalination projects depends on site-specific conditions, so each project requires unique treatment and brine disposal analyses.

The role of the State in furthering the development of desalination projects

The role of the State is to continue technical efforts and to provide leadership and support to further the development of cost-effective water supplies from seawater or brackish groundwater desalination in Texas. The TWDB identified opportunities for continued State involvement that include (1) supporting the advancement of seawater and brackish groundwater desalination studies, (2) facilitating meetings between water providers or municipalities and regulatory or planning agencies to assist with the financial application and permitting processes, and (3) providing financing through existing TWDB loan programs to entities interested in pursuing seawater and brackish desalination.

Anticipated appropriation from general revenues

The TWDB's baseline budget request for FY 2022–2023 includes $2 million for the BRACS Program to continue progress toward meeting statutory requirements for designating brackish groundwater production zones by the new legislative deadline of December 1, 2032. The TWDB did not request additional funding for the Desalination Program to advance seawater and brackish groundwater desalination activities.

1 Introduction

In 2002, Governor Rick Perry announced his vision of meeting future water supply needs through seawater desalination and directed the TWDB to recommend a large-scale seawater desalination demonstration project. Thus, TWDB desalination efforts began with the identification of sites for a seawater desalination demonstration project. The first step was to issue a request for statements of interest to develop large-scale seawater desalination. In 2003, the TWDB selected three locations (cities of Corpus Christi, Brownsville, and Freeport) for feasibility studies. The 78th Texas Legislature subsequently appropriated $1.5 million to fund these studies. In 2005, the 79th Texas Legislature appropriated $2.5 million for seawater desalination pilot testing. Between 2006 and 2008, the TWDB contracted for two pilot-plant studies: one at the Brownsville Ship Channel by the Brownsville Public Utilities Board and the second on South Padre Island by the Laguna Madre Water District. In 2009 and 2010, the TWDB funded research studies on environmental permitting requirements to implement seawater desalination along the Texas Gulf Coast.

To build on the governor's desalination initiative, the TWDB established the Brackish Groundwater Desalination Initiative in 2004. The goal was to demonstrate the use of innovative and cost-effective desalination technologies and offer practical solutions to key challenges such as concentrate management and energy optimization. In 2005, the 79th Texas Legislature appropriated funds to support the first round of demonstration projects. In 2007, the Texas Legislature appropriated funds to support five new studies and, in 2009, allocated additional funding to support four new demonstration projects. Texas Legislative appropriations for the Desalination Program ended in 2009.

In 2003, the 78th Texas Legislature passed House Bill 1370 directing the TWDB to pursue seawater desalination and to report progress in a biennial report due December 1 of each even-numbered year. In 2015, the 84th Texas Legislature passed House Bill 30 directing the TWDB to also provide status updates on brackish groundwater desalination and designation of brackish groundwater production zones. Overall, Texas Water Code §16.060 requires the TWDB to undertake necessary steps to further the development of cost-effective water supplies from seawater or brackish groundwater desalination in the state and report the results of its studies and activities to the governor, lieutenant governor, and House speaker. The report includes

1. the results of the TWDB's studies and activities related to seawater and brackish groundwater desalination during the preceding biennium;
2. identification and evaluation of research, regulatory, technical, and financial impediments to implementing seawater or brackish groundwater desalination projects;

3. evaluation of the role the State should play in furthering the development of large-scale seawater or brackish groundwater desalination projects in the state;
4. the anticipated appropriation from general revenue necessary to continue investigating water desalination activities in the state during the next biennium; and
5. identification and designation of local or regional brackish groundwater production zones in areas of the state with moderate to high availability and productivity of brackish groundwater that could be used to reduce the use of fresh groundwater.

The 2020 biennial report is the third report to discuss both seawater and brackish groundwater desalination, as well as the identification and designation of local or regional brackish groundwater production zones. With respect to seawater desalination, this is the ninth report in the series and marks the completion of 18 years of activities toward advancing seawater desalination. The report also marks 16 years of activities furthering brackish groundwater desalination in Texas and the third time these activities have been described.

The 2020 biennial report is intended to satisfy requirements of Texas Water Code §16.060 as well as the 86th Session General Appropriations Act, Article VI, TWDB Rider 24. This rider directed the TWDB to report to the legislature each year on the agency’s progress on studies relating to designating priority zones for the production of brackish groundwater in aquifers throughout the state, excluding the Dockum Aquifer.

2 Current state of desalination

Desalination is an important strategy that has created new water supplies around the world. The desalination process removes dissolved solids and other minerals from saline water sources, including brackish groundwater and seawater. Membranes are generally used to physically separate the dissolved solids from water. The most widely used commercial membrane technology is reverse osmosis, which uses high pressure to push water through the membranes.

The treatment process in a desalination plant typically consists of pretreatment, reverse osmosis, and post treatment. The raw (untreated) water enters the plant and goes through a series of filtration or membrane processes (such as strainers, cartridge filters, and microfiltration) to remove sand and suspended solids. Operators dose the water with antiscalant and acid to help prevent clogging the membranes. The operator then pumps the feed water to the reverse osmosis system, which results in two streams: (1) the permeate (the desalinated water) and (2) the concentrate (or brine where the salts are accumulated). In post treatment, operators add chemicals to the permeate or blend the permeate with raw water to add minerals and make it less corrosive. With the required permits, the concentrate from brackish desalination can be discharged to an appropriate water body, sanitary sewer, injection well, or evaporation pond. For seawater desalination, the brine is typically discharged back to the ocean through a permitted outfall. A reverse osmosis system generally operates with 75 to 85 percent recovery for brackish desalination (every 100 gallons desalinated produces 75 to 85 gallons of fresh water) and 50 percent recovery for seawater desalination. The higher the recovery of the system and the higher the total dissolved solids of the raw water, the more energy required to desalinate the water and the higher the costs.

2.1 Seawater desalination

Various countries around the world use seawater desalination to produce freshwater supplies, and this technology has gained momentum in the United States in the past decade. Seawater has a total dissolved solid concentration of about 35,000 milligrams per liter or greater.

In the United States, there are two large operational seawater desalination facilities for municipal use with design capacity greater than 25 million gallons per day (28,000 acre-feet per year), both of which were financed through public-private partnerships. The first large plant is the Tampa Bay Seawater Desalination plant in Tampa, Florida, that began operating in December 2007 and has a design capacity of 25 million gallons per day (28,000 acre-feet per year). Florida has two smaller desalination plants operated by the Florida Keys Aqueduct Authority, which serve as emergency supplies to Lower and Middle Keys (FKAA, 2020). The second large plant is the Claude “Bud” Lewis Carlsbad Desalination Plant located in Carlsbad, California, which became operational on December 14, 2015, and has a design capacity of 50 million gallons per day

(56,000 acre-feet per year). Additionally, there are 10 smaller active seawater desalination facilities on the Pacific Coast, of which seven are used for municipal purposes (Cooley, 2016).

Texas does not have an operational seawater desalination facility but has made progress toward this goal in recent years. While there are six recommended water management strategy projects for seawater desalination in the 2017 State Water Plan located throughout the Gulf Coast, recent activities have been concentrated in the Corpus Christi area (Figure 1). The City of Corpus Christi has been the most active entity and has advanced from planning to the permitting of a seawater desalination plant. Other entities that are or were pursuing seawater desalination included the Port of Corpus Christi Authority, Corpus Christi Polymers (formerly known as M&G Resins USA, LLC), Seven Seas Water, and Poseidon Water in partnership with City of Ingleside (Pankratz, 2020).

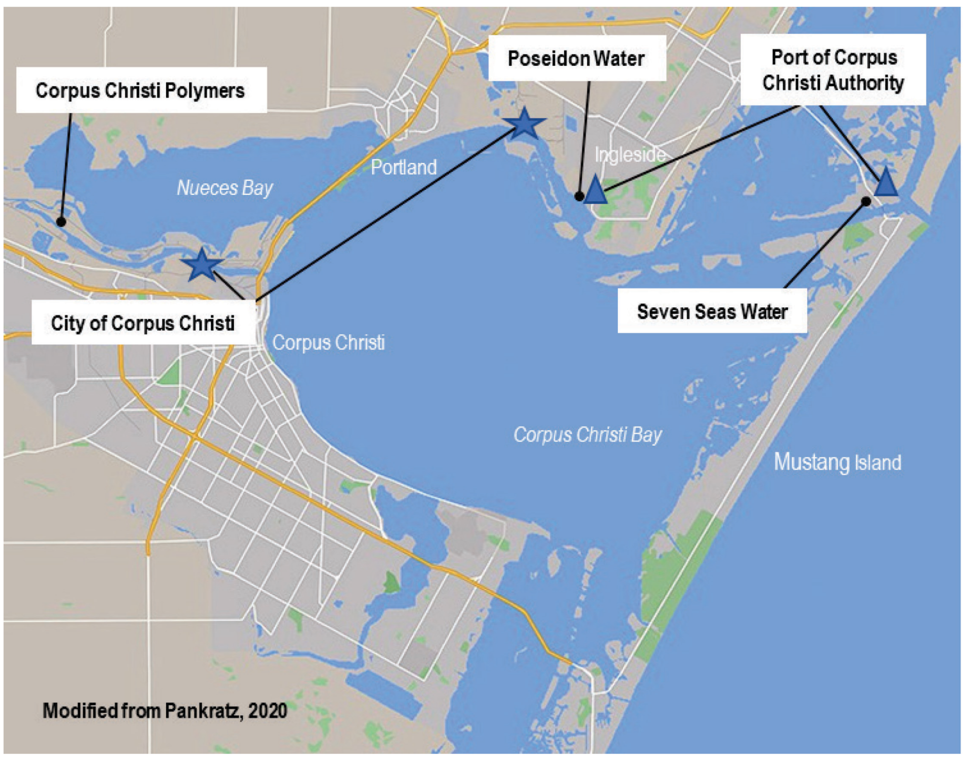

Figure 1. Seawater desalination activities within the Corpus Christi area

Initial investigations into seawater desalination in this area date back to 2004, when the TWDB and the City of Corpus Christi completed a feasibility study that identified two sites, Barney Davis Power Plant and DuPont-OxyChem, as potential locations for a seawater desalination plant. For a decade, no additional work was conducted. In 2013, the City of Corpus Christi and the U.S. Bureau of Reclamation funded a 30-month seawater desalination study to complete a literature review, desalination plant siting, pilot testing criteria, and pilot testing protocol. The City, however, decided not to move forward with the 12-month-long pilot testing.

In 2015, the City partially funded and participated in a feasibility study on seawater desalination for industrial purposes alongside 14 other stakeholders consisting of industries, water providers, and regional authorities. Since industrial stakeholders use 50 percent of the region's municipal water supplies, they considered developing seawater desalination as potential new water supplies to ensure service continuity to industrial customers in the event of extreme drought. The study concluded that stakeholders preferred to build two seawater desalination plants, each with a capacity of 10 million gallons per day (11,200 acre-feet per year). One plant could be located in Corpus Christi on the Inner Harbor Ship Channel and the other in Ingleside on the La Quinta Channel. The City finished their participation in the feasibility study and pursued seawater desalination on its own.

In July 2017, the City received a $2.75 million loan from the TWDB for planning tasks, which they have completed. In August 2018, they also considered other alternative water supplies when they issued a request for information for projects that could produce 10 million gallons per day (11,200 acre-feet per day) of potable water over a 30-year period. In July 2020, the City of Corpus received a $222 million loan from the TWDB to obtain permits for two sites and design and build a seawater desalination plant with a maximum capacity of 30 million gallons per day (33,600 acre-feet per year) for municipal use at one of the two sites. The desalination plant would initially have a capacity of 20 million gallons per day (22,400 acre-feet per year) and expand to the full capacity in the future. More recently in September 29, 2020, the City invited some entities to present on their alternative water supply projects submitted in response to the request for information.

2.2 Brackish water desalination

Brackish water from surface water, groundwater, or reclaimed water sources is an important water source that can help reduce demand on freshwater sources. For this report, brackish water is considered water that contains dissolved salts with total dissolved solid concentration ranging from 1,000 to 10,000 milligrams per liter.

In the United States, there are 406 municipal brackish groundwater desalination plants—with the majority located in Florida (40 percent), California (14 percent), and Texas (13 percent) (Mickley, 2018). In South Florida alone, there are 38 brackish groundwater desalination plants with a total capacity of 279 million gallons per day (312,480 acre-feet per year) (South Florida Water Managament District, 2020). In California, there are 23 brackish groundwater desalination plants with a total capacity of 124 million gallons per day (139,627 acre-feet per year) (California Department of Water Resources, 2014). Most plants are located in Southern California, and the capacity of the largest plant is 15 million gallons per day (16,800 acre-feet per day). The majority (72 percent) of desalination plants in the nation employ reverse osmosis treatment technology (Mickley, 2018).

Brackish groundwater is also an important water supply source in Texas. The state is estimated to have more than 880 trillion gallons (2.7 billion acre-feet) of brackish groundwater in 26 of its major and minor aquifers in Texas (LBG-Guyton Associates, 2003). In the last two decades, municipal brackish desalination capacity in Texas has increased steadily (Figure 2).

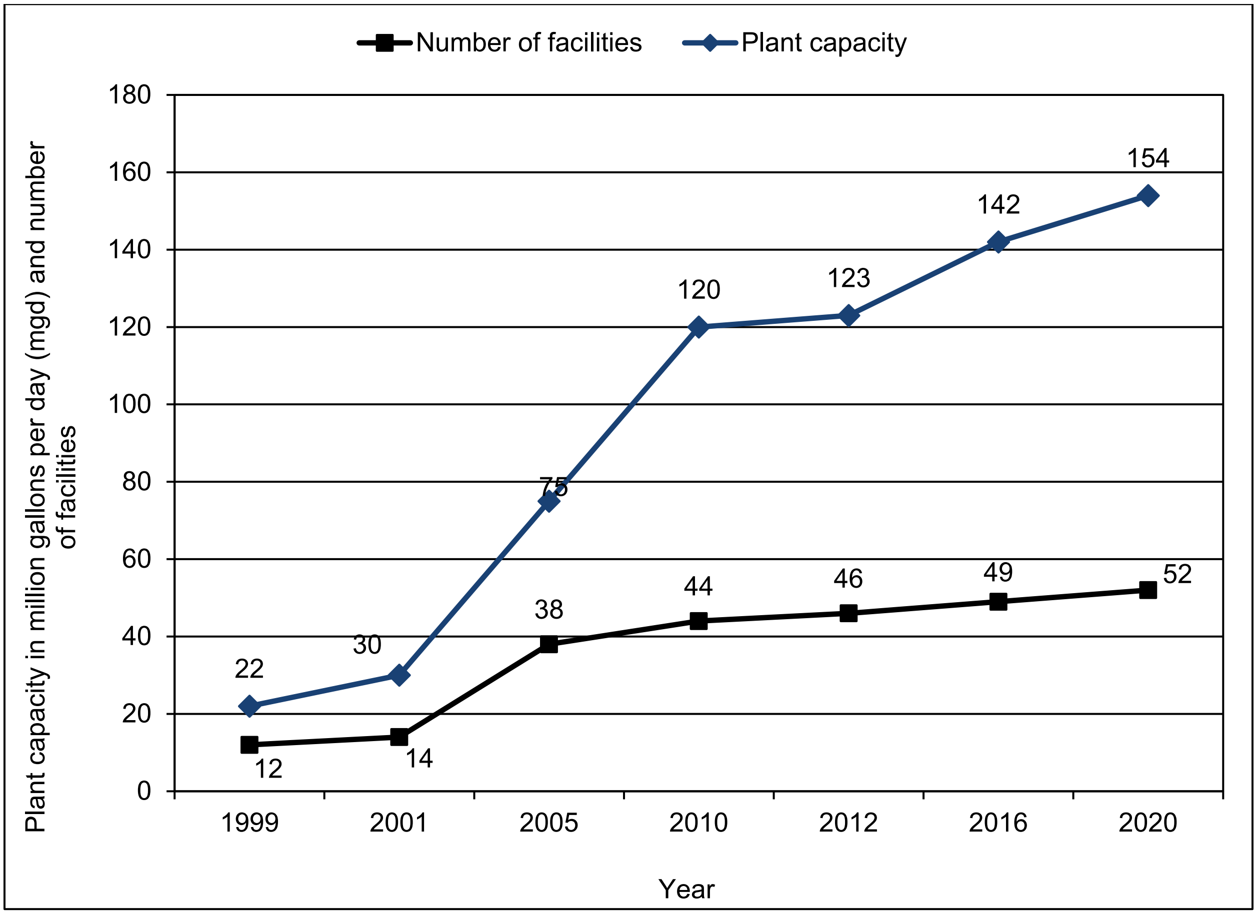

Figure 2. **The growth of municipal desalination facilities and installed design capacity in Texas, 1999 through 2020**

In 2005, the TWDB funded a project to develop an initial desalination plant database to track the growth of desalination across the state (Nicot and others, 2005). In 2010, 2016, and 2020, TWDB staff updated the information by sending self-reported surveys to existing desalination plants in the database and to new desalination plants identified by staff. For entities that responded to the survey, their information was either updated or added to the database, online at www2.twdb.texas.gov/apps/waterdatainteractive/GroundwaterDataViewer/?map=desal. Since the desalination plant database relies on utilities to submit self-reported surveys, it may not capture every plant in operation or plants constructed after August 2020.

As of August 2020, there were 53 desalination plants for municipal use with a per-facility capacity greater than 25,000 gallons per day that responded to the survey (Table 1). Of these facilities, 16 treat brackish surface water, 36 treat brackish groundwater, and 1 treats reclaimed water (Figure 3). In total, Texas has a desalination design capacity of approximately 157 million gallons per day (176,013 acre-feet per year) for municipal use. More specifically, the state has a design capacity of 90 million gallons per day (100,769 acre-feet per year) for brackish groundwater desalination, 65 million gallons per day (72,443 acre-feet per year) for brackish surface water desalination, and 2.5 million gallons per day (2,800 acre-feet per year) for advanced treated reclaimed water. The largest inland desalination plant in the state and nation is the Kay Bailey Hutchison Desalination Plant located in El Paso (27.5 million gallons per day or 30,937 acre-feet per day). Reverse osmosis is the predominant desalination technology used in the desalination facilities of the state.

Table 1. Municipal brackish desalination facilities in Texas with a capacity greater than 0.025 million gallons per day in the database

Facility name	City	Water source	Facility startup year	Facility design capacity[1] (mgd)
Big Bend Motor Inn	Terlingua	Groundwater	1989	0.057
Bob Elder Water Treatment Plant	Milsap	Surface water	2014	1.000
Brazoria County Municipal Utility District 21	Rosharon	Groundwater	2018	2.572
Brazos Regional Public Utility Agency/Surface Water Advanced Treatment System	Granbury	Surface water	1989	15.000
City of Abilene (Hargesheimer Treatment Plant)	Tuscola	Surface water	2003	12.000
City of Ballinger	Ballinger	Surface water	2005	2.000
City of Bardwell	Bardwell	Groundwater	1980	0.252
City of Bayside	Bayside	Groundwater	1990	0.045
City of Beckville	Beckville	Groundwater	2004	0.216
City of Benjamin	Benjamin	Groundwater	2012	0.072
City of Brady	Brady	Surface water	2005	3.000
City of Clarksville City	White Oak	Groundwater	2006	0.288
City of Evant	Evant	Groundwater	2010	0.100
City of Fort Stockton Osmosis/Desalination Facility	Fort Stockton	Groundwater	1996	7.000
City of Granbury	Granbury	Surface water	2007[2]	2.500
City of Hubbard	Hubbard	Groundwater	2002	0.648
City of Kenedy	Kenedy	Groundwater	1995	2.858
City of Robinson Reverse Osmosis Surfacewater Treatment Plant	Waco	Surface water	1994	2.400
City of Rule	Rule	Groundwater	2015	0.086
City of Seadrift	Seadrift	Groundwater	1998	0.610
City of Seymour	Seymour	Groundwater	1940	3.000
City of Sherman	Sherman	Surface water	1993	10.000
City of Tatum	Tatum	Groundwater	1999	0.324

Facility name	City	Water source	Facility startup year	Facility design capacity[1] (mgd)
Cypress Water Treatment Plant	Wichita Falls	Surface water	2008	10.000
Dell City	Dell City	Groundwater	1968	0.100
DS Waters of America, LP	Katy	Groundwater	1997	0.090
Fort Hancock Reverse Osmosis (RO) Plant No. 1	Fort Hancock	Groundwater	2012	0.430
H2Oaks Center	Elmendorf	Groundwater	2016	12.000
Holiday Beach Water Supply Corporation	Fulton	Groundwater	1960	0.150
Horizon Regional Municipal Utility District	Horizon City	Groundwater	2001	6.000
Kay Bailey Hutchison Desalination Plant	El Paso	Groundwater	2007	27.500
Klondike ISD	Lamesa	Groundwater	2018	0.430
Military Highway Water Supply Corporation - Progreso	Progreso	Groundwater	2010	1.000
Military Highway Water Supply Corporation – Las Rusias	Los Indios	Surface water	2014	2.100
Midland Country Club	Midland	Groundwater	2004	0.023
Millersview-Doole	Millersview	Surface water	2012	1.530
Mitchell County Desalination Plant	Colorado City	Groundwater	2017	0.025
North Alamo Water Supply Corporation (Doolittle)	San Juan	Groundwater	2008	3.500
North Alamo Water Supply Corporation (Lasara)	Edinburg	Groundwater	2005	1.200
North Alamo Water Supply Corporation (Owassa)	Raymondville	Groundwater	2008	2.000
North Cameron/Hidalgo Water Authority	Rio Hondo	Groundwater	2006	2.340
Oak Trail Shores	Granbury	Surface water	1985	1.584
Possum Kingdom Water Supply Corporation	Graford	Surface water	2003	0.850
Raw Water Production Facility	Big Spring	Reclaimed	2013	2.500
River Oaks Ranch	Pflugerville	Groundwater	1985[3]	0.115
Southmost Regional Water Authority	Brownsville	Groundwater	2004	11.000
Sportsman's World Municipal Utility District	Strawn	Surface water	1984	0.083
Study Butte Terlingua Water System	Terlingua	Groundwater	2000	0.140
Texas Park and Wildlife Department – Caprock Canyons	Quitaque	Groundwater	2012	0.540
The Cliffs	Graford	Surface water	1991	0.381
Valley Municipal Utility District #2	Olmito	Groundwater	2000	1.000
Veolia Water Treatment Plant	Port Arthur	Surface water	1992	0.245
Victoria Road Reverse Osmosis Plant #5	Donna	Groundwater	2012	2.250
			Total	**157.134**

Notes: mgd = million gallons per day
[1]Plant design capacity includes blending
[2]Plant constructed in 1984; reverse osmosis implemented in 2007
[3]Plant rehabilitated in 2011

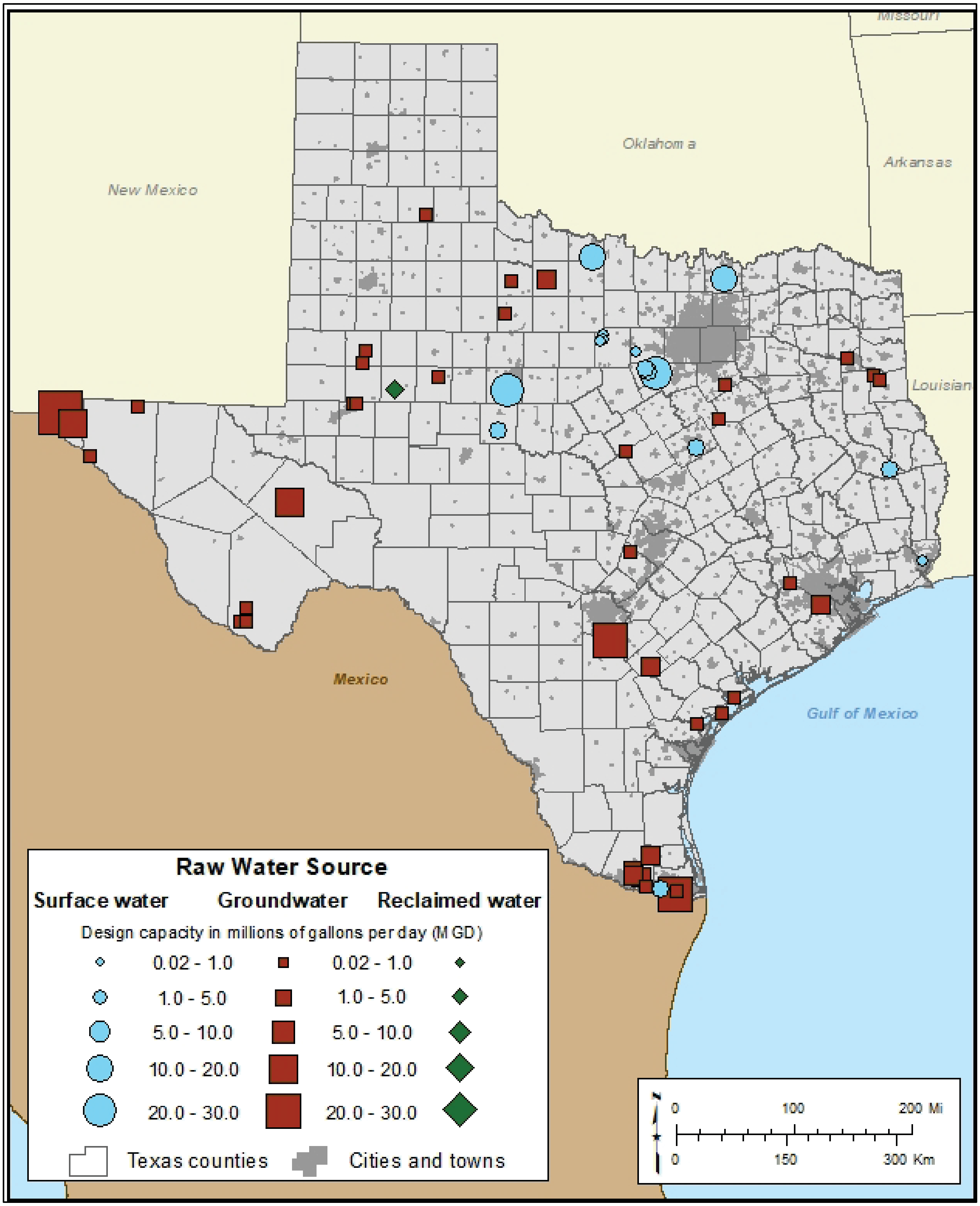

Figure 3. Distribution, size, and source water of municipal brackish desalination facilities in Texas with a design capacity of more than 0.025 million gallons per day, 2020

3 Results of the TWDB's studies and activities in desalination

In 2003, the 78th Texas Legislature passed House Bill 1370, directing the TWDB to undertake or participate in research, feasibility and facility planning studies, investigations, and surveys it considers necessary to further the development of cost-effective water supplies from seawater desalination. In 2015, the 84th Texas Legislature passed House Bill 30, directing the TWDB to also engage and report on brackish groundwater desalination in the state. This chapter describes desalination activities (1) funded through the Desalination Program, (2) in the 2017 State Water Plan, (3) and funded through other TWDB grant and loan programs.

3.1 Desalination Program

The TWDB created the Desalination Program in 2002 in response to Governor Rick Perry announcing his seawater initiative and the 78th Texas Legislature passing House Bill 1370 that directed the TWDB to pursue seawater desalination and to report progress in a biennial report. Initially, the program covered activities for seawater desalination and in 2004 added brackish groundwater desalination. The legislature last appropriated funding for seawater desalination in 2005 and brackish groundwater desalination in 2009.

3.1.1 Seawater desalination studies

Since 2002, the TWDB has funded $3.2 million in studies related to seawater desalination, including three feasibility studies, two pilot-plant projects, and several guidance and research studies (Table 2). In 2005, the 79th Texas Legislature made its last appropriation of $2.5 million for seawater desalination demonstration activities, which was spent by 2010. Since then, the TWDB has not funded additional seawater desalination studies.

Table 2. TWDB-funded reports on seawater desalination

Report title	Study location	Study type
Lower Rio Grande Valley, Brownsville Seawater Desalination Demonstration Project (Brownsville Public Utilities Board, 2004)	City of Brownsville	Feasibility study
Large-Scale Demonstration Desalination Feasibility Study (City of Corpus Christi, 2004)	City of Corpus Christi	Feasibility study
Freeport Seawater Desalination Project (Brazos River Authority, 2004)	City of Freeport	Feasibility study
Pilot Study Report, Texas Seawater Desalination Demonstration Project (Brownsville Public Utilities Board, 2008)	City of Brownsville	Pilot-plant study
Feasibility and Pilot Study, South Padre Island Seawater Desalination Project (Laguna Madre Water District, 2010)	South Padre Island	Pilot-plant study
Guidance Manual for Permitting Requirements in Texas for Desalination Facilities Using Reverse Osmosis Processes (R.W. Beck, Inc., 2004)	Not applicable	Guidance document
Lessons Learned from the Brownsville Seawater Pilot Study (Reiss Engineering Inc., 2009)	City of Brownsville	Guidance document
Texas Desal Project (Brownsville Public Utilities Board, 2011)	City of Brownsville	Guidance document

3.1.2 Brackish groundwater desalination studies

Since 2004, the TWDB has funded 11 studies totaling $2.1 million related to brackish groundwater desalination, which include implementing demonstration projects, preparing guidance manuals, and completing research studies (Table 3). Since 2009, the Texas Legislature has not appropriated funds to the TWDB for the Desalination Program to support brackish groundwater desalination projects.

Table 3. Brackish groundwater desalination studies funded through the Desalination Program

Report title	Contractor	Description	Study type	Year funded	Grant amount
Guidance Manual for Brackish Groundwater Desalination in Texas	North Cameron Regional Water Supply Corporation	The project prepared a brackish groundwater desalination guidance manual using a desalination plant in Cameron County as an example.	Demonstration	2006	$150,000
Demonstration of Efficiencies Gained by Utilizing Improved Reverse Osmosis Technologies	City of Kenedy/San Antonio River Authority	The project demonstrated the efficiencies gained by installing a new reverse osmosis system in an existing brackish groundwater desalination plant.	Demonstration	2006	$150,000

Report title	**Contractor**	**Description**	**Study type**	**Year funded**	**Grant amount**
Assessment of the Whitehorse Aquifer as a Potential Source of Water Supply for the City of San Angelo	City of San Angelo/Upper Colorado River Authority	The project assessed the feasibility of the Whitehorse Aquifer in Irion County as a source of brackish water for the City of San Angelo.	Demonstration	2006	$300,000
Evaluation of Concentrate Management and Assessment of the Vibratory Shear Enhanced Process	San Antonio Water System	The project conducted a pilot test to assess the cost and technical feasibility of the Vibratory Shear Enhanced Process as a tool for reducing the volume of desalination concentrate.	Demonstration	2007	$205,000
Improving Recovery: A Concentrate Management Strategy for Inland Desalination	The University of Texas at Austin	The study investigated anti-scalant precipitation and electrodialysis to increase recovery in desalination of brackish groundwater.	Demonstration	2007	$238,500
Pilot Study to Demonstrate Volume Reduction of Reverse Osmosis Concentrate	El Paso Public Utilities Board	The study evaluated silica reduction in reverse osmosis concentrate through the addition of lime and application of the vibratory shear enhanced process. A second phase of the project tested the use of seawater reverse osmosis membranes to increase water recovery.	Demonstration	2007	$228,557
An Integrated Wind-Water Desalination Demonstration Project for an Inland Municipality	City of Seminole	The City of Seminole conducted pilot testing using wind energy to desalinate brackish groundwater.	Demonstration	2008	$300,000
Permitting Guidance Manual to Dispose Desalination Concentrate into a Class II Injection Well	CDM Smith, Inc.	The study developed an instruction manual and road map for permitting a Class II well for dual Class I-Class II purposes.	Demonstration	2010	$130,000
Upflow Calcite Contractor Design	Carollo Engineers, Inc.	The study developed design criteria for the post-treatment of permeate water using an upflow calcite contactor.	Demonstration	2010	$188,403
Demonstration of Fiberglass Well Casings in Brackish Groundwater Wells	North Alamo Water Supply Corporation	The project demonstrated the viability of using fiberglass well casing in water wells installed in brackish aquifers.	Demonstration	2010	$100,000

Report title	Contractor	Description	Study type	Year funded	Grant amount
Demonstration of a High Recovery and Energy Efficient Reverse Osmosis System for Small-Scale Brackish Water Desalination	Texas Tech University	The study demonstrated the use of a reverse osmosis system with parallel elements for small-scale desalination with high recovery and energy efficiency.	Demonstration	2010	$101,597

3.2 2017 State Water Plan

The TWDB develops the state water plan every five years through a locally driven planning process guided by 16 regional water planning groups. Each planning group assesses existing water supplies and future needs. If there are anticipated water shortages, the planning group identifies both recommended and alternative water management strategies and/or projects to create new water supplies. The difference between a water management strategy and project is that a strategy is a plan to meet a water need and the project is the infrastructure required to implement the strategy. Projects would develop, deliver, or treat additional water supply volumes at a specified capital cost. One project may be associated with multiple water management strategies.

This section describes seawater and brackish groundwater desalination activities in the 2017 State Water Plan (TWDB, 2017).

3.2.1 Seawater desalination

In the 2017 State Water Plan, four regional water planning groups (regions H, L, M, and N) included 10 seawater desalination recommended water management strategies (Appendix A, Table A-1). If implemented, these recommended strategies would produce an estimated 116,000 acre-feet of new water supply by 2070. This constitutes about 1.4 percent of all recommended water management strategies in the state water plan.

The Rio Grande Regional Water Planning Group (Region M) included seawater desalination as an alternative water management strategy, which can replace a recommended strategy in the regional water plan and consequently the state water plan if it turns out the original recommended strategy cannot be achieved (Texas Administrative Code §357.10(1)). If implemented, the 28 alternative seawater desalination strategies in Region M (Appendix A, Table A-2) would provide 81,000 acre-feet per year of water supplies by 2070.

To implement recommended or alternative water management strategies, water user groups may need to execute projects to obtain the new water supplies. Regional water planning groups identified six recommended water management strategy projects and five alternative projects for seawater desalination (Table 4). The recommended water management strategy projects in Region L are not assigned to serve a specific water user group (in other words, the projects are recommended but are not planned to provide water to users during the 50-year planning period).

The statewide weighted-average[1] seawater desalination unit cost of recommended projects is $1,431 per acre-foot ($4.39 per thousand gallons). The projects are distributed along the Gulf Coast (Figure 4). For a few projects, sponsors have completed feasibility or pilot studies with the assistance of TWDB research funds.

Table 4. Seawater desalination projects in the 2017 State Water Plan

ID	Region	Project sponsor	Project name	Feasibility study completed	Pilot study completed	Project level recommendation type
1	H	Brazos River Authority	Freeport seawater desalination	Yes	--	Recommended
2	L	San Antonio Water System	Seawater desalination	--	--	Recommended
3	L	Guadalupe Blanco River Authority	Integrated water-power project	Yes	--	Recommended
4	M	Brownsville Public Utilities Board	Brownsville seawater desalination demonstration	Yes	Yes	Recommended
5	M	Brownsville Public Utilities Board	Brownsville seawater desalination implementation	Yes	Yes	Recommended
6	N	Corpus Christi	Seawater desalination	Yes	--	Recommended
7	M	Laguna Madre Water District	Laguna Madre seawater desalination	Yes	Yes	Alternative
8	M	RGRWA	RGRWA ocean desal - Phase I	--	--	Alternative
9	M	RGRWA	RGRWA ocean desal - Phase II	--	--	Alternative
10	M	RGRWA	RGRWA ocean desal - Phase III	--	--	Alternative
11	M	RGRWA	RGRWA ocean desal - Phase IV	--	--	Alternative

Note: RGRWA = Rio Grande Regional Water Authority

[1] The weighted average is the average of values scaled by the relative volume of each strategy.

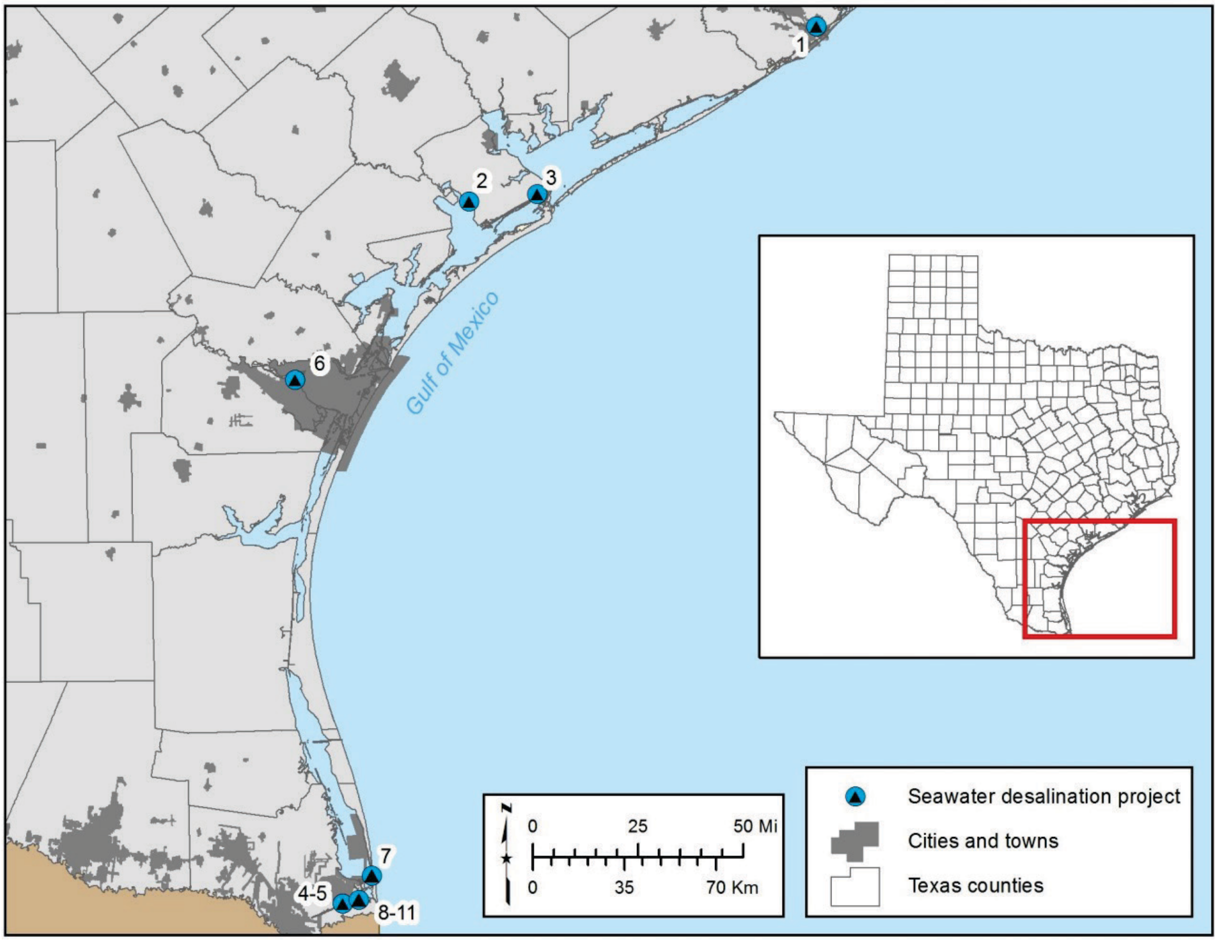

Figure 4. Location of seawater desalination projects in the 2017 State Water Plan. Numbers refer to projects in Table 4.

3.2.1.1 Region H Regional Water Planning Area

Seawater desalination is recommended as a water management strategy to meet manufacturing demands in Brazoria County by 2040 (Freese and Nichols and others, 2015). The Brazos River Authority proposes a seawater desalination plant with an initial capacity of 10 million gallons per day (11,200 acre-feet per year) at the Dow Chemical Company complex in the City of Freeport. The facility would use an existing intake and discharge outfall and Dow's withdrawal and discharge permits, which would reduce construction costs and environmental impacts. The estimated capital cost to build the plant is about $133 million.

3.2.1.2 South Central Texas (Region L) Regional Water Planning Area

The 2016 South Central Texas (Region L) Regional Water Plan includes two seawater desalination projects (HDR Engineering, Inc., 2015a). The San Antonio Water System proposes to build a seawater desalination plant adjacent to San Antonio Bay near the City of Seadrift, with a design capacity of 75 million gallons per day (84,000 acre-feet per year). A 126-mile-long pipeline would convey treated water to a location in southern Bexar County near the H2Oaks Center. The concentrate would be discharged 13 miles offshore to the Gulf of Mexico. The estimated total capital cost for the project is about $1.6 billion.

The Integrated Water-Power Project would involve building an 89.3-million-gallon-per-day (100,000-acre-foot-per-year) seawater desalination plant near Port O'Connor in Calhoun County. Water would be conveyed via a 138-mile-long pipeline to Calhoun, Victoria, Gonzales, and Dewitt counties. The estimated total capital costs of the project are $1.6 billion. The Guadalupe-Blanco River Authority is no longer pursuing this seawater desalination project

3.2.1.3 Rio Grande (Region M) Regional Water Planning Area

The Brownsville Public Utilities Board proposes to locate a seawater desalination plant on the south shore of the Brownsville Ship Channel (Black & Veatch, 2015). The initial phase of the facility was planned to come online by 2020 with an initial capacity of 2.5 million gallons per day (2,800 acre-feet per year); however, this strategy has been delayed. If implemented, the second phase would expand the plant to 25 million gallons per day (28,000 acre-feet per year) by 2060. The estimated capital costs of the desalination plant are about $56 million for Phase I and about $310 million for Phase II.

3.2.1.4 Coastal Bend (Region N) Regional Water Planning Area

The City of Corpus Christi recommends a 20-million-gallon-per-day (22,400-acre-foot-per-year) seawater desalination project that would come online by 2030 (HDR Engineering, Inc., 2015b). The treatment plant, estimated to cost $248 million, could be located between Nueces and Corpus Christi bays or at the Inner Ship Channel adjacent to the Broadway Wastewater Treatment Plant near the northeast corner of Corpus Christi Bay. The plant would serve Nueces and San Patricio counties.

3.2.2 Brackish groundwater desalination

In the 2017 State Water Plan, eight regional water planning groups (regions E, F, H, J, L, M, N, and O) included 78 brackish groundwater desalination recommended water management strategies (Appendix A, Table A-3). If these recommended strategies are implemented, brackish groundwater desalination would produce about 111,000 acre-feet per year of additional water supplies by 2070. This would constitute about 1.3 percent of all recommended water management strategies in the state water plan. Additionally, there are five water management strategies in regions F, L, and P not currently assigned to serve a specific water user group.

Four planning groups (regions K, L, M, and N) included 36 groundwater desalination alternative water management strategies (Appendix A, Table A-4). If implemented, these alternative strategies would produce 32,449 acre-feet per year of new water supplies by 2070. Additionally, there are eight alternative water management strategies in regions F, K, and L not currently assigned to serve a specific water user group.

Regional water planning groups propose to implement 35 brackish groundwater desalination projects (Table 5). The proposed desalination projects are concentrated in the western, central, and southern parts of Texas (Figure 5). The statewide weighted-average[2] groundwater desalination unit cost of recommended projects is about $713 per acre-foot ($2.19 per 1,000 gallons). Project components may include pipelines, wells, new desalination plants, and expansions of existing plants. The implementation of the recommended water management strategies may lead to the development of 27 desalination plants (27 projects have a new treatment plant component).

Additional groundwater desalination may occur in the future as a result of implementing "groundwater wells and other" and "aquifer storage and recovery" recommended water management strategies.

Table 5. Brackish groundwater desalination recommended projects in the 2017 State Water Plan

ID	Region	Project sponsor	Project name	Capital cost (estimated)
1	E	Hudspeth County-other	Hudspeth County-other (Dell City) - brackish groundwater desalination facility	$1,299,000
2	E	El Paso	El Paso Water Utilities - expansion of the Kay Bailey Hutchison Desalination Plant	$37,200,000
3	E	El Paso	El Paso Water Utilities - brackish groundwater at the Jonathan Rogers Wastewater Treatment Plant	$65,865,000
4	E	Horizon Regional Municipal Utility District	Horizon Regional Municipal Utility District - additional wells and expansion of desalination plant	$56,443,000
5	E	Lower Valley Water District	Lower Valley Water District - groundwater from proposed well field - Rio Grande Alluvium Aquifer	$37,490,000
6	F	San Angelo	Desalination of other aquifer supplies in Tom Green County - San Angelo	$57,967,000
7	F	Concho Rural Water Corporation	Desalination of other aquifer supplies in Tom Green County - Concho Rural Water Supply Corporation	$5,131,000
8	H	Conroe	Conroe brackish groundwater desalination	$40,691,342
9	H	Brazosport Water Authority	Brackish groundwater development	$34,016,950
10	L	San Antonio Water System	Brackish Wilcox groundwater for San Antonio Water System	$53,162,000
11	L	Canyon Regional Water Authority	Brackish Wilcox groundwater for Canyon Regional Water Authority	$62,787,000

[2] The weighted average is the average of values scaled by the relative volume of each strategy.

ID	Region	Project sponsor	Project name	Capital cost (estimated)
12	L	Schertz-Seguin Local Government Corporation	Brackish Wilcox groundwater for Schertz-Seguin Local Government Corporation	$54,133,000
13	L	S S Water Supply Corporation	Brackish Wilcox groundwater for S S Water Supply Corporation	$16,864,000
14	L	San Antonio Water System	Expanded brackish Wilcox project - San Antonio Water System	$723,175,000
15	M	East Rio Hondo Water Supply Corporation; North Alamo Water Supply Corporation	North Cameron Regional Water Treatment Plant wellfield expansion	$1,881,000
16	M	Alamo	Alamo brackish groundwater desalination plant	$13,532,000
17	M	El Jardin Water Supply Corporation	El Jardin new brackish groundwater desalination plant	$8,272,000
18	M	Hebbronville	Hebbronville new brackish groundwater desalination plant	$8,275,000
19	M	La Feria	La Feria water well with reverse osmosis unit	$6,260,000
20	M	Lyford	Lyford brackish groundwater desalination	$6,950,000
21	M	McAllen	McAllen brackish groundwater desalination plant	$31,218,000
22	M	Mission	Mission brackish groundwater desalination plant	$31,914,000
23	M	Union Water Supply Corporation	Union Water Supply Corporation brackish groundwater desalination plant	$8,282,000
24	M	Laguna Madre Water District	Laguna Madre new brackish groundwater desalination plant	$22,564,000
25	M	North Alamo Water Supply Corporation	North Alamo Water Supply Corporation delta area reverse osmosis water treatment plant expansion	$22,709,000
26	M	Primera	Primera brackish groundwater desalination plant	$14,318,000
27	M	Sharyland Water Supply Corporation	Sharyland well and reverse osmosis at water treatment plant 2	$13,253,000
28	M	Sharyland Water Supply Corporation	Sharyland well and reverse osmosis at treatment plant 3	$13,253,000
29	M	San Juan	San Juan water treatment plant No. 1 expansion	$9,561,000
30	M	North Alamo Water Supply Corporation	North Alamo Water Supply Corporation La Sara reverse osmosis expansion	$13,260,000
31	N	Alice	Brackish groundwater development - Alice	$33,277,000
32	O	Seminole	Gaines County - Seminole groundwater desalination	$31,572,000
33	O	Abernathy	Hale County - Abernathy groundwater desalination	$10,100,000
34	O	Lubbock	Lubbock County - Lubbock brackish well field at the south water treatment plant	$34,531,740
35	P	Lavaca-Navidad River Authority	Lavaca-Navidad River Authority desalination	$31,393,000
			Total	**$2,198,787,010**

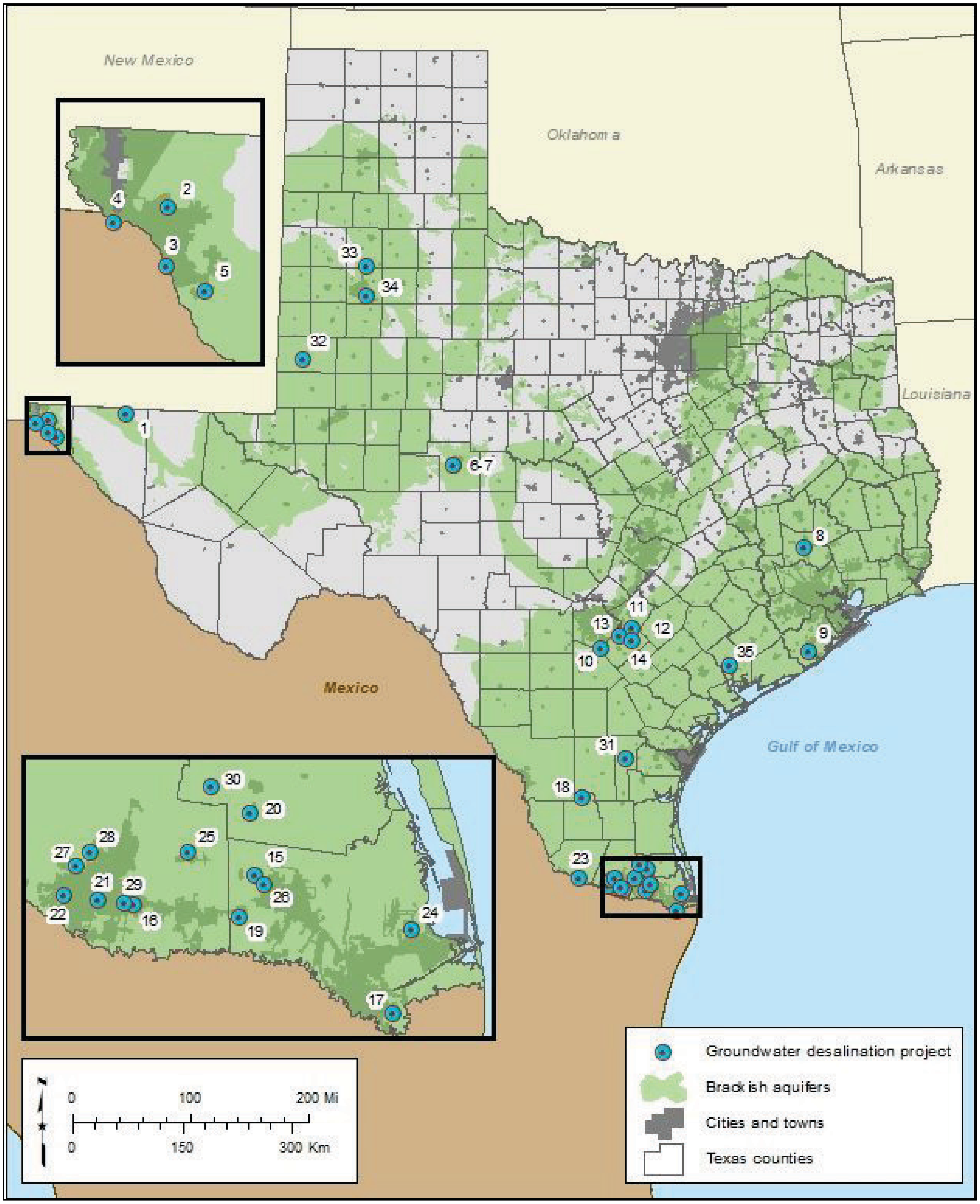

Figure 5. **Location of brackish groundwater desalination projects in the 2017 State Water Plan. Numbers refer to projects in Table 5.**

3.2.2.1 Far West Texas (Region E) Regional Water Planning Area

Brackish groundwater desalination is recommended as a water management strategy in the 2016 Far West Texas (Region E) Regional Water Plan to meet water demands starting by 2020. The desalination projects include the development of new wells, the construction of new desalination plants, and the expansion of existing facilities.

El Paso Water Utilities proposes developing 10 new wells and building a new desalination plant near the Jonathan Rogers Water Treatment Plant. The brine would be disposed via a deep injection well. The capital costs of the project are estimated at $65.9 million. As part of a separate project, El Paso Water Utilities also plans to expand the Kay Bailey Hutchison Desalination Plant from 27.5 to 32 million gallons per day (30,800 to 35,840 acre-feet per year). The project is planned to be completed in phases, which would include seven new wells and one new deep injection well, for a total capital cost of $37.2 million.

In addition, the utility plans to import brackish groundwater from the Dell City area. Total capital costs would be $110 million, which would include purchasing land, rehabilitating 15 wells and a pump station, and building a 12-mile pipeline and an 18-million-gallon-per-day (20,160-acre-foot-per-year) desalination plant. However, this recommended project is associated with a "groundwater well development" water management strategy and is not listed in Table 5. The TWDB provided a $50 million loan on December 2, 2015, and a $150 million multi-year loan on July 21, 2016, both from the State Water Implementation Fund for Texas, to El Paso Water Utilities to purchase land and water rights above the Bone Spring-Victorio Peak Aquifer.

The Lower Valley Water District proposes to develop a 10-million-gallon-per-day (11,200-acre-foot-per-year) plant along with a water storage tank, a disposal well, and seven new wells. Total capital costs would be $37.5 million and include the land purchase. The District proposes a similar project, with capital costs of $41.1 million, that would develop groundwater from the Hueco Bolson Aquifer instead of the Rio Grande Alluvium Aquifer. However, this recommended project is labeled as a "groundwater well development" water management strategy and is not listed in Table 5.

The Horizon Municipal Utility District plans to expand its existing desalination plant from 6.0 to 21.4 million gallons per day (6,720 to 23,968 acre-feet per year). Expansion would include the development of nine new wells and project capital costs of $56.4 million. Dell City also plans to expand its existing plant by replacing the electrodialysis reversal system with a reverse osmosis system at a capital cost of $1.3 million.

3.2.2.2 Region F Regional Water Planning Area

The City of San Angelo and the Upper Colorado River Authority propose a 7-million-gallon-per-day (7,840-acre-foot-per-year) desalination plant with six deep injection wells and a six-mile-long concentrate disposal pipeline. The project's capital costs are estimated at $58 million. The Concho Rural Water Corporation plans to build a 0.27-million-gallon-per-day (302-acre-foot-per-year) desalination plant and dispose of the concentrate in evaporation ponds. Capital costs would be $5.1 million.

3.2.2.3 Region H Regional Water Planning Area

The City of Conroe proposes to build a desalination facility and treat groundwater from the Catahoula Aquifer. Capital costs for the project are estimated at $40.7 million.

The Brazosport Water Authority plans to drill three groundwater wells and build a 6-million-gallon-per-day (6,720 acre-foot-per-day) desalination plant to treat the groundwater. In Phase II, they plan to drill two additional wells and expand the capacity of the plant to 12 million gallons per day (13,440 acre-feet per year). The concentrate would be discharged to a segment of the Brazos River below State Highway 332. The project's capital costs for phases I and II would be $34 million.

3.2.2.4 Plateau (Region J) Regional Water Planning Area

The Upper Guadalupe River Authority and Eastern Kerr County propose to build a 1.2-million-gallon-per-day (1,344-acre-foot-per-year) facility using the Ellenburger Aquifer and dispose of the concentrate via evaporation ponds. Capital costs for the project are estimated at $14.5 million. However, this recommended project is labeled as a "groundwater well development" water management strategy and is not listed in Table 5.

3.2.2.5 South Central Texas (Region L) Regional Water Planning Area

The S S Water Supply Corporation plans to pump brackish groundwater from the Wilcox Aquifer and treat it in a 2-million-gallon-per-day (2,240-acre-foot-per-year) desalination plant. The project would consist of three new groundwater wells, a two-mile-long pipeline, a storage water tank, and a deep injection well. Capital costs would be approximately $16.9 million.

The Schertz-Seguin Local Government Corporation plans to develop six groundwater wells that would pump water to a 5-million-gallon-per-day (5,600-acre-foot-per-year) desalination facility. The concentrate would be disposed via deep well injection. Capital costs of the project are estimated at approximately $54.1 million.

The Canyon Regional Water Authority plans to develop up to 20 supply wells for a new brackish groundwater desalination plant. The project also includes separate water and concentrate pipelines and a deep injection well for concentrate disposal. Capital costs would be approximately $62.8 million.

The San Antonio Water System plans to expand the capacity of its existing desalination plant to 30 million gallons per day (33,600 acre-feet per year). The expansion will be completed in phases, which include a 12-million-gallon-per-day (13,440-acre-foot-per-year) expansion in the second phase and a 6-million-gallon-per-day (6,720-acre-foot-per-year) expansion in the third phase. Even though San Antonio Water System has plans to expand the desalination facility as described above, it is restricted in the state water plan to the modeled available groundwater (MAG) volume of 5.4 million gallons per year (6,059 acre-feet per year). The version of the project in the state water plan would include developing six wells, expanding the plant, and installing one concentrate injection well. Capital costs of the MAG-constrained project would be $53.1 million, which is what is represented in Table 5.

The San Antonio Water System envisions another similar project that would include the development of two wellfields, with 32 wells in one wellfield and 19 wells in the other. The groundwater would be conveyed by a 36-mile-long pipeline to two new desalination plants with design capacities of 31.2 and 44.6 million gallons per day (34,944 and 49,952 acre-feet per year), respectively. Concentrate disposal would occur via nine deep injection wells. Capital costs of the project are estimated at approximately $723 million.

3.2.2.6 Rio Grande (Region M) Regional Water Planning Area

The Rio Grande Regional Water Planning Area has several desalination projects that include constructing new plants and expanding existing facilities. The capacity of the North Cameron Regional Water Supply Corporation desalination plant would be increased from 1.15 to 2.30 million gallons per day (1,288 to 2,576 acre-feet per year) with the addition of a water supply well. Capital costs of the project are estimated to be $1.9 million. Similarly, the North Alamo Water Supply Corporation plans to increase the capacity of the La Sara Desalination Plant by 1 million gallons per day (1,120 acre-feet per year) with the addition of groundwater wells and reverse osmosis systems. Capital costs are estimated at $13.3 million. The City of San Juan is also recommending the expansion of its existing brackish groundwater desalination facilities at a capital cost of $9.6 million.

The City of El Jardin plans to build a new 0.5-million-gallon-per-day (560-acre-foot-per-year) desalination plant at a total capital cost of about $8.3 million. The City of La Feria also proposes to build a new desalination plant with a capacity of 1.25 million gallons per day (1,400 acre-feet per year) and capital costs of approximately $6.3 million. Laguna Madre Water District recommends the building of a 2-million-gallon-per-day (2,240-acre-foot-per-year) desalination facility at a total capital cost of $22.6 million. Similarly, North Alamo Water Supply Corporation also plans to build a 2-million-gallon-per-day (2,240-acre-foot-per-year) desalination facility at a capital cost of $22.7 million. Other entities (Alamo, Hebbronville, Lyford, McAllen, Mission, Primera, Sharyland Water Supply Corporation, and Union Water Supply Corporation) also recommend the construction of new brackish groundwater desalination facilities to provide new water supplies for the region.

3.2.2.7 Coastal Bend (Region N) Regional Water Planning Area

The City of Alice proposes to build a 4-million-gallon per-day (4,480-acre-foot-per-year) desalination facility and two new wells that would pump groundwater from the Jasper Formation. The concentrate would be piped and discharged to San Diego Creek, which ultimately flows into San Fernando Creek. Capital costs for the project are estimated at about $33.3 million.

3.2.2.8 Llano Estacado (Region O) Regional Water Planning Area

The City of Abernathy plans to develop a 0.13-million-gallon-per-day (146-acre-foot-per-year) desalination facility with four production wells and one deep injection well. The City of Seminole proposes to develop a larger desalination plant with 11 production wells and 6 deep injection wells. The groundwater source for both projects would be the Santa Rosa Formation (Dockum Aquifer). Estimated capital costs are $10.1 million for the Abernathy project and $31.6 million for the Seminole project.

The City of Lubbock plans to build a 1.5-million-gallon-per-day (1,680-acre-foot-per-year) desalination plant with four wells that would also produce groundwater from the Santa Rosa Formation. Desalinated water would be blended with water from the South Water Treatment Plant, and the concentrate would be disposed through two deep injection wells. Capital costs would run approximately $34.5 million.

3.2.2.9 Lavaca (Region P) Regional Water Planning Area

The Lavaca-Navidad River Authority plans to develop a brackish groundwater desalination facility to provide water supplies for manufacturing at Formosa Plastics. The Authority plans to build a 5.8-million-gallon-per-day (6,497 acre-foot-per-year) desalination plant with three groundwater supply wells. Concentrate would be discharged to Lavaca Bay. The project's capital costs are estimated at approximately $31.4 million.

3.3 Grant programs

There is currently no active TWDB grant program for desalination activities. Historically, the Regional Facility Planning Grant Program and the Research and Planning Fund were internal grant programs intended to fund projects related to a variety of topics, such as reuse and desalination. Beginning in 2014, the Research and Planning Fund was no longer available due to loss of funding, and the Regional Facility Planning Grant Program was discontinued in 2016. Table 6 lists past projects funded through these grant programs but is not exhaustive. The last two projects funded by the Regional Facility Planning Grant Program were the Barton Springs/Edwards Aquifer Conservation District's feasibility study to treat saline groundwater from the Edwards Aquifer at a desalination facility and store the desalinated water in an aquifer storage and recovery system (Carollo Engineers, 2018) and the Rio Grande Regional Water Authority's plan to evaluate alternative water supplies for the Lower Rio Grande Valley (Blandford and Jenkins, 2016).

Table 6. Brackish groundwater desalination projects funded through the Research and Planning Fund

Report title	Contractor	Description	Study type	Year funded	Grant amount
Brackish Groundwater Manual for Texas Regional Water Planning Groups	LBG-Guyton Associates	The study identified potential brackish groundwater sources in Texas for future potable use.	Research	2003	$99,940
A Desalination Database for Texas	Bureau of Economic Geology at The University of Texas at Austin	The study developed a desalination database for Texas.	Research	2004	$75,000
Self-Sealing Evaporation Ponds for Desalination Facilities in Texas	Bureau of Economic Geology at The University of Texas at Austin	The study investigated regulatory requirements for developing a self-sealing evaporation pond.	Research	2005	$49,928
Assessment of Osmotic Mechanisms Pairing Desalination Concentrate and Wastewater Treatment	CH2M Hill	The study investigated the use of reverse osmosis concentrate as a draw solution in a forward osmosis process for recovering water from wastewater.	Research	2008	$90,000
Energy Optimization of Brackish Groundwater Reverse Osmosis Desalination	Affordable Desalination Collaboration	This study assessed and demonstrated energy optimization strategies for brackish groundwater desalination by reverse osmosis.	Research	2009	$496,783
Alternative to Pilot Plant Studies for Membrane Technologies	Carollo Engineers, Inc.	The project evaluated alternatives to the current regulatory requirements for pilot testing membranes.	Research	2011	$150,000

3.4 Loan assistance programs

The TWDB's loan programs are available to public entities to fund the planning, design, and construction phases of seawater and brackish groundwater desalination plants. Since 1989, the TWDB has financed 46 desalination projects (Table 7) with a total value of approximately $612 million. Desalination projects are eligible for financing from various agency programs, including the Drinking Water State Revolving Fund, the State Participation Program, and the Texas Water Development Fund. Desalination projects in the state water plan are also eligible to benefit from the State Water Implementation Fund for Texas (SWIFT). To date, the TWDB has funded three seawater desalination projects (two for Corpus Christi and one for Guadalupe-Blanco River Authority) and one brackish groundwater desalination project (Brazosport Water Authority) through the SWIFT program. The Guadalupe-Blanco River Authority canceled its seawater desalination feasibility study to focus on near-term projects.

Table 7. Desalination projects funded through TWDB's financial programs as of August 2020

No.	Entity	Funding program	Funding amount*	Funding date	Project name
1	Brazosport Water Authority	GRG	$200,000	NA	Brackish groundwater reverse osmosis water treatment plant and water wells
2	Corpus Christi	SWIFT	$222,475,000	7/23/2020	Seawater desalination
3	North Alamo Water Supply Corporation	DWSRF	$17,406,373	3/12/2020	Energy-efficient brackish groundwater desalination project
4	Alice	DWSRF	$5,499,000	7/22/2019	Supplemental water resource
5	Ropesville	DWSRF	$1,268,750	6/4/2019	Fluoride removal water treatment project
6	Parker County Special Utility District	DWSRF	15,080,000	3/28/2019	Phase I water system improvements
7	Shallowater	DWSRF; WDF	$2,500,000	12/13/2018	Water and wastewater improvements
8	Granbury	DWSRF	$13,810,000	11/12/2018	2018 DWSRF water treatment plant phase II expansion
9	Stephens Regional Special Utility District	DWSRF	$900,000	11/12/2018	Stephens Regional Special Utility District treatment improvements
10	Elmendorf	DWSRF; WDF	$10,770,000	5/3/2018	Water supply project
11	Holiday Beach Water Supply Corporation	DWSRF	$700,000	1/22/2018	Urgent need request: Hurricane Harvey
12	Corpus Christi	SWIFT	$2,750,000	7/20/2017	Seawater desalination
13	Commodore Cove Improvement District	DWSRF	$200,000	12/15/2016	Reverse osmosis treatment
14	Wellman	DWSRF	$1,122,654	05/05/2016	Nitrate and fluoride removal
15	Seymour	DWSRF	$4,140,476	04/11/2016	Water system improvements

No.	Entity	Funding program	Funding amount*	Funding date	Project name
16	Loop Water Supply Corporation	DWSRF	$170,000	12/14/2015	Water treatment plant improvements
17	Brazosport Water Authority	SWIFT	$28,300,000	07/23/2015	Brackish groundwater reverse osmosis water treatment plant and water wells
18	Guadalupe-Blanco River Authority	SWIFT	$2,000,000	07/23/2015	Integrated water and power plant project
19	Granbury	DWSRF	$16,430,000	03/26/2015	City of Granbury water treatment plant
20	Baylor Water Supply Corporation	DWSRF	$500,000	02/25/2015	Urgent need - Bufkin well field development
21	San Antonio Water System	DWSRF	$75,920,000	11/06/2014	Water resources integration pipeline
22	Raymondville	DWSRF	$3,800,000	09/19/2013	Well and reverse osmosis system
23	Dell City	DWSRF	$244,450	05/16/2013	Reverse osmosis treatment plant
24	Montgomery County Municipal Utility District #8 and #9	WDF	$5,450,000	09/22/2011	Walden conjunctive use water treatment plant design
25	Roscoe	DWSRF	$1,765,000	05/04/2011	Reverse osmosis water treatment plant
26	Stephens Regional Special Utility District	DWSRF; WDF	$5,800,000	01/20/2011	Water treatment plant and transmission lines
27	Fort Hancock Water Improvement Control District	EDAP	$3,012,990	04/22/2010	Water well and reverse osmosis treatment facility
28	Fort Griffin Special Utility District	DWSRF	$2,355,000	10/15/2009	Throckmorton County water lines
29	Millersview-Doole Water Supply Corporation	DWSRF	$10,857,148	10/15/2009	Surface water treatment plant and distribution lines
30	San Antonio Water System	WIF	$109,550,000	07/16/2009	Brackish groundwater desalination
31	Greater Texoma Utility Authority	WIF	$835,000	12/15/2008	Northwest Grayson County Water Improvement Control District #1 surface water treatment plant
32	Possum Kingdom Water Supply Corporation	DWSRF	$1,625,000	07/18/2006	Water treatment plant expansion
33	East Rio Hondo Water Supply Corporation	RWAF	$4,150,000	11/15/2005	North reverse osmosis plant transmission line
34	Clarksville City	WDF	$1,530,000	02/15/2005	George Richey Road water wells
35	Ballinger	DWSRF	$3,865,000	06/16/2004	Lake Ballinger water line
36	El Paso	WAF; SAAP	$1,240,000	03/20/2002	Eastside desalination plan
37	Horizon Regional Municipal Utility District	WDF	$7,780,000	11/14/2001	Reverse osmosis treatment plant
38	Burleson Co Municipal Utility District #1	DWSRF	$1,560,000	09/19/2001	Reverse osmosis treatment facility

No.	Entity	Funding program	Funding amount*	Funding date	Project name
39	Holiday Beach Water Supply Corporation	WDF	$470,000	11/15/2000	Reverse osmosis water plant
40	Harlingen	CWSRF	$1,845,000	04/19/2000	Wastewater treatment plant #2 sludge process
41	Brady	DWSRF	$9,405,000	03/09/2000	New surface water treatment plant and storage tank
42	Palmer	DWSRF	$1,405,000	07/14/1999	Reverse osmosis plant
43	Possum Kingdom Water Supply Corporation	DWSRF	$4,700,000	12/17/1998	Regional water system
44	Lorena	WDF	$3,335,000	10/16/1997	Robinson transmission line
45	Haciendas del Norte Water Improvement District	WDF	$1,725,000	08/20/1997	East Montana transmission and reverse osmosis unit
46	Harlingen	WAF	$2,000,000	04/20/1989	Wastewater treatment plant #2 expansion

Note: *Funding amount = final funded amount after all withdrawals and alterations

CWSRF = Clean Water State Revolving Fund
DWSRF = Drinking Water State Revolving Fund
EDAP = Economically Distressed Areas Program
GRG = General Revenue Grant
RWAF = Rural Water Assistance Fund
SWIFT = State Water Implementation Fund for Texas
WIF = Water Infrastructure Fund
WAF = Water Assistance Fund
WDF = Water Development Fund

4 Designation of local or regional brackish groundwater production zones

In 2015, the 84th Texas Legislature passed House Bill 30, directing the TWDB to conduct studies to identify and designate brackish groundwater production zones in areas of the state with moderate to high availability and productivity of brackish groundwater that can be used to reduce the use of fresh groundwater. The production zones must meet statutory requirements and exclusion criteria. This chapter describes the Brackish Resources Aquifer Characterization System (BRACS) program; completed, ongoing, and future aquifer studies; the House Bill 30 requirements, implementation process, and key challenges; the status of brackish groundwater production zone designation; and the future permitting framework for zones.

4.1 Brackish Resources Aquifer Characterization System Program

Mapping of Texas' saline water resources dates back to 1956. The U.S. Geological Survey in colloboration with the U.S. Department of the Interior "outlined the occurrence, quantity, and quality of saline groundwater and surface water available in Texas" for the Department of Interior's Saline Water Conversion Program (Winslow and Kister, 1956). In 1970, the TWDB funded a study "to make a reconnaissance and inventory of the principal saline aquifers in Texas that discussed the salinity, the productivity, and the geology of the aquifers" (Core Laboratories, 1972). In 2003, the TWDB funded a study to map the brackish aquifers of the state and calculate the volume of brackish (slightly to moderately saline) groundwater available in these aquifers (LBG-Guyton Associates, 2003). The study was done to support the regional water planning process and to help identify alternative sources to meet water demands. It estimated there are 880 trillion gallons (2.7 billion acre-feet) of brackish groundwater in the state's aquifers. While the study demonstrated that brackish groundwater is an important resource, it also highlighted the need for detailed aquifer studies, which led to the creation of the BRACS program.

In 2009, the 81st Texas Legislature provided funding to the TWDB to establish the BRACS program. The goal of the program is to map and characterize the brackish portions of the aquifers in Texas in sufficient detail to provide useful information and data to regional water planning groups and other entities interested in using brackish groundwater as a water supply.

In total, the TWDB has funded 10 contracts in the BRACS program to conduct technical studies (Table 8). In 2010, with the aid of legislative funding, the TWDB funded three research projects totaling $449,500 to support the initiation of the BRACS program. Following the passage of House Bill 30 in 2015 by the 84th Texas Legislature, the TWDB funded seven contracts for eight aquifers or portions of aquifers, totaling just under $1.7 million. One of the contracts was an interagency contract in which the scope of an ongoing TWDB-funded study was expanded to cover three aquifers (Carrizo-Wilcox, Queen City, and Sparta aquifers).

Table 8. TWDB-funded projects of the Brackish Resources Aquifer Characterization System Program

Report title	Description	Contractor	Study type	Year funded	Grant amount
Geophysical Well Log Data Collection Project	Geophysical well logs from brackish aquifers in the state were collected from multiple sources, digitized, and entered into a database.	Bureau of Economic Geology at The University of Texas at Austin	Research	2010	$300,000
Brackish Groundwater Bibliography Project	The project developed a comprehensive bibliography of Texas brackish aquifers.	INTERA, Inc.	Research	2010	$99,500
An Assessment of Modeling Approaches to Brackish Aquifers in Texas	The study assessed groundwater modeling approaches for brackish aquifers.	INTERA, Inc.	Research	2010	$50,000
Identification of Potential Brackish Groundwater Production Areas – Carrizo-Wilcox, Queen City, and Sparta aquifers	The project mapped and characterized the aquifer and evaluated it for potential production areas. This was one intra-agency contract that covered two aquifer projects	Bureau of Economic Geology at The University of Texas at Austin	Research	2016	$181,446
Identification of Potential Brackish Groundwater Production Areas – Gulf Coast Aquifer	The project mapped and characterized the aquifer and evaluated it for potential production areas.	INTERA, Inc.	Research	2016	$500,000
Brackish Groundwater in the Blaine Aquifer System, North Central Texas	The project mapped and characterized the aquifer and evaluated it for potential production areas.	Daniel B. Stephens & Associates, Inc.	Research	2016	$200,000
Identification of Potential Brackish Groundwater Production Areas – Rustler Aquifer	The project mapped and characterized the aquifer and evaluated it for potential production areas.	INTERA, Inc.	Research	2016	$200,000
Identification of Potential Brackish Groundwater Production Areas – Blossom Aquifer	The project mapped and characterized the aquifer and evaluated it for potential production areas.	LBG-Guyton	Research	2016	$50,000
Identification of Potential Brackish Groundwater Production Areas – Nacatoch Aquifer	The project mapped and characterized the aquifer and evaluated it for potential production areas.	LBG-Guyton	Research	2016	$150,000

Report title	Description	Contractor	Study type	Year funded	Grant amount
Identification of Potential Brackish Groundwater Production Areas – Trinity Aquifer	The project mapped and characterized the aquifer and evaluated it for potential production areas.	Southwest Research Institute	Research	2016	$400,000

In the 2018–2019 biennium, the TWDB did not receive appropriations to continue implementing the statutory requirements. As a result, the TWDB would not have been able to map brackish groundwater resources and designate zones in the remaining aquifers by the statutory deadline of December 1, 2022, even with future restoration of funds. The TWDB continued mapping brackish aquifers with existing resources at a slower pace and requested $2 million for the 2020–2021 biennium.

In 2019, the 86th Texas Legislature restored and appropriated $2 million to the TWDB for contract and administrative costs to support designation of brackish groundwater production zones in aquifers of the state, excluding the Dockum Aquifer. The legislature also passed Senate Bill 1041, which extended the deadline to complete zone designations from December 1, 2022, to December 1, 2032, and House Bill 722, which established a permitting framework for developing water supplies from TWDB-designated brackish groundwater productions zones.

Out of $2 million appropriated, $1.7 million was for professional technical service contracts to support the designation of brackish groundwater production zones. The TWDB has executed one interagency contract with the U.S. Geological Survey to sample high salinity waters and has contracted with four firms to undertake certain technical tasks related to brackish groundwater studies and the designation of zones. Work orders to initiate specific technical tasks were issued to the entities in August 2020, including

- entering data from geophysical well logs in the BRACS unprocessed collection into the BRACS Database;
- testing and analyzing cores of brackish aquifers for mineralogy, porosity, permeability, and cementation exponent;
- preparing a resource document that details how to drill and log the ideal exploratory brackish groundwater wells;
- preparing a resource document that details how to use seismic data to map brackish aquifers (1,000 to 5,000 feet depth);
- studying the comingling of groundwaters with different salinities with Texas Department of Licensing and Regulation as a stakeholder;
- depth calibrating geophysical well logs for stratigraphic interpretation; and
- other study tasks as determined by the TWDB.

In addition to these technical service contracts, the TWDB contracted a study to develop technically defensible mapping procedures and tools to improve and refine the existing default 15-mile buffer distance applied to Class II injections wells. The TWDB will form a technical advisory workgroup consisting of federal and state agencies and stakeholders that will be engaged throughout the study to build scientific consensus on appropriate buffers. Study deliverables are expected by August 2021.

4.2 Completed and ongoing brackish aquifer studies

For each BRACS aquifer study, the TWDB collects as much geological, geophysical, and water-well data as possible that is available in the public domain and uses the information to map and characterize both the vertical and horizontal extents of the aquifers in great detail. Groundwater is classified into five salinity classes: fresh (0 to 999 milligrams per liter), slightly saline (>1,000 to 2,999 milligrams per liter), moderately saline (>3,000 to 9,999 milligrams per liter), very saline (>10,000 to 35,000 milligrams per liter), or brine (>35,000 milligrams per liter) (Winslow and Kister, 1956). The volume of groundwater in each salinity class is estimated based on three-dimensional mapping of the salinity zones.

The project deliverables, including both the data and report, are available to the public on the TWDB BRACS website (www.twdb.texas.gov/innovativewater/bracs/). All project data is compiled into the BRACS Database, which is in Microsoft Access format and described in a detailed data dictionary (Meyer, 2020). Digital geophysical well logs used for the studies may be downloaded from the TWDB Water Data Interactive web viewer (www2.twdb.texas.gov/apps/waterdatainteractive/groundwaterdataviewer) or are available upon request. Processed data such as lithology, simplified lithologic descriptions, stratigraphic picks, aquifer water chemistry and salinity analysis, and interpreted results are provided in the form of GIS datasets.

Overall, the TWDB has completed 12 studies (Figure 6) and has five ongoing studies (Figure 7). TWDB staff completed 5 out of 12 aquifer studies internally, which included the Pecos Valley Aquifer (Meyer and others, 2012); Gulf Coast Aquifer in the Corpus Christi Aquifer Storage and Recovery Conservation District (Meyer, 2012); Queen City and Sparta aquifers in Atascosa and McMullen counties (Wise, 2014); Gulf Coast Aquifer in the Lower Rio Grande Valley (Meyer and others, 2014); and Lipan Aquifer (Robinson and others, 2018). Contractors completed work for the seven additional aquifers (Blaine, Blossom, Carrizo-Wilcox, Gulf Coast, Nacatoch, Rustler, and Trinity aquifers). Staff is currently working on five other aquifer studies.

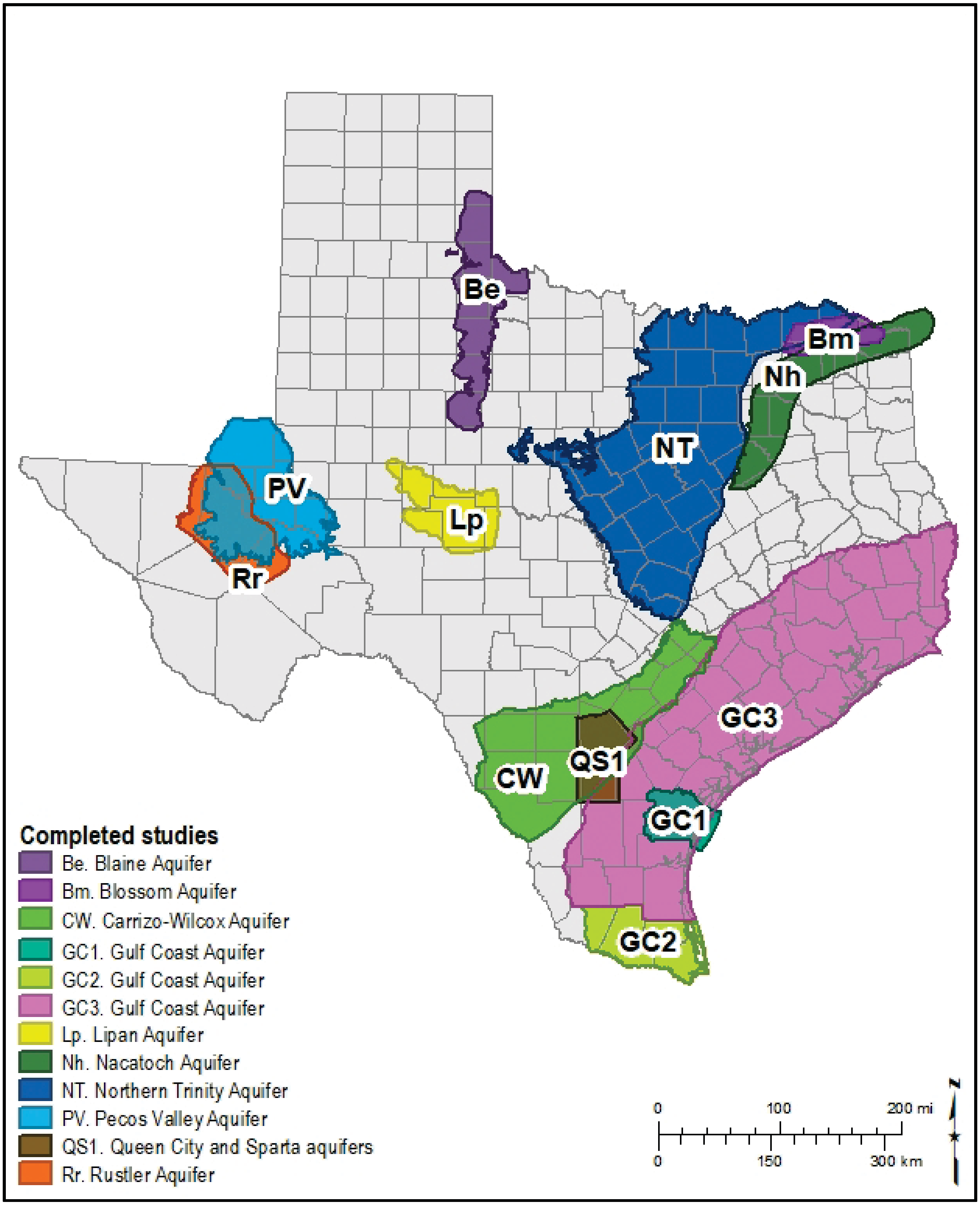

Figure 6. **Completed studies of the Brackish Resources Aquifer Characterization System Program**

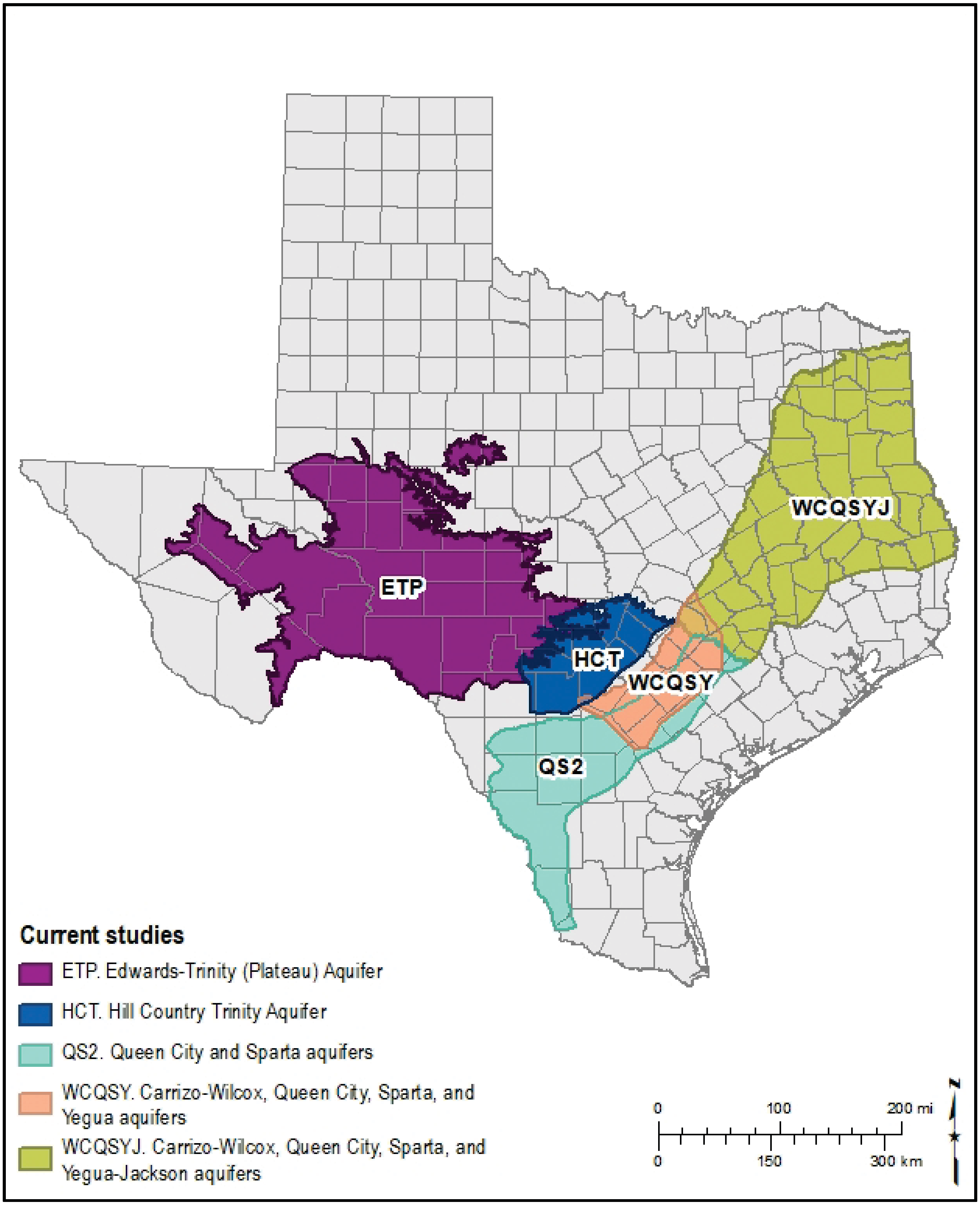

Figure 7. Ongoing studies of the Brackish Resources Aquifer Characterization System Program

4.3 Future zone evaluations and brackish aquifer studies

In the future, two aquifer studies completed prior to the passage of House Bill 30 will need to be evaluated for brackish groundwater productions zones: the Gulf Coast Aquifer in the Lower Rio Grande Valley and the Pecos Valley Aquifer. When completed, the five ongoing aquifer studies will also need to be evaluated for zones. Of the ongoing aquifer studies, those closest to completing the aquifer characterization include the south Queen City and Sparta aquifers and the Upper Coastal Plain Central aquifers.

The TWDB has identified seven aquifers that meet statutory requirements and exclusion criteria and are eligible for zone designation. These seven aquifers, excluding the Dockum Aquifer within the area of the High Plains Underground Water Conservation District No. 1, which is not eligible for zone designation (Figure 8), will be mapped and characterized first and then evaluated for production zones. The remaining 12 aquifers do not meet statutory requirements and will only be mapped and characterized after the TWDB meets the December 1, 2032, legislative deadline for completing the zone designations for qualifying aquifers (Figure 9).

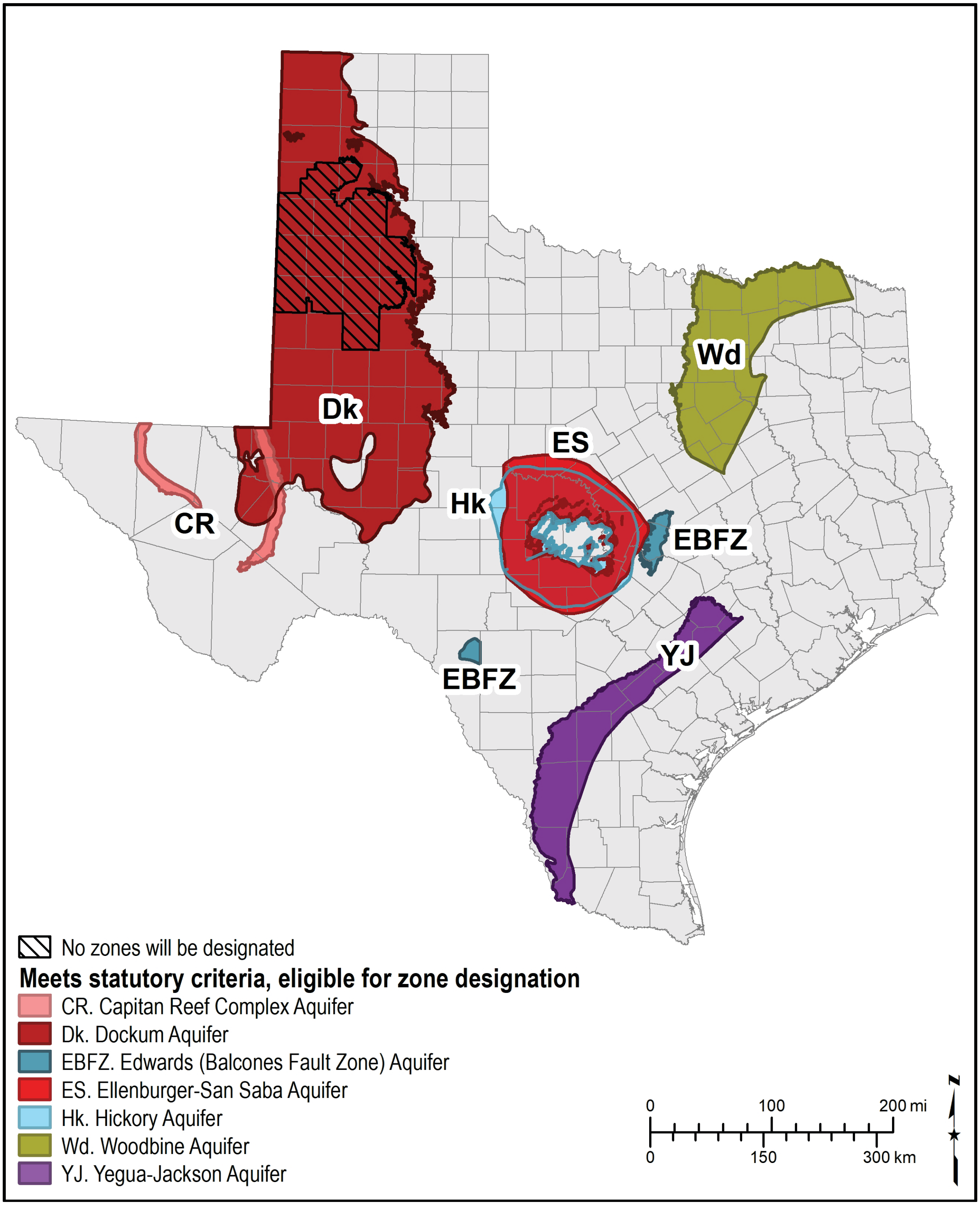

Figure 8. **Future brackish groundwater studies that meet statutory criteria**

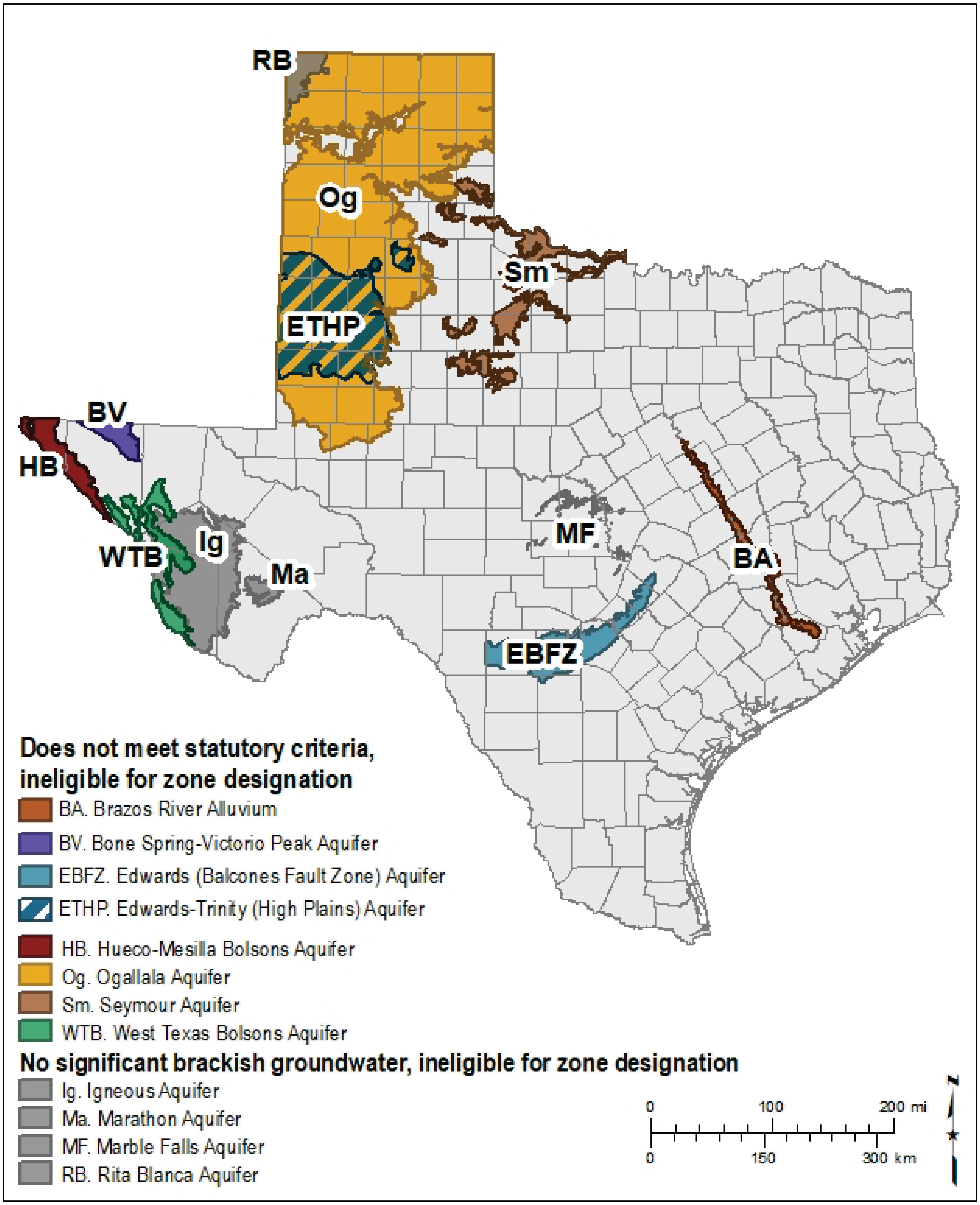

Figure 9. **Future brackish groundwater studies that do not meet statutory criteria**

4.4 Requirements of House Bill 30

In 2015, the 84th Texas Legislature passed House Bill 30, directing the TWDB to conduct studies to identify and designate brackish groundwater production zones in the state. The legislation directed the TWDB to make designations in four aquifers—the Carrizo-Wilcox Aquifer located between the Colorado River and the Rio Grande, the Gulf Coast Aquifer and sediments bordering that aquifer, the Blaine Aquifer, and the Rustler Aquifer—and to report the designations to the legislature by December 1, 2016. The legislation further required the TWDB to identify and designate brackish groundwater production zones in the remaining aquifers of the state before December 1, 2022, which has now been extended to December 1, 2032, with passage of Senate Bill 1041 of the 86th Legislature.

House Bill 30 requires that brackish groundwater production zones must be located in areas with moderate to high availability and productivity. They must also be separated by sufficient hydrogeologic barriers to prevent significant impacts to water availability or water quality in geologic strata that have average total dissolved solids concentrations of 1,000 milligrams per liter or less. The statute also excluded certain areas from zone designation:

- The Edwards (Balcones Fault Zone) Aquifer located within the jurisdiction of the Edwards Aquifer Authority
- Areas within the boundaries of the Barton Springs-Edwards Aquifer Conservation District, the Harris-Galveston Subsidence District, and the Fort Bend Subsidence District
- Area within a groundwater conservation district that overlies the Dockum Aquifer and includes wholly or partly 10 or more counties (High Plains Underground Water District)
- Aquifers, subdivisions of aquifers, or geologic strata that have an average total dissolved solids concentration of more than 1,000 milligrams per liter and serve as a significant source of water supply for municipal, domestic, or agricultural purposes
- Geologic formations that are designated or used for wastewater injection through the use of injection or disposal wells permitted under Texas Water Code Chapter 27

For each zone, the TWDB is required to (1) determine the amount of brackish groundwater that a zone is capable of producing over 30- and 50-year periods without causing a significant impact to water availability or water quality in surrounding aquifers, (2) make recommendations on reasonable monitoring to observe the effects of brackish groundwater production within the zone, (3) work with groundwater conservation districts and various stakeholders on the studies in general, and (4) provide a summary of zone designations in the biennial desalination report due December 1 of each even-numbered year.

4.5 Implementation of work process

To achieve the goals of House Bill 30, the TWDB undertook the following work process and will use the same process for each current and future study, updating as needed:

1. Conduct aquifer characterization of the whole or portion of the aquifer
2. Apply statutory requirements and exclusion criteria and evaluate areas for zone designation
3. Recommend potential areas to be considered by the Executive Administrator
4. Recommend proposed brackish groundwater production zones to the agency's Board for approval and designation

At each step, the work is documented, and the deliverables—including well data, GIS files, and reports—are made publicly available and are downloadable from the TWDB's website. Additionally, at each step of the implementation process, the TWDB makes reasonable efforts to engage groundwater conservation districts and stakeholders and provides them ample opportunities to review and comment on materials. Throughout development of the completed studies, TWDB staff gave presentations at local groundwater management and regional water planning meetings within the vicinity of each aquifer and notified stakeholders of the meetings in advance via email. Between December 2017 and August 2020, staff held eight aquifer-specific stakeholder meetings to request data, share results, and solicit feedback. Details of the meetings are as follows:

- Carrizo-Wilcox, Queen City, Sparta, and Yegua aquifers, Central Texas (Austin, TX, November 4, 2019)
- Edwards-Trinity (Plateau) Aquifer (Leakey, TX, May 15, 2019)
- Hill Country Trinity Aquifer
    - Bee Cave, TX, April 22, 2019
    - Pleasanton, TX, May 3, 2019
    - Leakey, TX, May 15, 2019
    - Austin, TX, July 10, 2019
    - San Antonio, TX, December 2, 2019
- Northern Trinity Aquifer (Shreveport, Louisiana, October 2, 2018)

Information pertaining to all stakeholder meetings, including announcements and presentations, is posted on the TWDB website (www.twdb.texas.gov/innovativewater/bracs/HB30.aspn a timely manner.

Once the aquifer characterization is complete, staff implement the statutory requirement's exclusion criteria and document the evaluation in an open-file report. These reviews require staff to modify stratigraphy, augment well data, and calculate salinity. Staff evaluate potential areas for (1) domestic, municipal, and agricultural water wells and place a 3-mile buffer or more around each well; (2) Class II (type 1, 2, and 3) injection wells and place a 15-mile buffer around each well; (3) Class I, II [type 4 to 7], Class III, Class IV, and Class V injection wells and evaluate on a case-by-case basis and buffer as needed; and (4) hydrogeologic barriers with a minimum thickness of 100 feet.

TWDB staff then finalize the potential areas and provide them to the Executive Administrator with a recommendation for the Board to designate the areas as brackish groundwater production zones. The Board memorandum containing the Executive Administrator's recommendation is posted on the TWDB website before the Board meeting, and stakeholders are notified via email about its availability for review and comment. If comments are received, they are provided to the Board before the meeting.

4.6 Key challenges

In the ongoing process of conducting the aquifer studies, TWDB staff encountered the same four challenges found during the 2016 aquifer studies: data gaps, limited water well and injection data availability, groundwater model accessibility, and injection well buffer applicability.

The first key challenge is the lack of data for the deeper portions of an aquifer. Most existing water wells are relatively shallow. However, if wells are drilled in deeper portions of the aquifer, all the necessary data collection activities are not conducted, such as running a full suite of geophysical logs, testing cores for key parameters, and conducting water samples at all intervals. The TWDB is attempting to close data gaps by using restored funds for sampling high salinity water and testing cores of interest.

The second key challenge is that there is not a single database in Texas that has complete records of all installed water wells (domestic, municipal, and agricultural) and injection wells (Class I, II, III, IV, and V). Available datasets are maintained by different agencies, in different formats, and often have incomplete information. Since statute excludes designation of brackish groundwater production zones in specific areas, identifying water wells and injection wells within potential production zone areas is critically important in the agency's evaluation process. For each aquifer study, the TWDB attempts to contact groundwater conservation districts and stakeholders to obtain existing well information.

The third key challenge is that the agency does not have a calibrated groundwater model for each zone to estimate the volume of brackish groundwater production that will account for simultaneous well fields and regional water pumping. As a result, past studies used a simple analysis to estimate the impact to freshwater resources and to determine groundwater volume based on aquifer parameters and simulated drawdown.

The final challenge is that TWDB staff does not know the distance that injected fluids may have traveled both laterally and vertically from Class II (types 1, 2, and 3) injection wells. Determining the distance that injected fluids travel is important, as TWDB staff have discovered that several Class II injection zones are installed above, below, lateral to, or overlapping with geologic stratum containing brackish groundwater. In past evaluations, the TWDB placed a 15-mile buffer around injection wells, which is a very conservative buffer distance that needs further refinement. The TWDB is now initiating a study that will develop procedures and tools to design technically defensible mapping procedures and tools to improve and refine the existing default 15-mile buffer distance. In the future, the agency may revise zone designations accordingly if the applicable buffers are adjusted.

In July 2017, the TWDB began collaborating with the Groundwater Advisory Unit of the Railroad Commission (RRC) to discuss different aspects of their programs and to hold monthly meetings. On January 23, 2018, the RRC provided a presentation on its Underground Injection Control Permit Program, and TWDB staff learned of a recent project completed by the RRC that is relevant to the BRACS Program. The State of Texas Aquifer Exemption Project involved researching and verifying records for about 62,500 Class II injection well permits that allow injection into Underground Sources of Drinking Water (groundwater less than 10,000 milligrams per liter of total dissolved solids). On February 27, 2018, the TWDB requested and subsequently obtained the report for the State of Texas Aquifer Exemption Project, the RRC's internal searchable database of injection wells, and the geographic information system files and metadata developed for this project. The TWDB will use these data when evaluating brackish groundwater production zones for future studies. Staff from both agencies met several more times on the same topic. The meetings have evolved and expanded to larger coordination meetings, with the addition of three more agencies, the Bureau of Economic Geology, Texas Commission on Environmental Quality, and U.S. Geological Survey.

It is essential that the TWBD have a thorough understanding of the RRC's Class II injection well data and methodology so we can accurately use the data when evaluating and delineating brackish groundwater production zones. It is also important for RRC staff to understand the statutory requirements and learn how the TWDB uses their information to support the BRACS Program. Key topics for continued discussion include (1) the methodology the RRC applies to determine the geologic separation between the federally designated Underground Source of Drinking Water and the top of the injection zone and (2) specific injection wells that may be outside the permitted aquifer exemption boundaries that allow injection into the Underground Sources of Drinking Water.

4.7 Status of zone designations

To date, the TWDB has designated a total of 31 brackish groundwater production zones in the state with moderate to high availability and productivity of brackish groundwater that meet the statutory requirements and exclusion criteria (Figure 10). On October 20, 2016, the TWDB designated eight brackish groundwater production zones including: one zone in the Carrizo-Wilcox Aquifer south of the Colorado River, four zones in the Gulf Coast Aquifer and bordering sediments, and three zones in the Rustler Aquifer. The TWDB designated the Blaine Aquifer as having no production zones. On March 28, 2019, the TWDB designated a total of 23 brackish groundwater production zones including: 3 zones in the Blossom Aquifer, 5 zones in the Nacatoch Aquifer, and 15 zones in the Northern Trinity Aquifer. The TWDB designated the Lipan Aquifer as having no production zones.

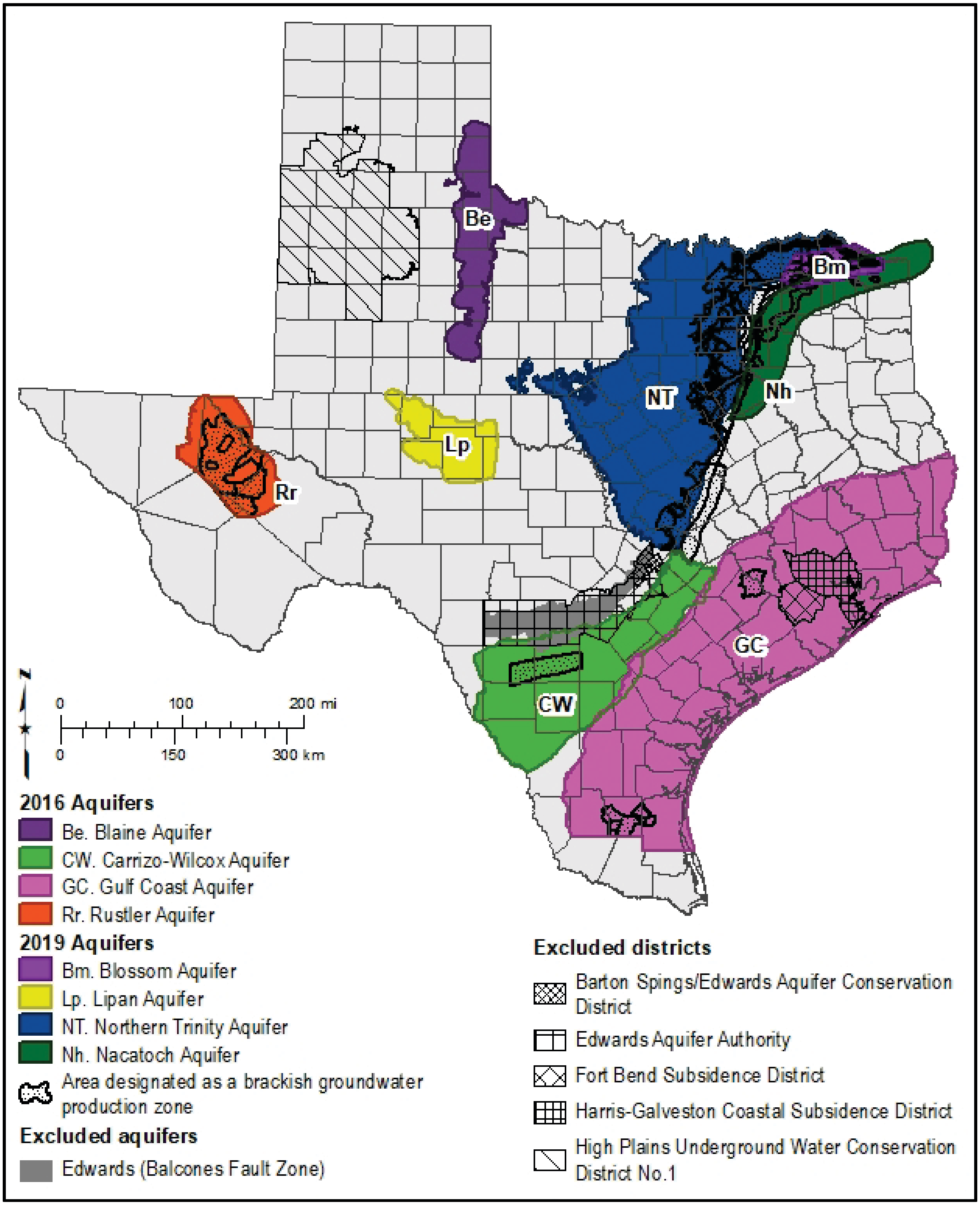

Figure 10. **Areas designated as brackish groundwater production zones and statutorily excluded aquifers and districts**

4.8 Blossom Aquifer

The Blossom Aquifer is defined by the TWDB as a minor aquifer, which outcrops in northeast Texas in Bowie, Red River, and Lamar counties. The Blossom Formation consists of interbedded clays, marls, and sands. The sand portion of the Blossom Formation acts as the aquifer. The official minor aquifer boundary is from the outcrop area where fresh groundwater is present and extends downdip to where groundwater salinity becomes 3,000 milligrams per liter total dissolved solids. The Blossom Aquifer is capable of producing usable quality groundwater in the outcrop area and within a short distance downdip of the outcrop.

4.8.1 Implemented exclusion criteria in study area

TWDB staff implemented the statutory requirements and exclusion criteria and documented the evaluation in an open-file report (Andrews and Croskrey, 2019). To act as a horizontal-distance hydrogeologic barrier to jurisdictions and existing use, a 3-mile buffer was applied to the freshwater line, the state line, and 86 known municipal, domestic, and agricultural water wells. No Class I, III, IV, or V injection wells were found injecting into the Blossom Sand within the study area. Less than 15 miles downdip of the potential production areas, 13 Class II (type 1, 2, and 3) injection wells were found in the Blossom Sand. These injection wells were determined to have hydrogeologic separation from the aquifer by the Mexia-Talco Fault Zone and, therefore, were not used to exclude areas from brackish groundwater production zone recommendations. Based on the contractor's modeling of pumping 100 acre-feet per year for 50 years, drawdown expected at the nearest receptor well was between 5 and 15 feet, which was determined not to be significant. After considering all criteria above, three brackish groundwater production zones were recommended (Figure 11).

Interlayered clays, marls, and chalk that overlie the Blossom Sand constitute a significant hydrologic barrier to prevent impact on freshwater wells completed more than 200 feet from the top of the Blossom Sand within the brackish groundwater production zones. The locations of the zones are sufficiently downdip of the fresh portion of the Blossom Aquifer that potential impacts on fresh groundwater resources are minimal under most of the pumping scenarios analyzed.

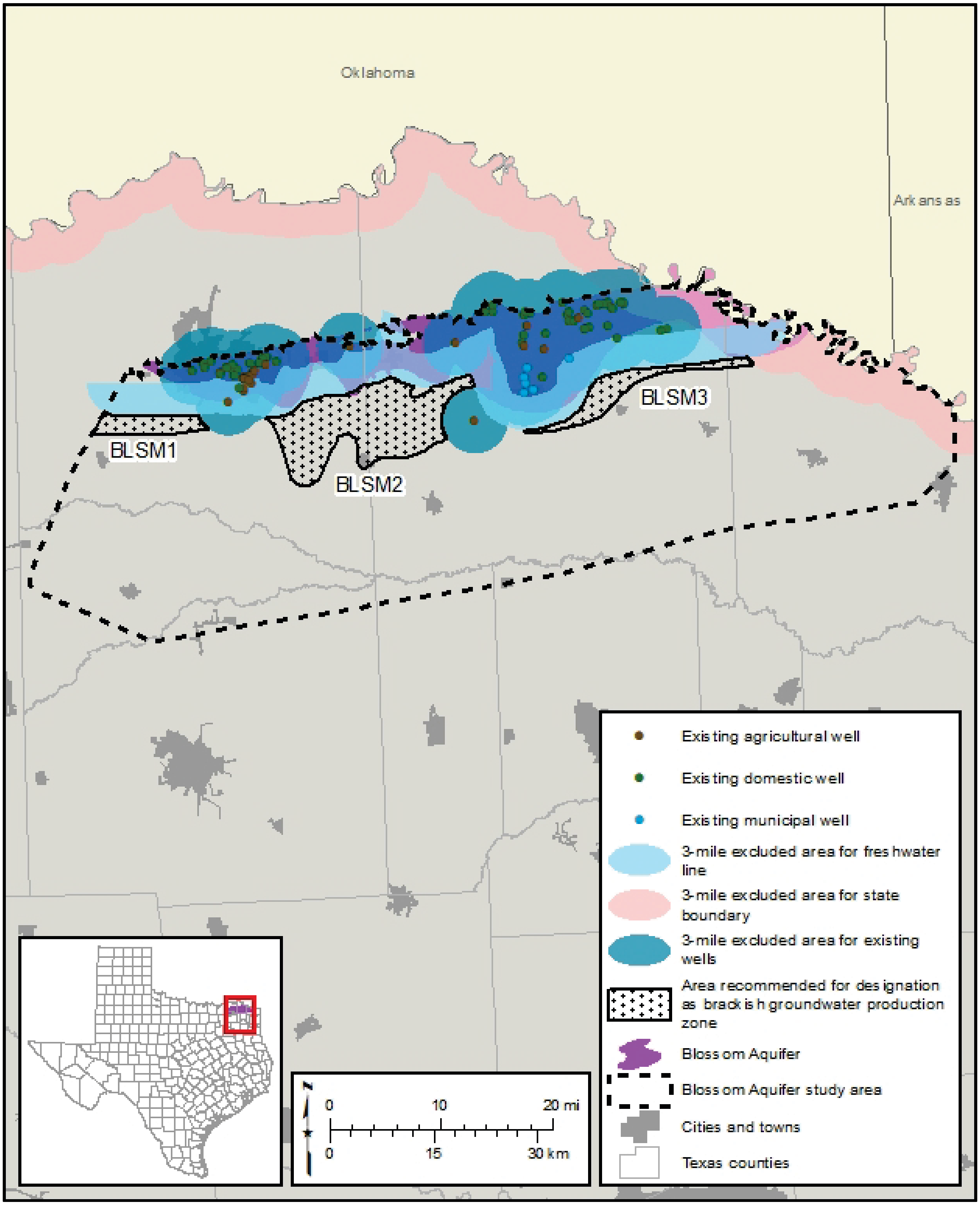

Figure 11. Blossom Aquifer study area showing areas excluded from areas designated as zones

4.8.2 Designated brackish groundwater production zones

In the Blossom Aquifer, the Board designated three areas as brackish groundwater production zones (Figure 12). The zones are located within the Blossom Sand geological formation. Zones BLSM1 and BLSM3 contain moderately saline groundwater (3,000 to 9,999 milligrams per liter total dissolved solids). Zone BLSM2 contains a small amount of slightly saline groundwater (1,000 to 2,999 milligrams per liter of total dissolved solids), but the majority is moderately saline groundwater. For each zone, the minimum, maximum, and average top surface depth and thickness were calculated (Table 9).

Table 9. Parameters of brackish groundwater production zones in the Blossom Aquifer

Zone name	Measured in feet					
	Minimum top depth	Maximum top depth	Average depth	Minimum thickness	Maximum thickness	Average thickness
BLSM1	115	370	234	98	180	129
BLSM2	0	746	381	224	385	288
BLSM3	339	666	488	268	345	289

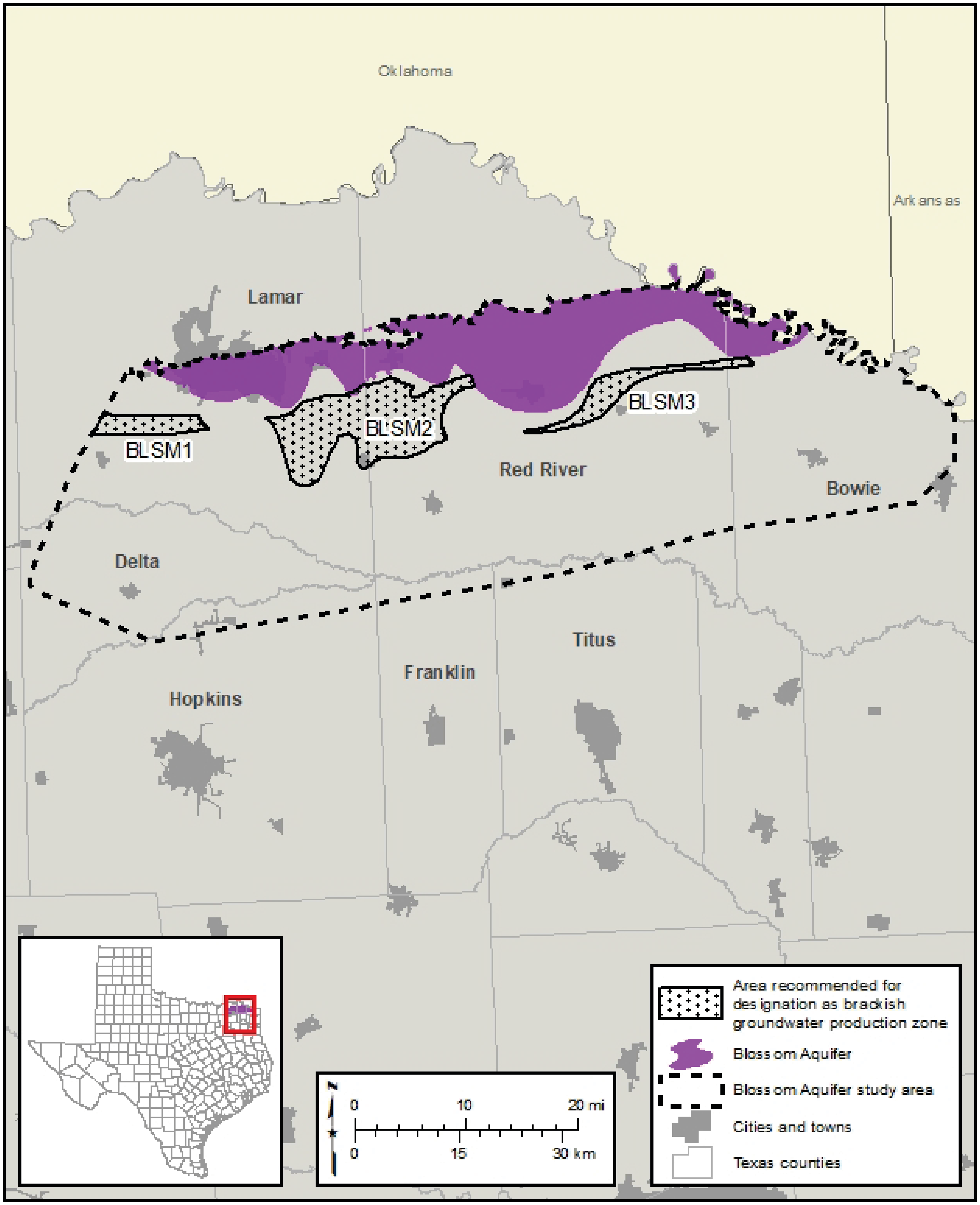

Figure 12. **Three designated brackish groundwater production zones in the Blossom Aquifer study area**

4.8.3 Brackish groundwater volumes in the zones

The volumes of brackish groundwater that could potentially be produced from BLSM1, BLSM2, and BLSM3 over 30- and 50-year periods were calculated based on the contractor's modeling (Table 10).

Table 10. Volumes of brackish groundwater that a zone can produce over 30- and 50-year periods without causing significant impact

Aquifer	Zone name	Annual pumpage (acre-feet/year)	30-year cumulative (acre-feet)	50-year cumulative (acre-feet)
Blossom	BLSM1	100	3,000	5,000
Blossom	BLSM2	100	3,000	5,000
Blossom	BLSM3	100	3,000	5,000

4.8.4 Groundwater monitoring in the zones

In general, groundwater monitoring in the Blossom Aquifer should focus on the various aquifers overlying the Blossom Aquifer. Monitoring in wells completed in these aquifers would ensure that the interlayered clays, marls, and chalk overlying the Blossom Sand provide an adequate hydrologic barrier. Freshwater resources of the Blossom Aquifer updip from the zones should also be monitored to prevent significant impact from potential production of brackish groundwater. Monitoring is not required below the Blossom Sand geological formation because there are no known fresh or brackish aquifers that would be impacted by pumping in the zones. Future wellfields in the brackish zones should include monitor wells to track water levels and water quality during production.

4.9 Lipan Aquifer

The Lipan Aquifer is defined by the TWDB as a minor aquifer and is centered around Tom Green County in west central Texas. The aquifer consists of Quaternary and Neogene sediments at or near the surface and underlying hydrologically connected Permian formations. Within the Lipan Aquifer study area, groundwater is produced from the Quaternary and Neogene sediments, Triassic Dockum Group, Cretaceous Trinity Group, and the weathered Permian units that are generally within 200 feet of the ground surface.

TWDB staff implemented the statutory requirements and exclusion criteria and determined that the aquifer did not meet two necessary requirements. First, hydrogeologic barriers do not exist between the brackish Permian units and the overlying Quaternary and Neogene sediments where fresh water occurs. A confining caliche layer is believed to occur within the sediments, but it is discontinuous and only occurs locally. Second, the Lipan Aquifer serves as a significant water source for municipal, domestic, and agricultural purposes, and the groundwater has an average total dissolved solids concentration greater than 1,000 milligrams per liter (Figure 13).

As a result, TWDB staff did not recommend areas in the Lipan Aquifer for designation as brackish groundwater production zones. Additionally, TWDB staff did not calculate brackish groundwater volumes and develop groundwater monitoring recommendations since no zones were recommended in the aquifer. However, as new wells are drilled in the Lipan Aquifer area, obtaining water quality information using discrete interval sampling methods from deeper brackish water formations would be helpful. In brackish water intervals that appear to contain significant groundwater, pump test data would greatly enhance knowledge of the hydraulic properties of these formations.

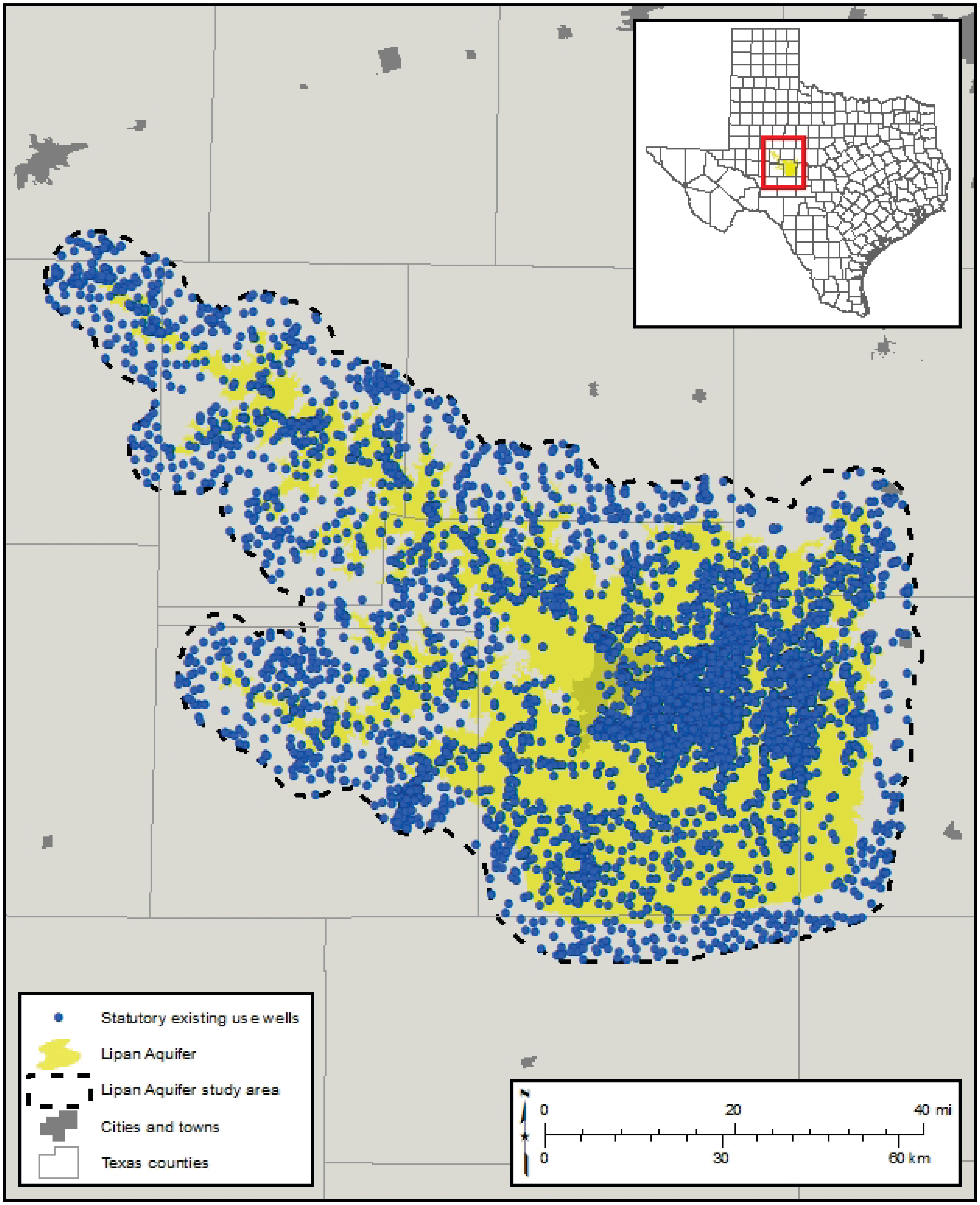

Figure 13. **Lipan Aquifer study area showing areas excluded from being designated as zones**

4.10 Nacatoch Aquifer

The Nacatoch Aquifer is defined by the TWDB as a minor aquifer and is located in northeast Texas. The aquifer is composed of sand interbedded with impermeable layers of mudstone or clay, the latter acting as aquitards that prevent mixing of waters from the different producing zones. The Nacatoch Sand occurs in the middle of the Navarro Formation below a marly sand unit known as the Lower Navarro Sand member. Fresh water occurs primarily in the outcrop, or within short distances downdip of the aquifer. Slightly saline groundwater is found frequently in the outcrop, but it dominates the downdip extent of the aquifer. Generally, the total dissolved solids concentration in the Nacatoch Aquifer increases downdip.

4.10.1 Implemented exclusion criteria in study area

TWDB staff implemented the statutory requirements and exclusion criteria and documented the evaluation in an open-file report (Croskrey and others, 2019). To act as a horizontal-distance hydrogeologic barrier to existing use, a 3-mile buffer was applied to the freshwater line, the state line, and 784 known water wells. Existing water wells include 94 agricultural wells, 572 domestic wells, and 118 municipal wells. No Class I or IV injection wells were found within 15 miles of the study area. There are 529 Class II (types 1, 2, and 3) injection wells injecting into the Nacatoch Aquifer, and a 15-mile buffer was applied to these wells. Three Class II (types 5, 6, and 7) injection wells for liquid petroleum gas are located in the study area, but these were not buffered since injection fluid is restricted to reservoir storage. Five Class III injection wells for brine mining were found in a salt dome in Van Zandt County, but these were not buffered since injection fluids are restricted to the mining activity as opposed to waste disposal. There are 19 Class V injection wells for heat flow and shallow aquifer remediation within 15 miles of the study area, but these were not buffered since they are shallow and do not pose an injection problem. Based on the TWDB's Theis modeling of pumping 200 acre-feet per year for 50 years, the drawdown expected at the nearest receptor well was between 24 and 43 feet, which was determined not to be significant. After considering all criteria above, TWDB staff recommended five areas as brackish groundwater production zones (Figure 14).

The interbedded sand and clay that overlie and underlie the Nacatoch Sand geological formation act as significant hydrogeologic barriers to isolate fresh groundwater in other aquifers. The Mexia-Talco fault zone consists primarily of strike-oriented normal faults that formed grabens and disrupt the basinward dip of the Nacatoch Aquifer layers. The faulting generally causes the normal downdip flow of groundwater to be halted or diverted, thus limiting the downdip extent of fresh water in the aquifer and providing an additional barrier against the interaction between the fresh and brackish parts of the Nacatoch Aquifer.

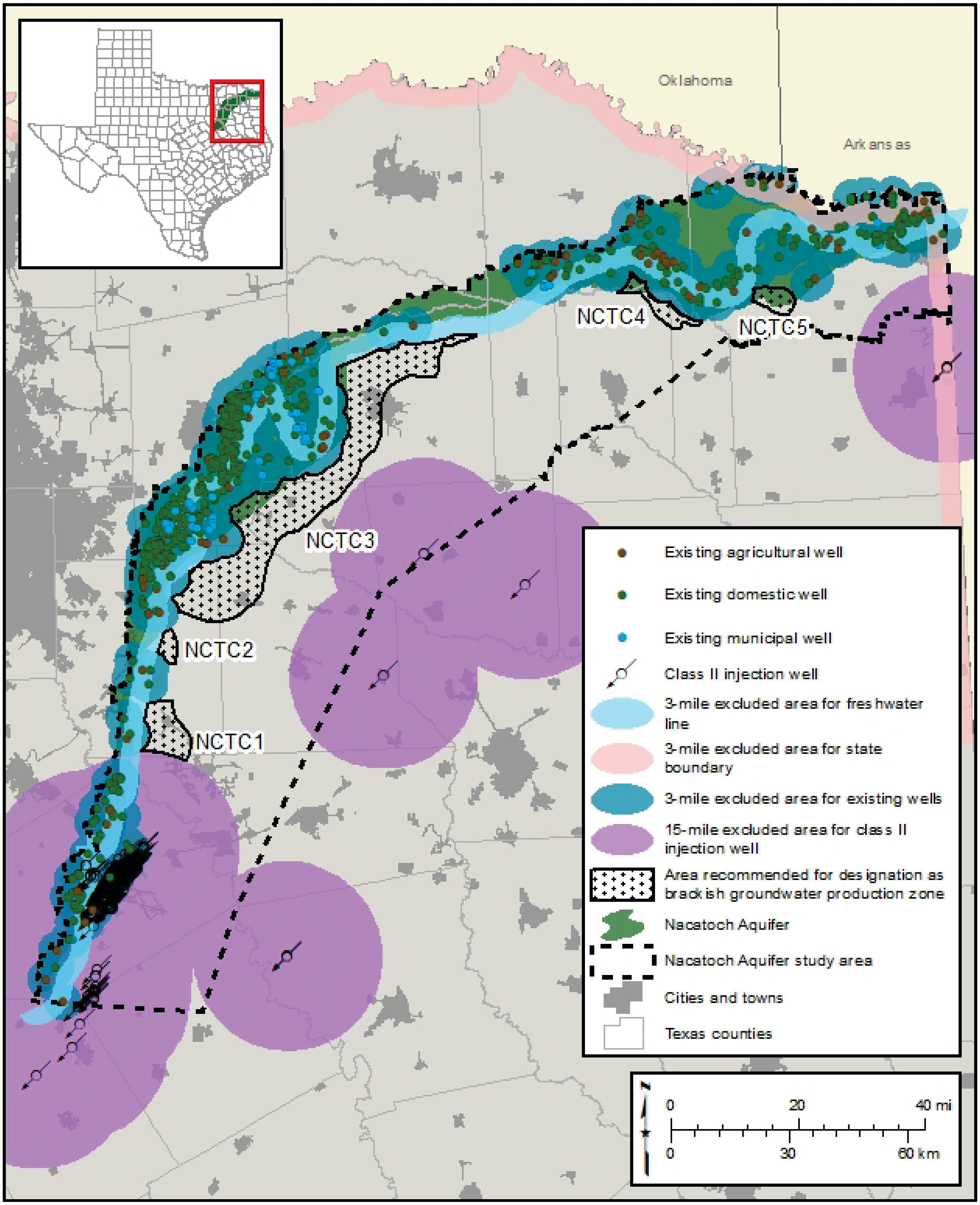

Figure 14. **Nacatoch Aquifer study area showing areas excluded from being designated as brackish groundwater production zones**

4.10.2 Designated brackish groundwater production zones

In the Nacatoch Aquifer, the Board designated five areas as brackish groundwater production zones (Figure 15). The zones are located within sands of the Nacatoch Aquifer and contain moderately saline groundwater (3,000 to 9,999 milligrams per liter total dissolved solids) with a small part of NCTC3 that has slightly saline groundwater (1,000 to 2,999 milligrams per liter total dissolved solids). For each zone, we calculated the minimum, maximum, and average top surface depth and thickness (Table 11).

Table 11. Parameters of brackish groundwater production zones in the Nacatoch Aquifer

Zone name	Measured in feet					
	Minimum top depth	Maximum top depth	Average depth	Minimum thickness	Maximum thickness	Average thickness
NCTC1	132	746	433	227	326	263
NCTC2	248	545	414	274	362	322
NCTC3	235	1,326	795	329	474	398
NCTC4	341	1,246	938	370	485	442
NCTC5	907	1,149	1,039	410	443	423

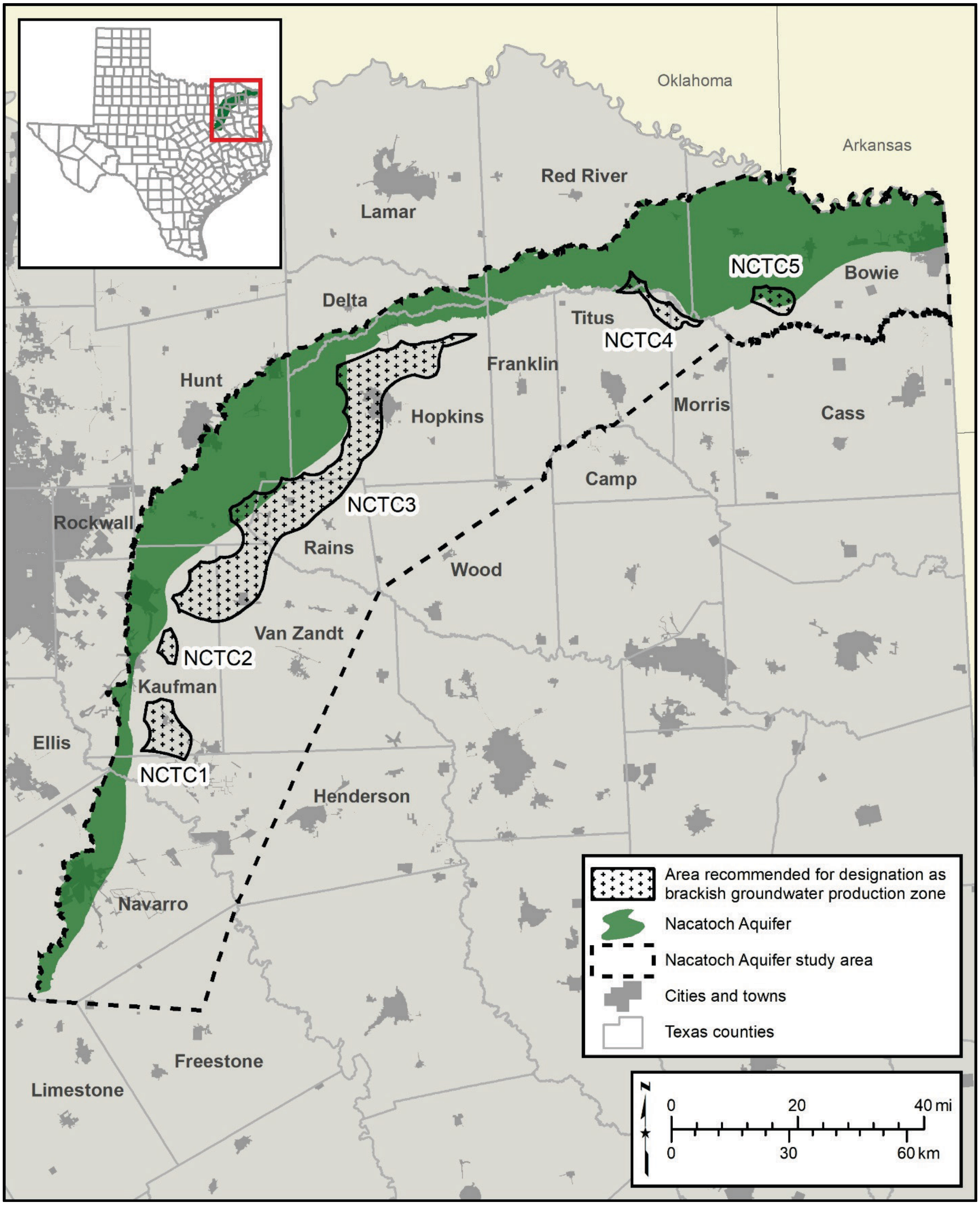

Figure 15. **Five designated brackish groundwater production zones in the Nacatoch Aquifer study area**

4.10.3 Brackish groundwater volumes in zones

The volumes of brackish groundwater that could potentially be produced from NCTC1, NCTC2, NCTC3, NCTC4, and NCTC5 over 30- and 50-year periods were calculated based on Theis modeling (Table 12).

Table 12. **Volumes of brackish groundwater that a zone can produce over 30- and 50-year periods without causing significant impact**

Aquifer	Zone name	Annual pumpage (acre-feet/year)	30-year cumulative (acre-feet)	50-year cumulative (acre-feet)
Nacatoch	NCTC1	200	6,000	10,000
Nacatoch	NCTC2	165	4,950	8,250
Nacatoch	NCTC3	400	12,000	20,000
Nacatoch	NCTC4	200	6,000	10,000
Nacatoch	NCTC5	200	6,000	10,000

4.10.4 Groundwater monitoring in the zones

In general, groundwater monitoring in the Nacatoch Aquifer should focus on the various aquifers overlying the Nacatoch Aquifer. Monitoring in wells completed in these aquifers would ensure that the marine clay in the upper Navarro Group overlying the Nacatoch Sand provides an adequate hydrologic barrier. Freshwater resources of the Nacatoch Aquifer, updip from the zones, should also be monitored to prevent significant impact from the production of brackish groundwater. Monitoring is not required below the basal sand unit of the Nacatoch Aquifer because there are no known fresh or brackish aquifers that would be impacted by pumping in these zones. Future wellfields in the brackish zones should include monitor wells to track water levels and water quality during production.

4.11 Northern Trinity Aquifer

The Trinity Aquifer is defined by the TWDB as a major aquifer and is located in south-central Texas and extends north into Oklahoma. The primary use of groundwater from the Trinity Aquifer is municipal, but it is also used for irrigation, livestock, industrial, and domestic purposes.

The Northern Trinity Aquifer is represented by the five hydrostratigraphic units defined for the Trinity Group. In the northwestern portion, outcrops of the Trinity Group consist of the undifferentiated sand, clay, silt, gravel, and conglomerates that have been mapped as the Antlers Formation. In the central portion, the top of the Trinity Group is composed of the Paluxy Formation, which consists of poorly consolidated sands. In the southern and western portions, the Paluxy thins dramatically. Beneath the Paluxy and Glen Rose are the Lower Cretaceous units.

In the central portion of the Northern Trinity Aquifer, these units are called the Twin Mountain Group, which consists of the Hensell Formation (sand); the Pearsall Formation (sand and clay); and the Hosston Formation (sand). In the southern portion of Northern Trinity Aquifer, the lower Cretaceous units are called the Travis Peak Group, which consists of the Hensell Formation (sand); the Pearsall Formation (sand and clay); the Cow Creek Formation (limestone); the Hammett Formation (shale); the Sligo Formation (limestone); and the Hosston Formation (sand).

4.11.1 Implemented exclusion criteria in study area

TWDB staff evaluated Class II (types 1, 2, and 3) injection well data and found one well injecting into the Paluxy Formation of the Northern Trinity Aquifer (Robinson and others, 2019). A 15-mile buffer was applied to account for injected fluids that may have traveled or will travel both laterally and vertically from this well. We then evaluated remaining areas for the presence of water wells (domestic, municipal, and agricultural), injection wells (Class I, Class III, Class IV, and Class V), and hydrogeologic barriers, in this order. For existing water wells, buffers ranging between 3 and 7 miles were applied to the various formations and were based upon modeled drawdown effects (Figure 16 to Figure 20).

The overlying geological formations contain shale that can act as a hydrogeologic barrier between the areas recommended for designation and the overlying aquifers. Hydrogeologic barriers in each brackish groundwater production zone in the study area include structural geological boundaries such as faults, the Fredericksburg Group that is present above the Trinity Aquifer, and the Pre-Cretaceous formations that are present below the aquifer. Within the Trinity Group there are significant vertical flow barriers formed by the Pearsall shale, Hammett shale, and massive limestone beds interspersed throughout that isolate the five hydrostratigraphic units.

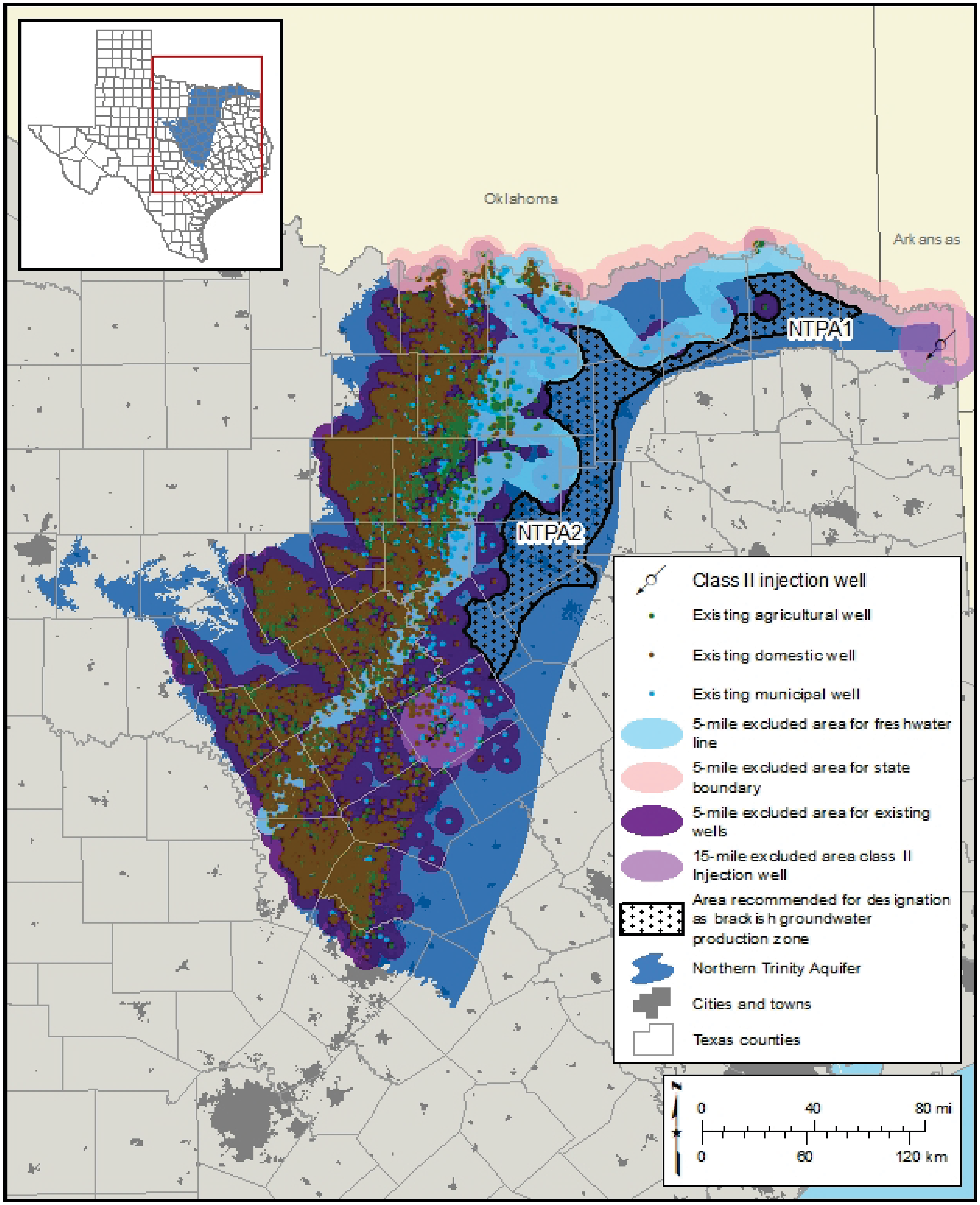

Figure 16. **Northern Trinity Aquifer study area showing areas excluded from being designated as Paluxy Formation brackish groundwater production zones**

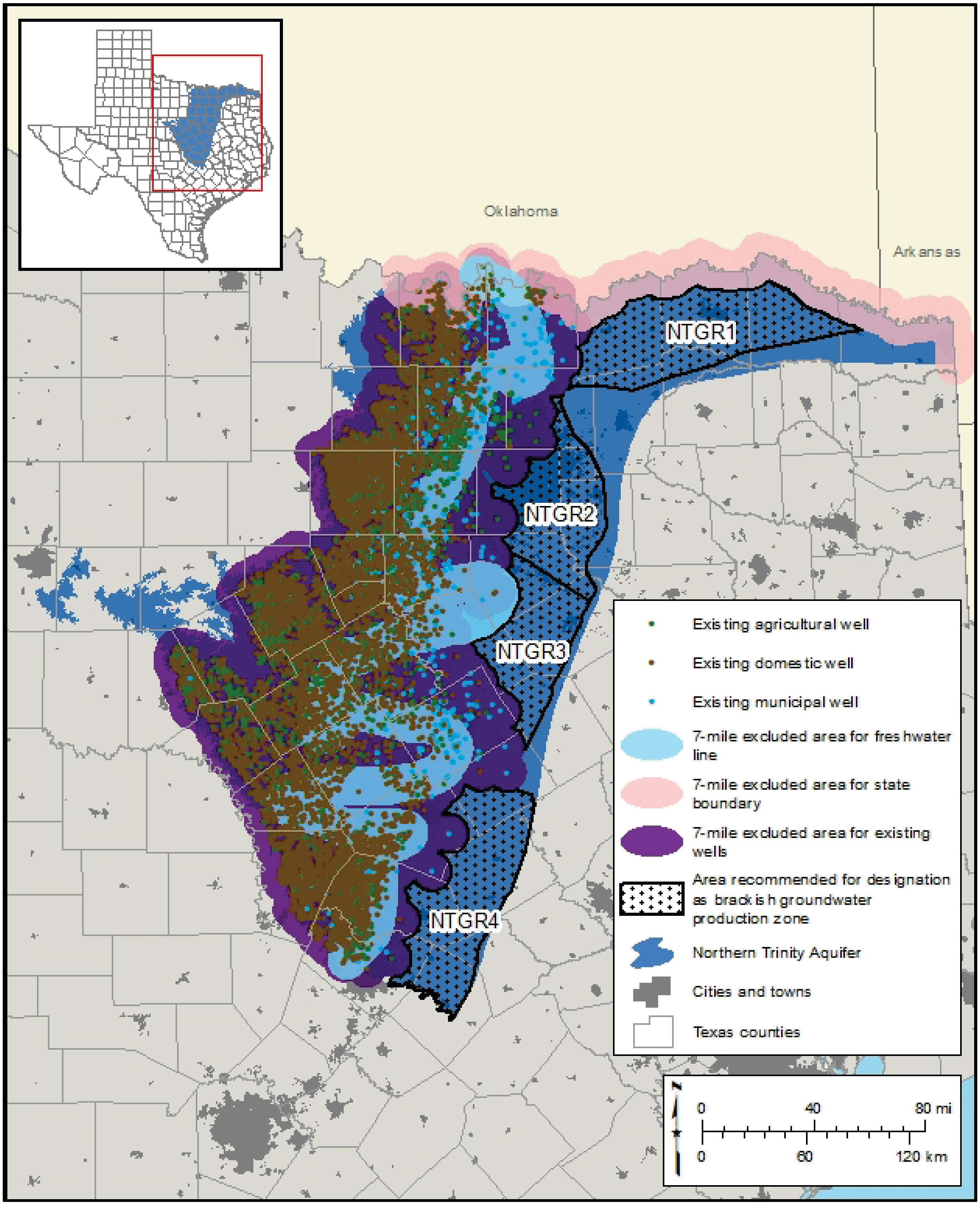

Figure 17. **Northern Trinity Aquifer study area showing areas excluded from being designated as Glen Rose Formation brackish groundwater production zones**

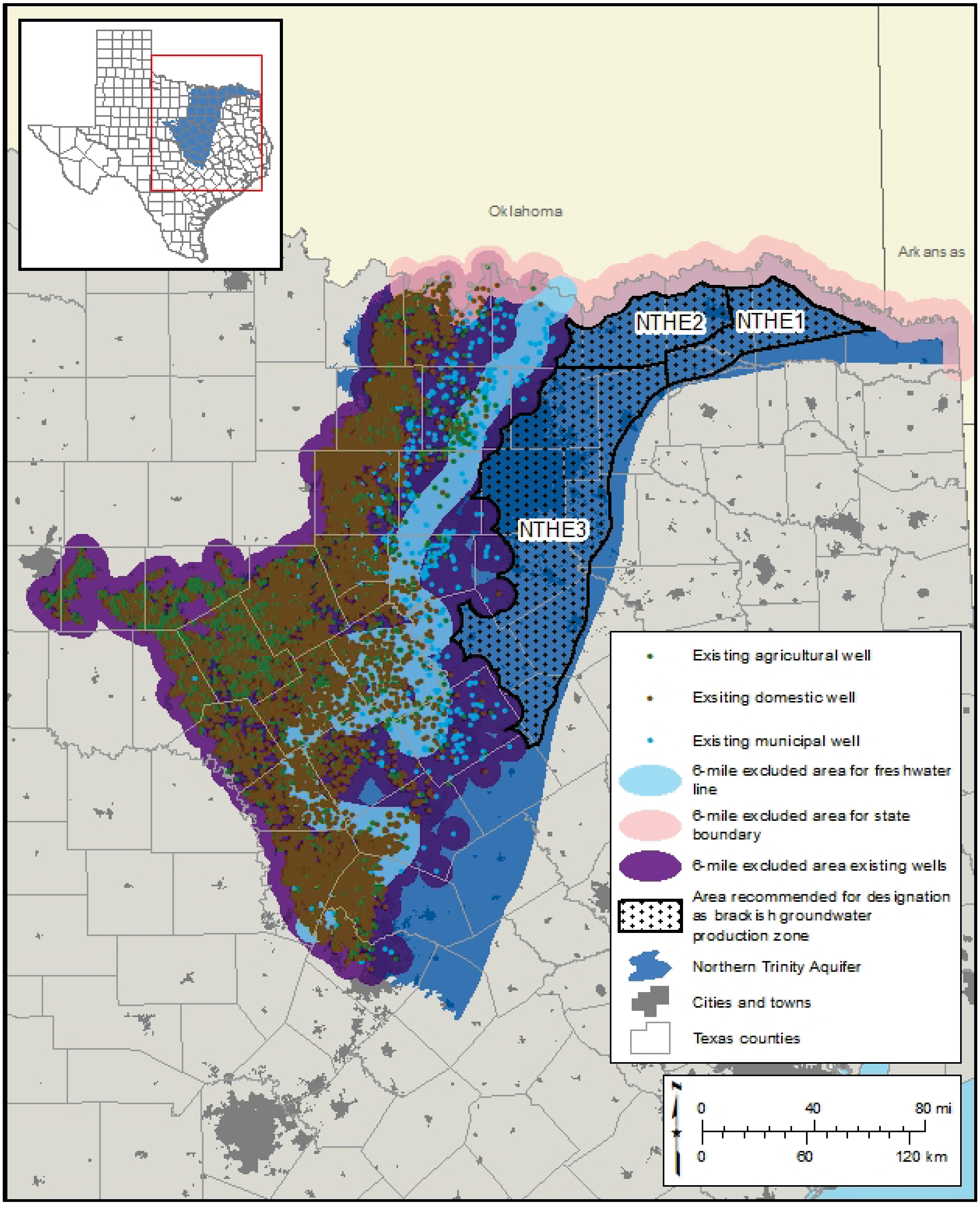

Figure 18. **Northern Trinity Aquifer study area showing areas excluded from being designated as Hensell Formation brackish groundwater production zones**

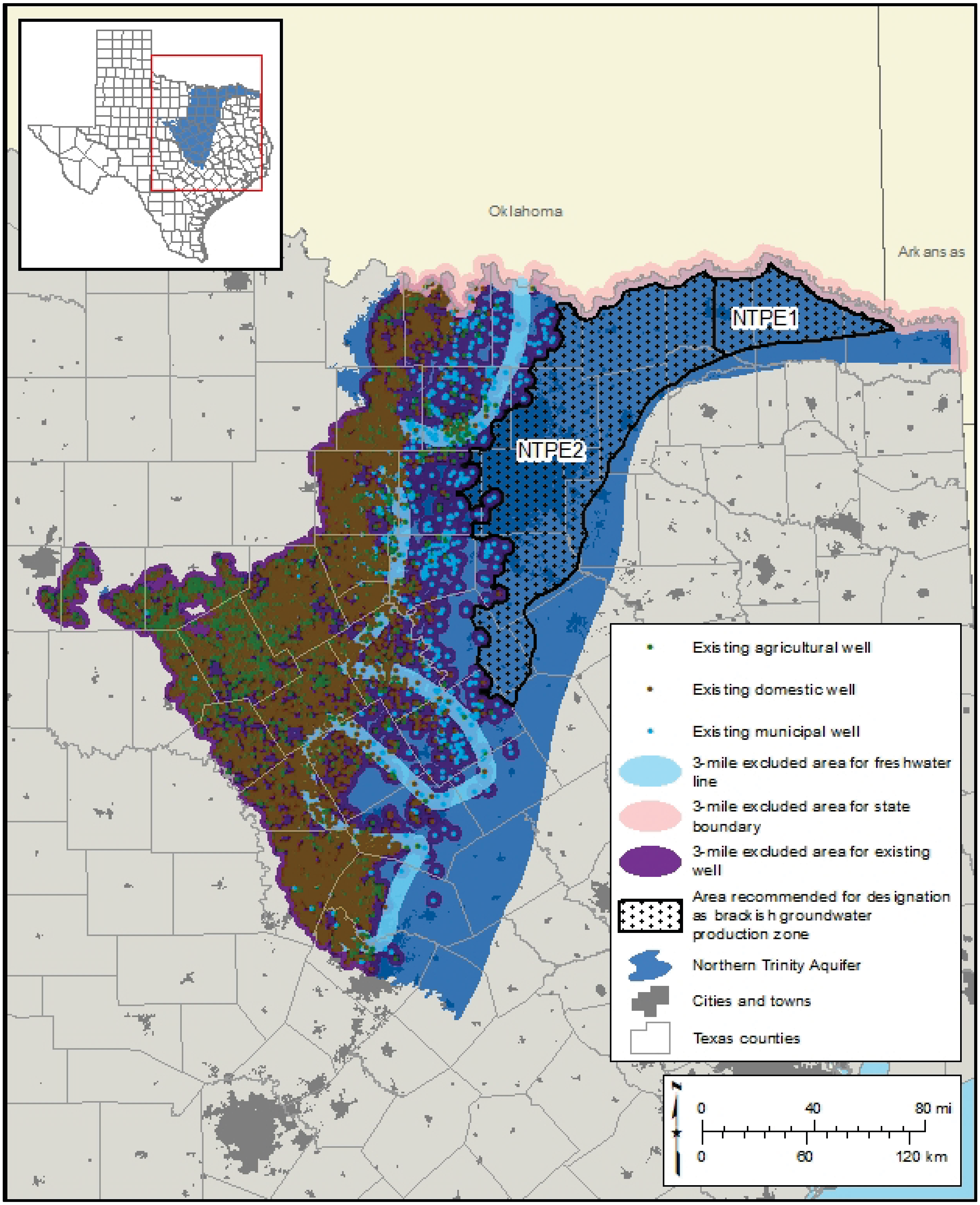

Figure 19. Northern Trinity Aquifer study area showing areas excluded from being designated as Pearsall Formation brackish groundwater production zones

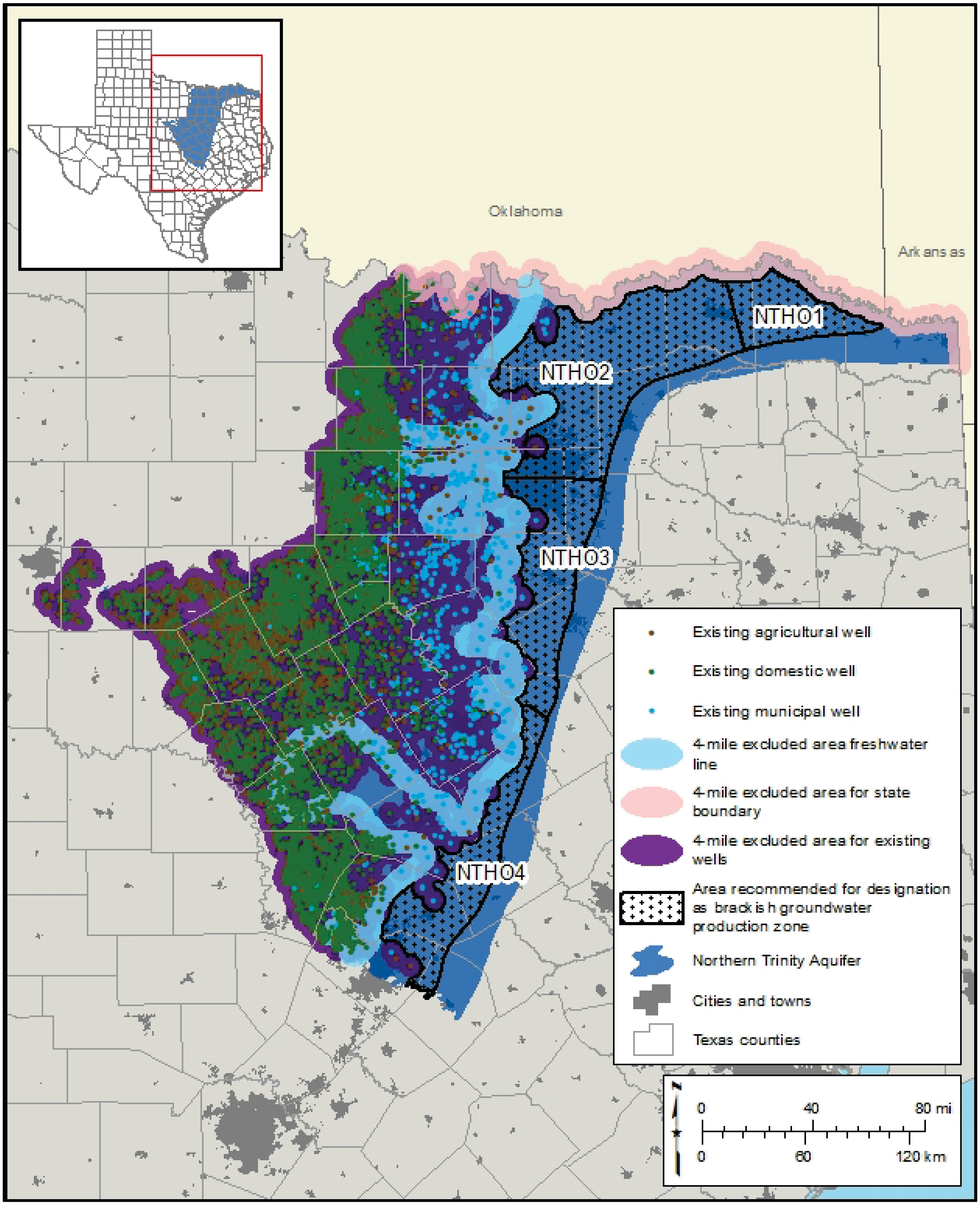

Figure 20. **Northern Trinity Aquifer study area showing areas excluded from being designated as Hosston Formation brackish groundwater production zones**

4.11.2 Designated brackish groundwater production zones

In the Northern Trinity Aquifer study area, the Board designated 15 areas as brackish groundwater production zones with two to four zones designated for each of the five hydrostratigraphic units that define the Northern Trinity Aquifer. There are two zones in the Paluxy unit (Figure 21), four zones in the Glen Rose unit (Figure 22), three zones in the Hensell unit (Figure 23), two zones in the Pearsall unit (Figure 24), and four zones in the Hosston unit (Figure 25). These recommended zones contain groundwater that is slightly to moderately saline (1,000 to 9,999 milligrams per liter of total dissolved solids). We calculated the maximum, minimum, and average top surface depth and thickness for each recommended zone (Table 13).

Table 13. Parameters of brackish groundwater production zones in the Northern Trinity Aquifer

Zone Name	Measured in feet					
	Minimum top depth	Maximum top depth	Average depth	Minimum thickness	Maximum thickness	Average thickness
NTPA1	998	3,992	2,476	109	465	393
NTPA2	716	4,916	2,698	53	405	185
NTGR1	1,420	4,063	2,654	248	869	538
NTGR2	1,214	4,687	3,001	363	1,010	716
NTGR3	1,120	3,996	2,505	539	946	783
NTGR4	1,032	6,614	3,056	411	1,269	934
NTHE1	1,676	4,729	3,387	57	133	96
NTHE2	1,496	4,071	2,795	66	113	89
NTHE3	1,132	5,577	3,326	30	169	72
NTPE1	1,316	4,541	3,046	57	494	250
NTPE2	1,155	5,669	3,070	81	610	260
NTHO1	1,655	5,946	4,092	61	1,089	453
NTHO2	1,398	6,645	3,721	56	913	415
NTHO3	2,114	6,404	4,189	194	1,170	605
NTHO4	1,707	8,116	4,289	205	1,670	1,050

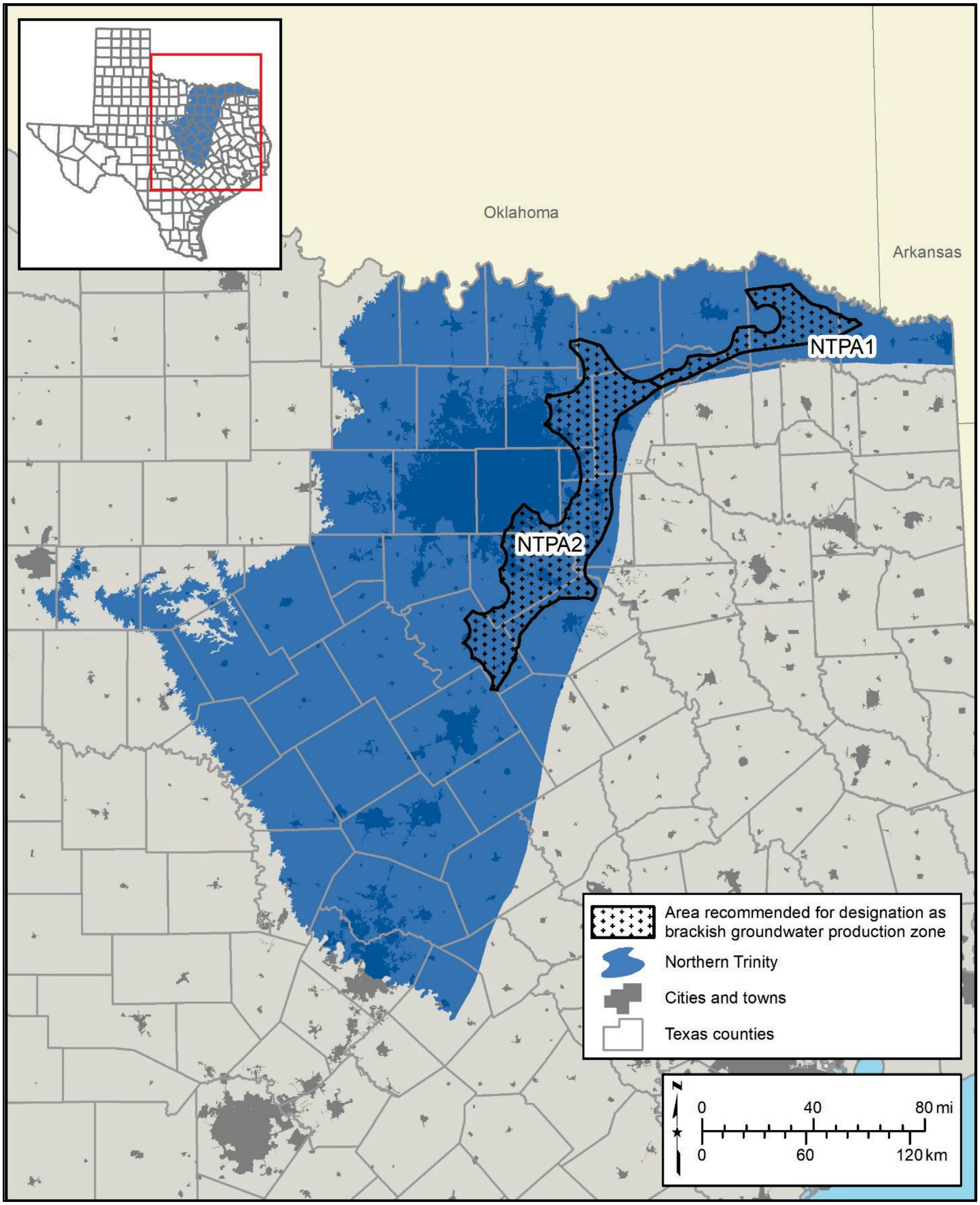

Figure 21. **Two designated brackish groundwater production zones in the Paluxy Formation of the Northern Trinity Aquifer study area**

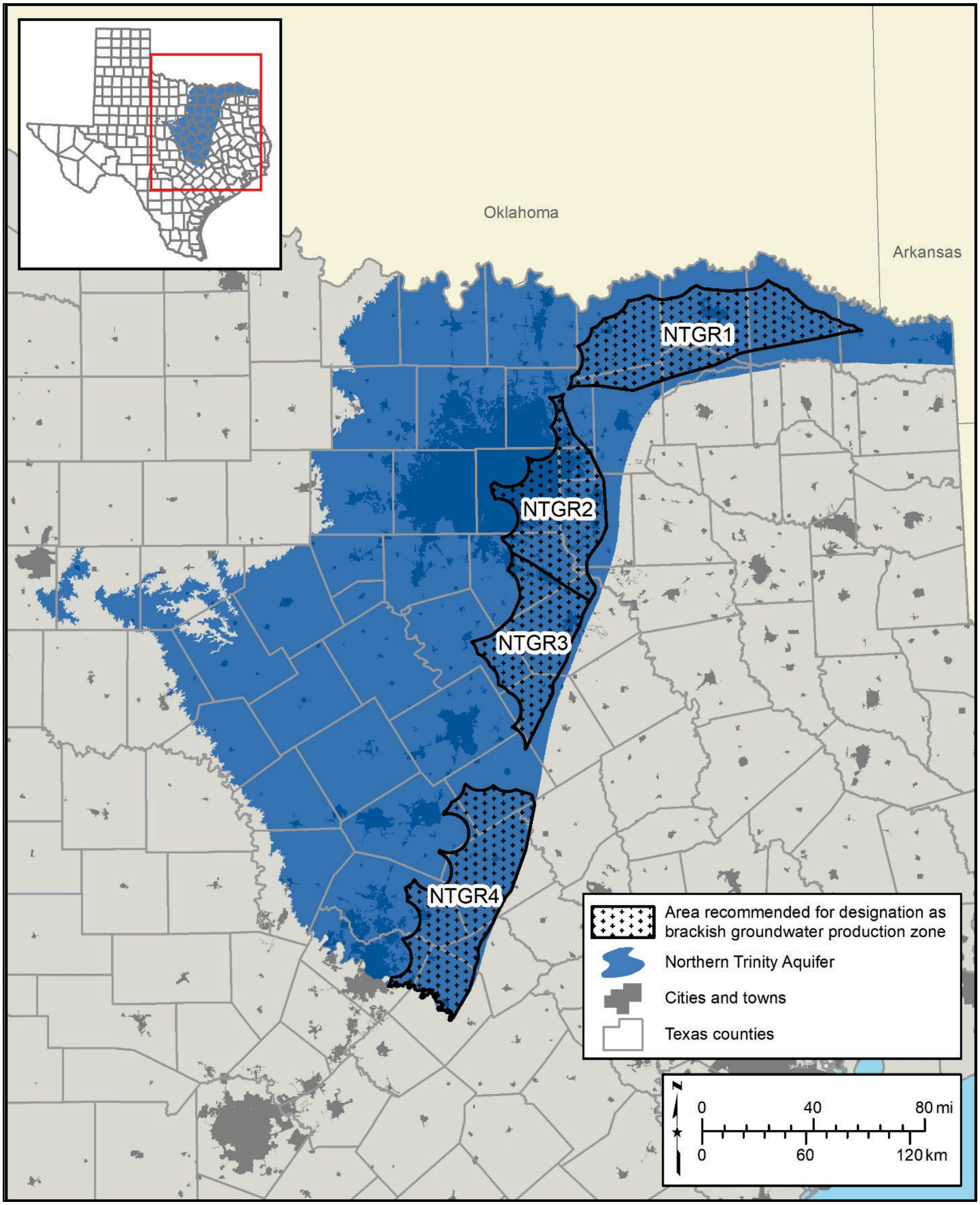

Figure 22. **Four designated brackish groundwater production zones in the Glen Rose Formation of the Northern Trinity Aquifer study area**

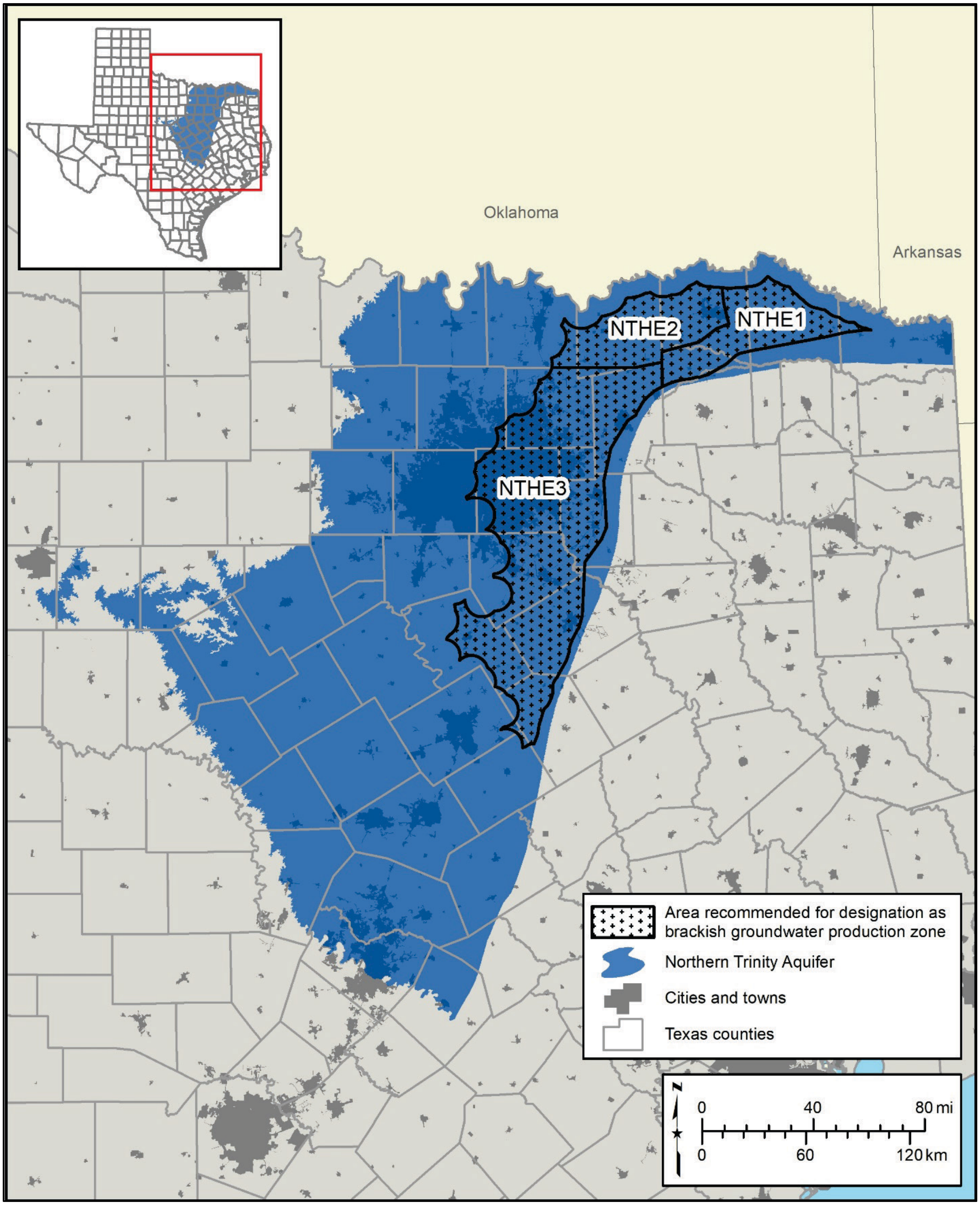

Figure 23. **Three designated brackish groundwater production zones in the Hensell Formation of the Northern Trinity Aquifer study area**

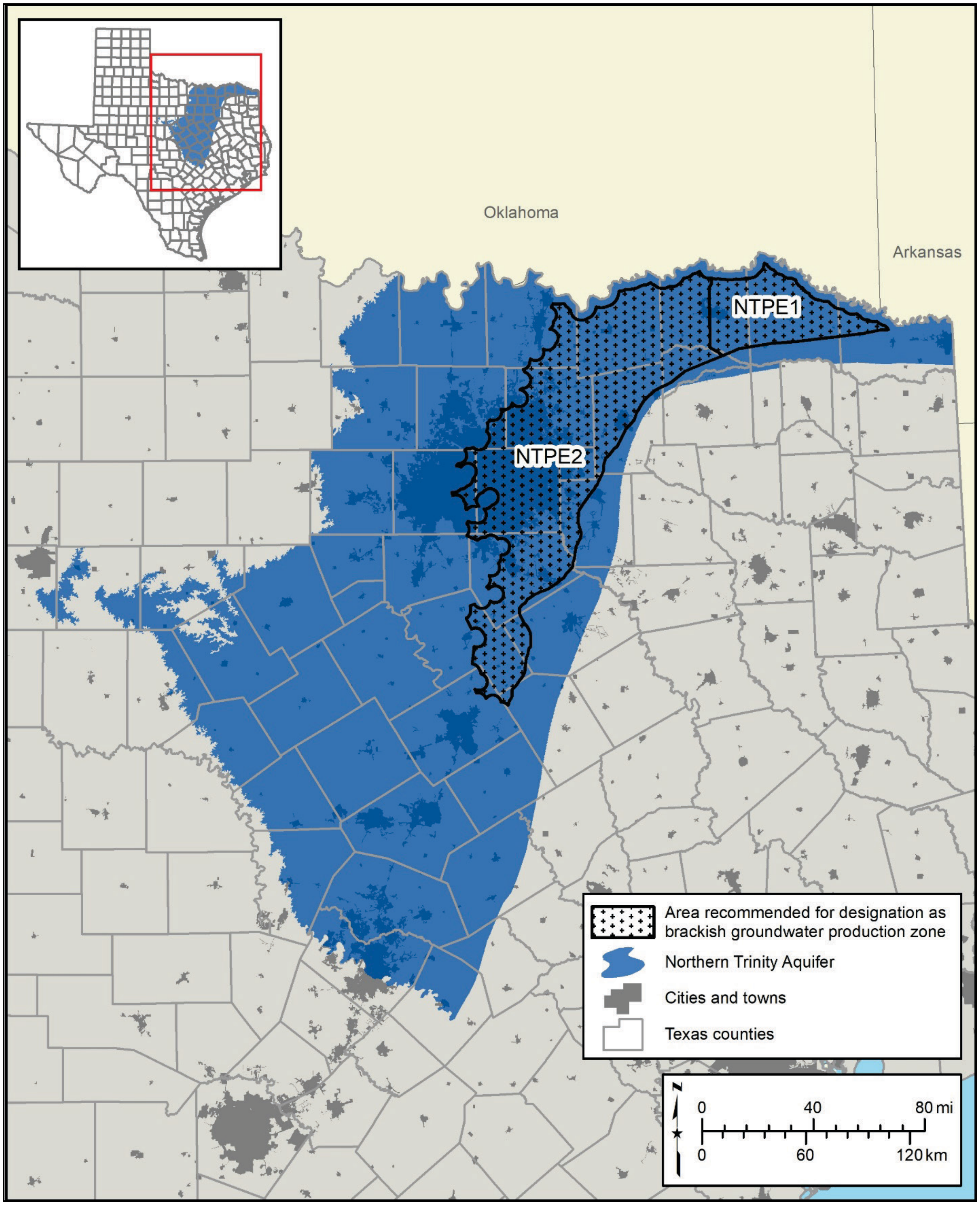

Figure 24. Two designated brackish groundwater production zones in the Pearsall Formation of the Northern Trinity Aquifer study area

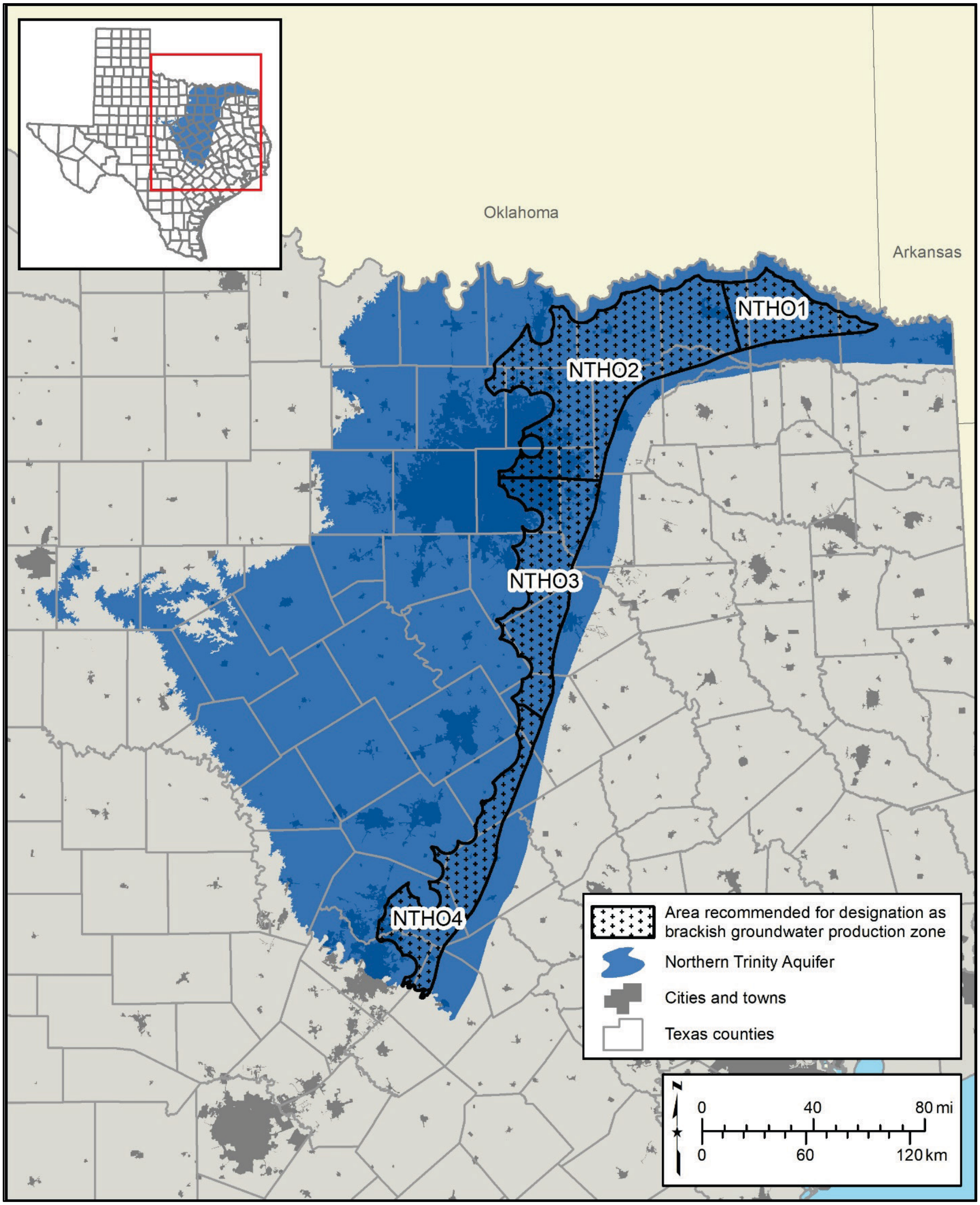

Figure 25. **Four designated brackish groundwater production zones in the Hosston Formation of the Northern Trinity Aquifer study area**

4.11.3 Brackish groundwater volumes in zones

We calculated the volumes of brackish groundwater that could potentially be produced from modeled single-well fields in the zones over 30- and 50-year periods (Table 14).

Table 14. Volumes of brackish groundwater that a zone can produce over 30- and 50-year periods without causing significant impact

Hydrostratigraphic unit	Zone name	Annual pumpage (acre-feet per year)	30-year cumulative (acre-feet)	50-year cumulative (acre-feet)
Paluxy	NTPA1	1,000	30,000	50,000
	NTPA2	380	11,400	19,000
Glen Rose	NTGR1	725	21,750	36,250
	NTGR2	315	9,450	15,750
	NTGR3	600	18,000	30,000
	NTGR4	780	23,400	39,000
Hensell	NTHE1	375	11,250	18,750
	NTHE2	350	10,500	17,500
	NTHE3	117	3,510	5,850
Pearsall	NTPE1	1,400	42,000	70,000
	NTPE2	1,600	48,000	80,000
Hosston	NTHO1	975	29,250	48,750
	NTHO2	3,950	118,500	197,500
	NTHO3	3,550	106,500	177,500
	NTHO4	1,165	34,950	58,250

4.11.4 Groundwater monitoring in the zones

In general, groundwater monitoring should focus on the overlying and laterally adjacent aquifers that contain freshwater wells or existing wells. Monitoring in hydrogeologic barriers is recommended to determine the potential source of impacts to freshwater or existing use due to development in surrounding aquifers or the Trinity Aquifer. Monitoring is not required below the Trinity Aquifer because there are no known fresh or brackish aquifers in the underlying Pre-Cretaceous formations in this area. Future wellfields in the brackish zones should include monitor wells to track water levels and water quality during production.

The northern extension of the Edwards (Balcones Fault Zone) Aquifer extends into the southern portion of the study area and overlies the Trinity Aquifer. Over 200 feet of non-water-bearing sediment of the lower Fredericksburg Group separate the Edwards Aquifer from the water-bearing units in the Trinity Aquifer. In Williamson and Bell counties there is the potential that the Edwards Aquifer may, as a result of faulting, be adjacent to porous units of the Trinity Aquifer.

Therefore, monitoring water levels in the Edwards Aquifer should be considered with development of the Glen Rose formation in zone NTGR4.

TWDB staff did not review the occurrence and effect that faults might have on the juxtaposition of water-bearing formations in detail. When developing brackish groundwater in the vicinity of large offset faults, monitoring in the shallower water-bearing units on the downthrown side is recommended.

4.12 Future permitting framework for zones

In 2019, the 86th Texas Legislature passed House Bill 722 and created a framework for groundwater conservation districts to establish permitting rules for producing brackish groundwater from TWDB-designated production zones for a municipal drinking water project or an electric generation project. Additionally, the legislature appropriated funding for one full-time equivalent staff member to support technical reviews associated with brackish groundwater production zone operating permits.

House Bill 722 directed the TWDB to conduct technical reviews of operating permit applications submitted to groundwater conservation districts and, when requested by a district, investigate the impacts of brackish groundwater production as described in the annual reports of the permitted production. House Bill 722 does not apply to a district that (1) overlies the Dockum Aquifer and (2) includes wholly or partly 10 or more counties, which is the High Plains Underground Water Conservation District No. 1.

When conducting a technical review of a brackish groundwater production zone operating permit application, the TWDB will submit a report to the groundwater conservation district that includes (1) findings regarding the compatibility of the proposed well field design with the designated brackish groundwater production zone and (2) recommendations for a monitoring system. There is no required timeline for conducting the technical review and preparing a report for the district. To date, no such permit applications have been submitted to the TWDB for technical review.

In response to a groundwater conservation district request for an investigation into permitted brackish groundwater production in designated production zones, the TWDB will submit a report to the district that addresses whether the production from the permitted project is projected to cause (1) significant, unanticipated aquifer level declines or (2) negative effects on water quality in the same or an adjacent aquifer, subdivision of an aquifer, or geologic stratum. The report will also include an analysis of any subsidence projected to be caused by brackish groundwater production during the permit term, if the brackish groundwater production zone is in the Gulf Coast Aquifer. The TWDB has 120 days to conduct the technical investigations and provide the report to the district after receiving a request.

To clarify the process for technical reviews of operating permit applications and associated annual production reports as required by House Bill 722, the Board approved the publication of proposed amendments to 31 Texas Administrative Code (TAC), Chapter 356, at the August 5, 2020, Board meeting. The proposed rulemaking will define two new terms that will be used in a new subchapter: 'brackish groundwater production zone operating permit' and 'designated brackish groundwater production zone.'

In addition, the new Subchapter G would include three sections:

- Section 356.70 will clarify how the agency identifies and designates local or regional brackish groundwater production zones in areas of the state that meet statutory requirements and exclusion criteria and the information required to be provided for each zone
- Section 356.71 will outline how the agency will conduct assessments and technical reviews of operating permit applications in brackish groundwater production zones
- Section 356.72 will outline how the agency will investigate and conduct technical reviews of annual reports, upon request by groundwater conservation districts

Sections 356.71 and 356.72 will also discuss the information required to conduct technical reviews of the annual permit reports upon request from groundwater conservation districts and the information contained in the reports that the TWDB will provide to the requesting districts. The proposed rules were posted to the Texas Register on August 21, 2020, with a 30-day comment period that ended on September 21, 2020. The TWDB reviewed and responded to submitted comments and will subsequently request that the Board approve the adoption of the rules with any recommended revisions in a future Board meeting.

4.13 Legislative Committees

In October 2019, the speaker of the Texas House of Representatives announced interim committee charges for the House Committee on Natural Resources. Interim Charge 3, on monitoring the implementation of relevant legislation passed by the 86th Texas Legislature, included House Bill 722 and the permitting framework within brackish groundwater production zones. On July 15, 2020, the committee requested written testimony on designation of brackish groundwater production zones and adoption of permitting rules in zones. The TWDB submitted such testimony on September 25, 2020.

Additionally, the Senate Natural Resources and Economic Development Committee and Senate Water and Rural Affairs Committee included two joint charges related to desalination and brackish water resources:

- Charge 1, Future Water Supply, examines current laws, processes, and water storage options and availability. It also requires development of recommendations promoting the state's water supply, storage, availability, valuation, movement, and development of new sources.
- Charge 2, Groundwater Regulatory Framework, requires the study of the state's groundwater regulatory framework and the development of recommendations to improve groundwater regulation, management, and permitting.

On January 22, 2020, the TWDB provided testimony on the BRACS program and on the status of designating brackish groundwater production zones. This information is related to Interim Charge 1.

5 Identification and evaluation of research, regulatory, technical, and financial impediments to implementing seawater or brackish groundwater desalination projects

Desalination projects, both seawater and brackish groundwater, are driven by site-specific conditions. Source water quality, permitting requirements, and construction and operation costs all depend on local site conditions. Thus, impediments for desalination projects can be different for each project.

5.1 Research

A common obstacle to conducting research is a lack of adequate funding. The Texas Legislature last appropriated funds to the TWDB to advance seawater and brackish groundwater desalination research in Texas in 2009. Should funding become available, potential research topics specific to Texas have been identified in past TWDB studies and biennial reports. However, there is a need to assess the relevance of the research topics and develop an updated desalination research agenda that contains research topics and tangible pilot- and demonstration-scale projects that would help advance desalination implementation in Texas. Guidance documents, such as the permit decision model (roadmap) developed by the TWDB in 2004, also need to be updated to reflect the new streamlined and flexible permitting process adopted as a requirement of House Bills 2031 and 4097 of the 84th Texas Legislature in 2015.

5.2 Regulatory

In general, the permitting process can be a barrier to public entities pursuing desalination. For seawater desalination, the Texas Commission on Environmental Quality and other agencies' permitting requirements will not be put into practice and firmly established until a few seawater desalination plants have been built and undergone the required permitting cycles. The City of Corpus Christi and the Port of Corpus Christi Authority are the first to initiate the permitting process and will be a learning opportunity for Texas. Another factor that can affect seawater desalination permitting is public opposition due to environmental concerns, as encountered in the Corpus Christi area. Currently, there is a need to update the permit decision model and corresponding guidance document for desalination that were prepared 10 and 16 years ago, respectively.

When desalination initiatives began, there was a need to develop a permitting roadmap that allowed entities to determine the permits required to build a seawater or brackish groundwater desalination plant. As a result, the TWDB funded a study to develop a permit decision model that identifies major requirements through a decision tree analysis (R.W. Beck, Inc., 2004). The model can be applied to either a seawater or brackish water desalination facility that uses a reverse osmosis system. The study also provides an example of how to apply the permit decision model to a seawater desalination plant co-located with a power plant.

There was also a need to determine the specific permits required to build a seawater desalination plant. A TWDB-funded study determined that a total of 26 federal and state permits may be required to implement a seawater desalination project along the Gulf Coast (Brownsville Public Utilities Board, 2011). The study also included information about the timeframe, costs, and regulatory agency associated with each permit.

5.3 Technical

Although there are currently brackish groundwater desalination facilities operating in the state and the TWDB has conducted desalination studies, desalination depends on site-specific parameters that require installing monitoring wells and conducting pilot- and demonstration-scale testing for a successful project. Therefore, providing public entities with grant funding for initial testing may help advance the implementation and construction of seawater and brackish groundwater desalination plants.

In addition, the Brownsville and South Padre Island seawater desalination pilot-plant studies conducted from 2008 to 2010 tested treatment technologies that are now 10 to 12 years old. Recent advances in desalination technology make the results of these pilot tests dated. Consequently, piloting of more recent and updated technologies may be needed to pursue seawater and brackish groundwater desalination.

5.4 Financial

Despite improvements to reverse osmosis membranes and the increased cost competitiveness of desalination, creating a new water supply from seawater or brackish groundwater is still relatively more expensive than developing supplies from existing fresh sources, if available. Desalinating seawater and brackish groundwater is more costly for a number of reasons, with salinity concentration (about 1,000 to 35,000 milligrams per liter) being the key driver. Higher-salinity water requires more pressure and energy in the treatment process, which increases costs. Other factors that affect cost include the type and location of intake and outfall structures, the size and depth of water supply wells, the pre-treatment process, the brine disposal method, and the length of distribution pipelines. Additionally, the permitting process can increase costs by requiring entities to obtain numerous permits and conduct environmental studies.

Therefore, public entities may need financial assistance from the state to implement seawater desalination projects. For the recommended 2.5-million-gallon-per-day (2,800-acre-foot-per-year) seawater desalination plant in Brownsville, the TWDB requested a $9.5 million financial grant from the 83rd Texas Legislature (TWDB, 2012) but did not ultimately receive it. Entities constructing brackish groundwater desalination plants would also benefit from state assistance to help drill monitoring wells and run geophysical well tools to characterize the water source.

To help develop uniform cost estimates for projects across the state, the TWDB funded a study to develop a Unified Costing Model for the 16 regional water planning groups (HDR Engineering, Inc. and Freese and Nichols, 2018). The groups first used the costing tool, which allows the user to employ a standardized costing framework for desalination plants in Texas, in the 2017 State Water Plan. The costing model was updated in November 2018.

6 Evaluation of the role the State should play in furthering the development of large-scale seawater or brackish groundwater desalination projects

The purpose of the Seawater and Brackish Groundwater Desalination initiatives was to accelerate the development of cost-effective desalinated water supplies and innovative technologies in Texas. Since their inceptions in 2002 and 2004, the initiatives' ultimate goal has been to install desalination plants—with particular focus on a full-scale seawater desalination facility—to demonstrate the potential of desalination as a new water source. However, both initiatives have stalled due to a lack of appropriations.

The role of the State (Texas Legislature) is to continue providing leadership and supporting the advancement of desalination in Texas. Fulfilling this role during the upcoming biennium would require consideration of the following:

- <u>Supporting the advancement of science</u>
  The State can assist by supporting the advancement of seawater and brackish groundwater desalination studies. The TWDB can continue to support entities by providing data and technical support through its existing programs and staff resources.

- <u>Facilitating an efficient permitting process</u>
  The State can assist in the permitting process by participating in and facilitating meetings between water providers or municipalities and regulatory agencies. The Texas Commission on Environmental Quality is the state agency that has regulatory authority over public drinking water quality and treatment requirements. It also oversees the issuance of permits for water diversions and waste discharges. For brackish groundwater, the TWDB will be providing technical reviews associated with brackish groundwater production zone operating permits as required by House Bill 722 from the 86th Texas Legislature. The bill's stated intent was to provide greater access to brackish groundwater by simplifying permitting procedures.

- <u>Informing public entities of funding opportunities</u>
  The State can assist by informing public entities of funding opportunities. The TWDB can continue to support cities, counties, utility districts, and other political subdivisions by

informing them of the TWDB loan and grant programs and providing low-interest loans for water supply projects, including seawater and brackish desalination projects.

7 Anticipated appropriation from general revenues necessary to continue investigating water desalination activities during the next biennium

The TWDB's baseline budget request for FY 2022–2023 included $2 million for the Brackish Aquifer Characterization System (BRACS) Program to continue progress toward meeting statutory requirements for designating brackish groundwater production zones by the new legislative deadline of December 1, 2032.

The TWDB did not request funds for the Desalination Program and will continue to monitor desalination activities with current limited resources. At present, one staff member covers the Desalination Program in the Innovative Water Technologies Department in addition to other job duties.

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Appendix A: Tables

Table A-1. Recommended water management strategies for seawater desalination in the 2017 State Water Plan

Region	Water management strategy	Water user group	Water supplies by decade (acre-feet per year)					
			2020	2030	2040	2050	2060	2070
H	Freeport seawater desalination	Manufacturing, Brazoria County	0	0	11,200	11,200	11,200	11,200
L	Integrated water-power project	Guadalupe Blanco River Authority*	-	-	-	-	-	-
L	Seawater desalination	San Antonio Water System*	-	-	-	-	-	-
L	Seawater desalination	San Antonio	0	0	12,319	23,337	37,364	48,278
L	Seawater desalination	San Antonio Water System	0	0	5,700	5,700	5,700	5,700
M	Brownsville seawater desalination	Brownsville	2,603	2,603	2,603	2,603	26,022	26,022
M	Brownsville seawater desalination	El Jardin Water Supply Corporation	108	108	108	108	1,081	1,081
M	Brownsville seawater desalination	Manufacturing, Cameron County	56	56	56	56	565	565
M	Brownsville seawater desalination	Steam electric power, Cameron County	33	33	33	33	332	332
N	Seawater desalination	Manufacturing, Nueces County	0	9,000	9,000	9,000	9,000	9,000
N	Seawater desalination	Manufacturing, San Patricio County	0	9,000	9,000	9,000	9,000	9,000
N	Seawater desalination	Steam electric power, Nueces County	0	4,420	4,420	4,420	4,420	4,420
		Total	**2,800**	**25,220**	**54,439**	**65,457**	**104,684**	**115,598**

Notes: *The strategy is currently not assigned to serve a specific water user group (in other words, the strategy is recommended but is not planned to provide water to users during the 50-year planning period).

Table A-2. **Alternative water management strategies for seawater desalination in the 2017 State Water Plan**

Region	Water management strategy	Water user group	Water supplies by decade (acre-feet per year)					
			2020	2030	2040	2050	2060	2070
M	Laguna Madre seawater desalination	Laguna Vista	390	390	390	390	390	390
M	Laguna Madre seawater desalination	Port Isabel	213	213	213	213	213	213
M	Laguna Madre seawater desalination	South Padre Island	517	517	517	517	517	517
M	RGRWA regional facility project – seawater desalination	Agua Supply Utility District	0	69	43	467	1,282	2,176
M	RGRWA regional facility project – seawater Desalination	Alamo	183	147	137	475	1,017	1,508
M	RGRWA regional facility project – seawater desalination	Brownsville	0	0	31	1,224	4,222	7,864
M	RGRWA regional facility project – seawater desalination	Donna	0	15	40	201	502	822
M	RGRWA regional facility project – seawater desalination	East Rio Hondo Water Supply Corporation	0	5	40	209	557	925
M	RGRWA regional facility project – seawater desalination	Edinburg	762	623	571	1,957	4,222	6,202
M	RGRWA regional facility project – seawater desalination	Harlingen	0	0	68	564	1,686	2,981
M	RGRWA regional facility project – seawater desalination	Hidalgo	86	78	75	258	571	840
M	RGRWA regional facility project – seawater desalination	Hidalgo County Municipal Utility District #1	64	44	34	105	223	326
M	RGRWA regional facility project – seawater desalination	La Feria	0	5	12	64	167	274
M	RGRWA regional facility project – seawater desalination	Laguna Vista	183	123	102	338	711	1,028
M	RGRWA regional facility project – seawater desalination	McAllen	934	1,256	1,335	4,889	10,966	16,500
M	RGRWA regional facility project – seawater desalination	Mercedes	54	69	71	258	585	874
M	RGRWA regional facility project – seawater desalination	Military Highway Water Supply Corporation	236	201	189	669	1,463	2,193

Region	Water management strategy	Water user group	Water supplies by decade (acre-feet per year)					
			2020	2030	2040	2050	2060	2070
M	RGRWA regional facility project – seawater desalination	Mission	1,428	1,094	975	3,278	6,995	10,177
M	RGRWA regional facility project – seawater desalination	North Alamo Water Supply Corporation	0	172	192	1,410	3,442	5,808
M	RGRWA regional facility project – seawater desalination	Olmito Water Supply Corporation	0	0	0	16	70	137
M	RGRWA regional facility project – seawater desalination	Pharr	4	201	258	1,015	2,397	3,684
M	RGRWA regional facility project – seawater desalination	Port Isabel	97	64	53	177	362	531
M	RGRWA regional facility project – seawater desalination	Rancho Viejo	0	0	0	0	28	86
M	RGRWA regional facility project – seawater desalination	San Benito	0	0	0	0	167	428
M	RGRWA regional facility project – seawater desalination	San Juan	376	280	242	846	1,825	2,690
M	RGRWA regional facility project – seawater desalination	Sharyland Water Supply Corporation	226	422	478	1,804	4,375	6,117
M	RGRWA regional facility project – seawater desalination	South Padre Island	236	162	137	443	934	1,371
M	RGRWA regional facility project – seawater desalination	Weslaco	601	442	385	1,281	2,731	3,958
		Total	**6,590**	**6,592**	**6,588**	**23,068**	**52,620**	**80,620**

Note: RGRWA = Rio Grande Regional Water Authority

Table A-3. Groundwater desalination recommended water management strategies in the 2017 State Water Plan

Region	Water management strategy	Water user group	Water supplies by decade (acre-feet per year)					
			2020	2030	2040	2050	2060	2070
E	Additional groundwater wells - Rustler Aquifer	Mining, Culberson County	590	590	590	590	590	590
E	Additional groundwater well - West Texas Bolsons Aquifer	Mining, Culberson County	590	590	590	590	590	590
E	Dell City - brackish groundwater desalination facility	County-other, Hudspeth County	111	111	111	111	111	111
E	Brackish groundwater at the Jonathan Rogers Wastewater Treatment Plant	El Paso	0	0	11,000	11,000	11,000	11,000
E	Expansion of the Kay Bailey Hutchison Desalination Plant	El Paso	1,260	2,520	2,520	2,520	2,520	2,520
E	Hudspeth County Conservation and Reclamation District #1 - additional groundwater wells	Irrigation, Hudspeth County	230	230	230	230	230	230
E	Additional wells and expansion of desalination plant	Horizon City	0	1,457	3,195	4,923	6,562	8,107
E	Additional wells and expansion of desalination plant	Horizon Regional Municipal Utility District	8,652	8,652	8,652	8,652	8,652	8,652
	Additional wells and expansion of desalination plant	Horizon Regional Municipal Utility District	8,652	8,652	8,652	8,652	8,652	8,652
E	Mining - additional groundwater well	Mining, Hudspeth County	30	30	30	30	30	30
E	Groundwater from proposed well field – Rio Grande Alluvium Aquifer	Lower Valley Water District	6,800	6,800	6,800	6,800	6,800	6,800
F	Desalination of other aquifer supplies in Tom Green County	Concho Rural Water Supply Corporation	150	150	150	150	150	150
F	Desalination of other aquifer supplies	County-other, Tom Green County	0	0	0	96	105	115
F	Desalination of other aquifer supplies	Manufacturing, Tom Green County	0	0	0	312	366	425
F	Desalination of other aquifer supplies	San Angelo	0	0	0	2,928	2,600	2,973
F	Desalination of other aquifer supplies	San Angelo*	-	-	-	-	-	-
H	Brackish groundwater supplies	Montgomery County-other	0	0	0	0	3,622	10,000

Region	Water management strategy	Water user group	Water supplies by decade (acre-feet per year)					
			2020	2030	2040	2050	2060	2070
H	Brackish groundwater supplies	Dobbin-Plantersville Water Supply Corporation	153	327	570	890	1,337	1,930
H	Conroe brackish groundwater desalination	Conroe	5,600	5,600	5,600	5,600	5,600	5,600
H	New / expanded contract with Brazosport Water Authority - brackish groundwater	County-other, Brazoria County	1,147	1,063	1,003	937	865	800
H	Panorama and Shenandoah Joint Group	Shenandoah	0	0	472	472	472	472
H	San Jacinto River Authority Catahoula Aquifer supplies	County-other, Montgomery County	3,920	3,920	3,920	3,920	3,920	3,920
H	San Jacinto River Authority Catahoula Aquifer supplies	Steam-electric power, Montgomery County	3,920	3,920	3,920	3,920	3,920	3,920
J	Livestock - additional groundwater wells	Livestock, Kinney County	22	22	22	22	22	22
L	Brackish Wilcox Aquifer groundwater	Canyon Regional Water Authority*	-	-	-	-	-	-
L	Brackish Wilcox Aquifer groundwater	County Line Water Supply Corporation	0	0	0	251	440	641
L	Brackish Wilcox Aquifer groundwater	Green Valley Special Utility District	0	0	0	0	0	619
L	Brackish Wilcox Aquifer groundwater	Alamo Heights	796	848	820	807	805	805
L	Brackish Wilcox Aquifer groundwater	Atascosa Rural Water Supply Corporation	1,167	1,446	1,708	1,970	2,218	2,448
L	Brackish Wilcox Aquifer groundwater	County-other, Bexar County	0	0	0	1,898	2,113	1,823
L	Brackish Wilcox Aquifer groundwater	Kirby	137	207	181	172	169	169
L	Brackish Wilcox Aquifer groundwater	Leon Valley	97	147	196	254	317	377
L	Brackish Wilcox Aquifer groundwater	San Antonio	3,425	2,974	2,717	521	0	0
L	Brackish Wilcox Aquifer groundwater	S S Water Supply Corporation	0	0	0	0	0	234
L	Brackish Wilcox Aquifer groundwater	Schertz-Seguin Local Government Corporation*	-	-	-	-	-	-
L	Expanded brackish Wilcox Aquifer groundwater	San Antonio Water System*	-	-	-	-	-	-

Region	Water management strategy	Water user group	Water supplies by decade (acre-feet per year)					
			2020	2030	2040	2050	2060	2070
M	Alamo brackish groundwater desalination plant	Alamo	1,000	1,000	1,000	1,000	1,000	1,000
M	El Jardin new brackish groundwater desalination plant	El Jardin Water Supply Corporation	560	560	560	560	560	560
M	Hebbronville new brackish groundwater desalination plant	Hebbronville	560	560	560	560	560	560
M	La Feria water well with reverse osmosis unit	La Feria	1,120	1,120	1,120	1,120	1,120	1,120
M	Laguna Madre new brackish groundwater desalination plant	Laguna Vista	780	780	780	780	780	780
M	Laguna Madre new brackish groundwater desalination plant	Manufacturing, Cameron County	1	1	1	1	1	1
M	Laguna Madre new brackish groundwater desalination plant	Port Isabel	425	425	425	425	425	425
M	Laguna Madre new brackish groundwater desalination plant	South Padre Island	1,034	1,034	1,034	1,034	1,034	1,034
M	Lyford brackish groundwater well and desalination	Lyford	1,120	1,120	1,120	1,120	1,120	1,120
M	McAllen brackish groundwater desalination plant	McAllen	2,688	2,688	2,688	2,688	2,688	2,688
M	Mission brackish groundwater desalination plant	Mission	2,688	2,688	2,688	2,688	2,688	2,688
M	North Alamo Water Supply Corporation delta area reverse osmosis water treatment plant expansion	County-other, Hidalgo County	0	0	0	0	2	2
M	North Alamo Water Supply Corporation delta area reverse osmosis water treatment plant expansion	Edinburg	0	0	0	0	4	4
M	North Alamo Water Supply Corporation delta area reverse osmosis water treatment plant expansion	Military Highway Water Supply Corporation	0	0	0	0	1	1
M	North Alamo Water Supply Corporation delta area reverse osmosis water treatment plant	North Alamo Water Supply Corporation	0	0	0	0	1,410	1,410

Region	Water management strategy	Water user group	Water supplies by decade (acre-feet per year)					
			2020	2030	2040	2050	2060	2070
M	North Alamo Water Supply Corporation delta area reverse osmosis water treatment plant expansion	Primera	0	0	0	0	4	4
M	North Alamo Water Supply Corporation delta area reverse osmosis water treatment plant expansion	San Juan	0	0	0	0	800	800
M	North Alamo Water Supply Corporation delta area reverse osmosis water treatment plant expansion	San Perlita	0	0	0	0	19	19
M	North Alamo Water Supply Corporation La Sara reverse osmosis plant expansion	County-other, Hidalgo County	0	0	0	0	0	37
M	North Alamo Water Supply Corporation La Sara reverse osmosis plant expansion	Edinburg	0	0	0	0	0	2
M	North Alamo Water Supply Corporation La Sara reverse osmosis plant expansion	Manufacturing, Hidalgo County	0	0	0	0	0	1
M	North Alamo Water Supply Corporation La Sara reverse osmosis plant expansion	Manufacturing, Willacy County	0	0	0	0	0	1
M	North Alamo Water Supply Corporation La Sara reverse osmosis plant expansion	Military Highway Water Supply Corporation	0	0	0	0	0	1
M	North Alamo Water Supply Corporation La Sara reverse osmosis plant expansion	North Alamo Water Supply Corporation	0	0	0	0	0	997
M	North Alamo Water Supply Corporation La Sara reverse osmosis plant expansion	Primera	0	0	0	0	0	2
M	North Alamo Water Supply Corporation La Sara reverse osmosis plant expansion	San Juan	0	0	0	0	0	70
M	North Alamo Water Supply Corporation La Sara reverse osmosis plant expansion	San Perlita	0	0	0	0	0	9

Region	Water management strategy	Water user group	Water supplies by decade (acre-feet per year)					
			2020	2030	2040	2050	2060	2070
M	North Cameron regional water treatment plant wellfield expansion	County-other, Hidalgo County	1	1	1	1	1	1
M	North Cameron regional water treatment plant wellfield expansion	Edinburg	1	1	1	1	1	1
M	North Cameron regional water treatment plant wellfield expansion	Manufacturing, Hidalgo County	160	160	160	160	160	160
M	North Cameron regional water treatment plant wellfield expansion	Manufacturing, Willacy County	85	85	85	85	85	85
M	North Cameron regional water treatment plant wellfield expansion	Primera	1	1	1	1	1	1
M	North Cameron regional water treatment plant wellfield expansion	San Juan	52	52	52	52	52	52
M	North Cameron regional water treatment plant wellfield expansion	San Perlita	7	7	7	7	7	7
M	Primera reverse osmosis plant with well	Primera	1,120	1,120	1,120	1,120	1,120	1,120
M	San Juan water treatment plant upgrade and expansion to include brackish groundwater desalination	San Juan	1,792	1,792	1,792	1,792	1,792	1,792
M	Sharyland Water Supply Corporation well and reverse osmosis unit at water treatment plant #2	Alton	189	189	189	189	189	189
M	Sharyland Water Supply Corporation well and reverse osmosis unit at water treatment plant #2	Palmhurst	90	90	90	90	90	90
M	Sharyland Water Supply Corporation well and reverse osmosis unit at water treatment plant #2	Sharyland Water Supply Corporation	621	621	621	621	621	621
M	Sharyland Water Supply Corporation well and reverse osmosis unit at water treatment plant #3	Alton	171	171	171	171	171	171
M	Sharyland Water Supply Corporation well and reverse osmosis unit at water treatment plant #3	Palmhurst	72	72	72	72	72	72

Region	Water management strategy	Water user group	Water supplies by decade (acre-feet per year)					
			2020	2030	2040	2050	2060	2070
M	Sharyland Water Supply Corporation well and reverse osmosis unit at water treatment plant #3	Sharyland Water Supply Corporation	657	657	657	657	657	657
M	Union Water Supply Corporation brackish groundwater desalination plant	Union Water Supply Corporation	560	560	560	560	560	560
N	Brackish groundwater development - Alice	Alice	3,363	3,363	3,363	3,363	3,363	3,363
O	Gaines County - Seminole groundwater desalination	Seminole	500	500	500	500	500	500
O	Hale County - Abernathy groundwater desalination	Abernathy	150	150	150	150	150	150
O	Lubbock County - Lubbock brackish well field at the south water treatment plant	Lubbock	1,120	1,120	1,120	1,120	1,120	1,120
P	Lavaca Navidad River Authority desalination - brackish groundwater	Lavaca Navidad River Authority*	-	-	-	-	-	-
		Total	**70,137**	**72,944**	**86,337**	**91,906**	**99,706**	**110,773**

Note: [*]*The strategy is currently not assigned to serve a specific water user group (in other words, the strategy is recommended but is not planned to provide water to users during the 50-year planning period).

Table A-4. Groundwater desalination alternative water management strategies in the 2017 State Water Plan

Region	Water management strategy	Water user group	Water supplies by decade (acre-feet per year)					
			2020	2030	2040	2050	2060	2070
F	Midland - development of groundwater in Midland County (previously used for mining)	Midland*	-	-	-	-	-	-
F	Odessa - develop Capitan Reef Complex Aquifer supplies in Ward County	Odessa*	-	-	-	-	-	-
F	Odessa - develop Edwards-Trinity and Capitan Reef Complex Aquifer supplies in Pecos County - I & II	Odessa*	-	-	-	-	-	-
K	City of Austin - brackish groundwater desalination	Austin	0	5,000	5,000	5,000	5,000	5,000
K	Brackish groundwater desalination	Lower Colorado River Authority*	-	-	-	-	-	-
L	Brackish Wilcox	S S Water Supply Corporation	0	0	0	0	0	1,120
L	Brackish Wilcox groundwater	San Antonio Water System*	-	-	-	-	-	-
L	Brackish Wilcox groundwater	Canyon Regional Water Authority*	-	-	-	-	-	-
L	Expanded brackish project	San Antonio Water System*	-	-	-	-	-	-
L	Brackish Wilcox	Schertz-Seguin Local Government Corporation*	-	-	-	-	-	-
M	New brackish groundwater desalination plant	Agua Supply Utility District	0	0	0	1,212	1,212	1,212
M	Agua Supply Utility District new brackish groundwater desalination plant	County-other, Hidalgo County	0	0	0	14	14	14
M	Agua Supply Utility District new brackish groundwater desalination plant	La Joya	0	0	0	40	40	40
M	Agua Supply Utility District new brackish groundwater desalination plant	Mission	0	0	0	7	7	7
M	Agua Supply Utility District new brackish groundwater desalination plant	Palmview	0	0	0	160	160	160
M	Agua Supply Utility District new brackish groundwater desalination plant	Penitas	0	0	0	130	130	130
M	Agua Supply Utility District new brackish groundwater desalination plant	Sullivan City	0	0	0	117	117	117

Region	Water management strategy	Water user group	Water supplies by decade (acre-feet per year)					
			2020	2030	2040	2050	2060	2070
M	New brackish groundwater desalination plant	Combes	0	0	0	125	125	125
M	New brackish groundwater desalination plant	Donna	700	700	700	1,000	1,000	1,000
M	New brackish groundwater desalination plant	Eagle Pass	0	0	0	560	560	560
M	New brackish groundwater desalination plant	Elsa	560	560	560	560	560	560
M	Harlingen new brackish groundwater desalination plant	Combes	0	0	21	21	21	21
M	Harlingen new brackish groundwater desalination plant	County-other, Cameron County	0	0	10	10	10	10
M	Harlingen new brackish groundwater desalination plant	East Rio Hondo Water Supply Corporation	0	0	14	14	14	14
M	New brackish groundwater desalination plant	Harlingen	0	0	888	888	888	888
M	Harlingen new brackish groundwater desalination plant	Manufacturing, Cameron County	0	0	12	12	12	12
M	Harlingen new brackish groundwater desalination plant	Military Highway Water Supply Corporation	0	0	9	9	9	9
M	Harlingen new brackish groundwater desalination plant	Palm Valley	0	0	19	19	19	19
M	Harlingen new brackish groundwater desalination plant	Primera	0	0	26	26	26	26
M	New brackish groundwater desalination plant	La Villa	560	560	560	560	560	560
M	New brackish groundwater desalination plant	Laredo	0	0	0	5,000	5,000	5,000
M	New brackish groundwater desalination plant	Mercedes	0	0	435	435	435	435
M	New brackish groundwater desalination plant	Olmito Water Supply Corporation	560	560	560	560	560	560
M	Rio Grande City new brackish groundwater desalination plant	County-other, Starr County	0	43	43	43	43	43
M	New brackish groundwater desalination plant	Rio Grande City	0	469	469	469	469	469
M	Rio Grande City new brackish groundwater desalination plant	Rio Water Supply Corporation	0	48	48	48	48	48
M	New brackish groundwater desalination plant	Santa Rosa	0	560	560	560	560	560

Region	Water management strategy	Water user group	Water supplies by decade (acre-feet per year)					
			2020	2030	2040	2050	2060	2070
M	Valley Municipal Utility District 2 new brackish groundwater desalination plant	Brownsville	0	0	0	0	10	10
M	Valley Municipal Utility District 2 new brackish groundwater desalination plant	County-other, Cameron County	0	0	0	0	3	3
M	Valley Municipal Utility District 2 new brackish groundwater desalination plant	Rancho Viejo	0	0	0	0	87	87
M	New brackish groundwater desalination plant	Weslaco	0	1,630	1,630	1,630	1,630	1,630
N	Brackish groundwater desalination - regional	Manufacturing, Nueces County	0	0	4,000	4,000	4,000	4,000
N	Brackish groundwater desalination - regional	Manufacturing, San Patricio County	0	0	4,000	4,000	4,000	4,000
N	Brackish groundwater desalination - regional	Steam-electric power, Nueces County	0	0	4,000	4,000	4,000	4,000
		Total	**2,380**	**10,130**	**23,564**	**31,229**	**31,329**	**32,449**

Note: [*]*The strategy is currently not assigned to serve a specific water user group (in other words, the strategy is recommended but is not planned to provide water to users during the 50-year planning period).