CITY OF SAN ANTONIO EDWARDS AQUIFER PROTECTION PROGRAM, OFFICE OF EASTPOINT & REAL ESTATE

ASSESSMENT OF THE CURRENT STATUS AND LONG-TERM VIABILITY OF THE CITY'S EDWARDS AQUIFER PROTECTION PROGRAM

REPORT ATN30T1

Justin A. Cleveland
Larry S. Kobayashi
Karen M. Munson
Francis J. Reilly, Jr.
Eric L. Stephens
Mark D. Woolley

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City of San Antonio Edwards Aquifer Protection Program, Office of EastPoint & Real Estate: Assessment of the Current Status and Long-term Viability of the City's Edwards Aquifer Protection Program

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Executive Summary

The City of San Antonio's Office of EastPoint & Real Estate is conducting an environmental marketing and industry analysis in connection with the City's Edwards Aquifer Protection Program. LMI examined the ongoing program for the protection of the Edwards Aquifer, which uses real estate approaches to ensure both recharge volume and quality. We obtained data from Office of EastPoint & Real Estate to evaluate the amount of real estate in the program to protect Edwards Aquifer recharge. Using a variety of sources, we estimated the recharge rate from this real estate, compared it with known and projected benchmarks for San Antonio water requirements, and compared it with water conservation efforts of New York City, El Paso, Austin, Travis County, and the State of Hawaii. We also looked at the potential for water quality issues and estimated how successful the Edwards Aquifer Protection Program could be at meeting the future needs of the City of San Antonio.

We identified a few contaminants of concern in well water samples. None are pervasive, and none are sources of surface water impairment in either the contributing zone or the recharge area for the Edwards Aquifer. Nonetheless, the City of San Antonio should consider proposed changes to land-use practices in both the contributing and recharge areas of the Edwards Aquifer.

We evaluated water, land, and voter-approved conservation initiatives administered by Austin, El Paso, and Travis County, TX; New York City; and the State of Hawaii. None of these programs are identical to San Antonio's, but Austin and New York come close. El Paso leases and acquires land for the purpose of obtaining water rights and Travis County has several separate programs related to land conservation initiatives. While none of the Travis County programs are directly related to water conservation, overlapping and/or indirect benefits of these programs are water quality and quantity conservation. Hawaii unfortunately, has no water, land, or voter approved conservation initiatives. Only San Antonio has a planned program of land protection based on known recharge rates specifically chosen to protect recharge into an aquifer that is the primary source of municipal water.

The City's Edwards Aquifer Protection Program is currently "protecting" about half (51 percent) of what it currently withdraws from the aquifer and 38 percent of its current maximum withdrawals. Most of the City's projected increase in future water will be met by the 33 billion gallons of new non-Edwards Aquifer sources currently being pursued by the San Antonio Water System (SAWS).

LMI analyzed three policy options for Edwards Aquifer Protection Program:

1. *Continuation*. Assumes that the current funding level of $90 million every 5 years is reauthorized on an ongoing basis, with no adjustments for inflation.

2. *Reduced funding*. Assumes that, starting in 2015, funding levels are reduced to $45 million authorized every 5 years on an ongoing basis. This scenario will result in fewer acres conserved and therefore a slower rate of protection of the Edwards Aquifer recharge.

3. *Discontinuation*. Assumes that the program is not reauthorized and spending for conservation ceases after 2015. No additional conservation of Edwards Aquifer recharge will take place beyond 2015.

We compared projected conservation under each option to the goals of protecting 100 percent of San Antonio's (1) projected 2060 Edwards Aquifer withdrawals, (2) current permitted Edwards Aquifer withdrawals, and (3) projected 2060 total water needs.

By 2020, continuation would achieve

- 76 percent protection of 2060 Edwards demand,
- 68 percent protection of total SAWS withdrawal permits, and
- 51 percent protection of total projected 2060 water demand.

By 2020, reduced funding ($45 million) would achieve

- 67 percent protection of 2060 Edwards demand,
- 59 percent protection of total SAWS withdrawal permits, and
- 44 percent protection of total projected 2060 water demand.

By 2020, discontinuation would achieve

- 57 percent protection of 2060 Edwards demand,
- 51 percent protection of total SAWS withdrawal permits, and
- 38 percent protection of total projected 2060 water demand.

Only an ongoing policy of continuation would achieve the goals of 100 percent protection of 2060 Edwards withdrawals and 100 percent protection of total permitted Edwards withdrawal rights. These goals would be achieved in 2030 and 2037, respectively.

Under drought conditions, the level of protection is lower because aquifer recharge rates fall: protection of aquifer supplies range from a maximum of 27 percent of withdrawals under a policy of continuation to just 12 percent of withdrawals under discontinuation (in 2060).

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Chapter 1
Introduction

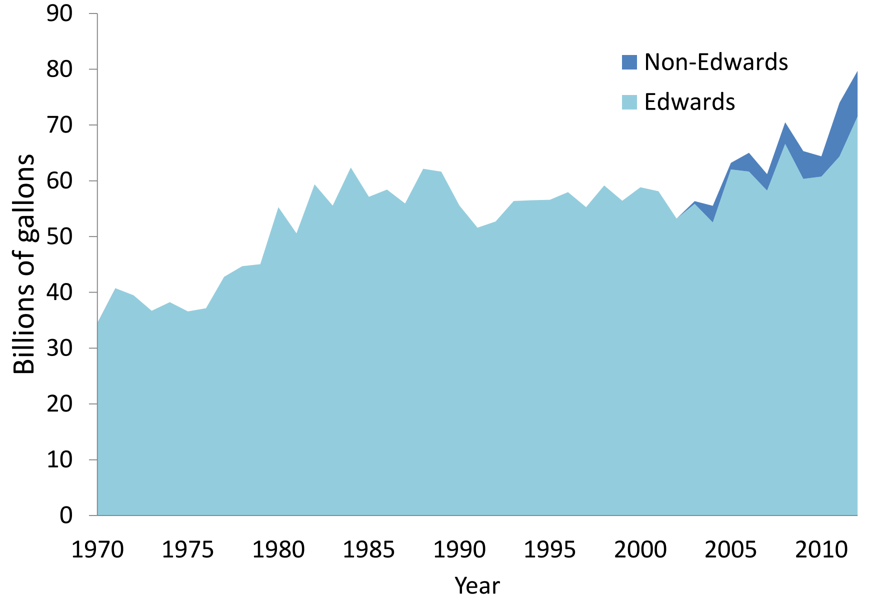
The City of San Antonio's Office of EastPoint & Real Estate is conducting an environmental marketing and industry analysis in connection with the City's Edwards Aquifer Protection Program (EAPP). It asked LMI to examine its ongoing program for the protection of the Edwards Aquifer using real estate approaches to ensure both recharge volume and quality. We also predicted the future applicability of the approach at various funding rates and compared the approach to that used by other municipalities. We worked closely with City staff to acquire the data needed to assess the program.

The Edwards Aquifer is the City of San Antonio's primary source of water. During the 20th century, the Edwards Aquifer provided virtually all of the city's water. In recent years, the San Antonio Water System (SAWS) has invested in alternative sources to decrease the city's dependence on the Edwards Aquifer. However, in 2012, the city still relied on the aquifer for 90 percent of its potable water supply.[1]

Figure 1-1 shows how the water needs of the City of San Antonio have increased over time. The demand for water has followed population growth, increasing from about 35 billion gallons in 1970 to nearly 80 billion gallons in 2012 (of which 72 billion gallons came from Edwards Aquifer). Demand for water will continue to increase as the City grows (see Chapter 4). To protect its water supply, the City of San Antonio initiated the EAPP, the goal of which is to protect the water that recharges the Edwards Aquifer by conserving the land in the aquifer's recharge and contributing zones.

[1] Throughout this analysis, we use water deliveries by SAWS as an approximation of the City of San Antonio's water needs. In 2012, SAWS merged with the former BexarMet utility, so all post-2011 numbers presented reflect the new, enlarged service area. The SAWS data are for potable water deliveries only (they do not include recycled water), and the data do not include large industrial water users. In 2012, SAWS delivered 16 billion gallons of recycled water to customers, 76 percent of which went to CPS Energy. Data from the Texas Water Development Board suggest that including industrial water users would increase water consumption figures by about 8 percent.

Figure 1-1. SAWS Potable Water Delivered, 1970–2012



Note: Graph shows potable water deliveries only; recycle water supply is not displayed.

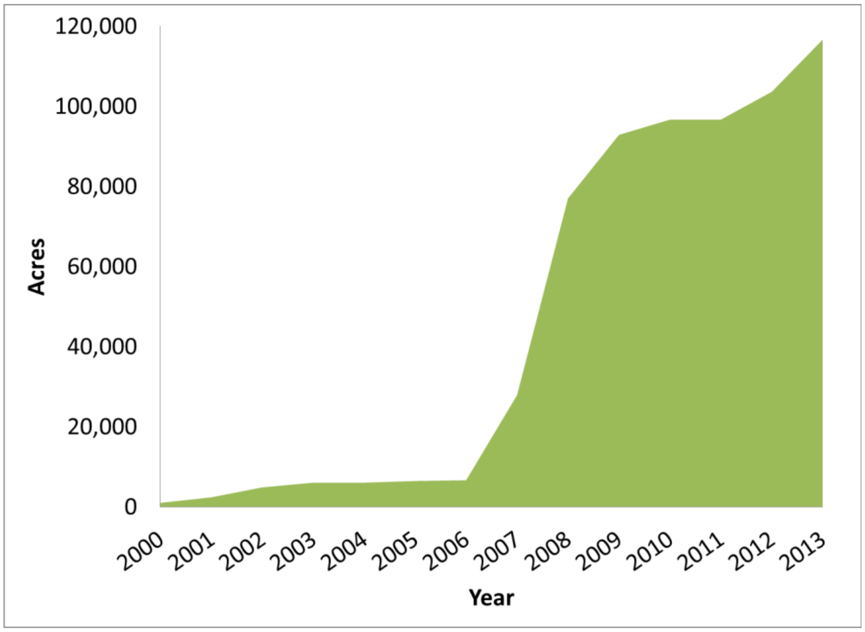
Through 2015, the City of San Antonio has authorized $225 million in total funding for the EAPP. Formally initiated in 2000, the EAPP has been funded with a 1/8 of 1 percent (0.125 percent) sales tax authorized by voter-approved propositions. Proposition 3, passed in 2000 with 55 percent voter support, authorized up to $45 million in funds. In May 2005, Proposition 1 passed with 55 percent approval and authorized an additional $90 million. Most recently, another $90 million in funding was reauthorized in November 2010, this time passing with two-thirds (66 percent) support of voters.[2]

By the end of 2013, the EAPP had conserved 116,683 acres in its target area, which includes land over the recharge and contributing zones in Bexar, Medina, and Uvalde counties. Figure 1-2 shows acreage conserved over time, demonstrating the rapid increase in conserved land under the EAPP, particularly since 2006.

Ninety-four percent of the property conserved under the EAPP uses conservation easements. Under a conservation easement, a landowner retains the deed to the property, but accepts legal limits on the types of land use and development allowed. Conservation easements are used to protect ecosystem services, such as preserving local water quality. Because they do not result in complete transfer of ownership, conservation easements are often a relatively economical means of achieving conservation goals.

[2] City of San Antonio Conservation Advisory Board presentation.

Figure 1-2. Total Acres Conserved under EAPP, by Year

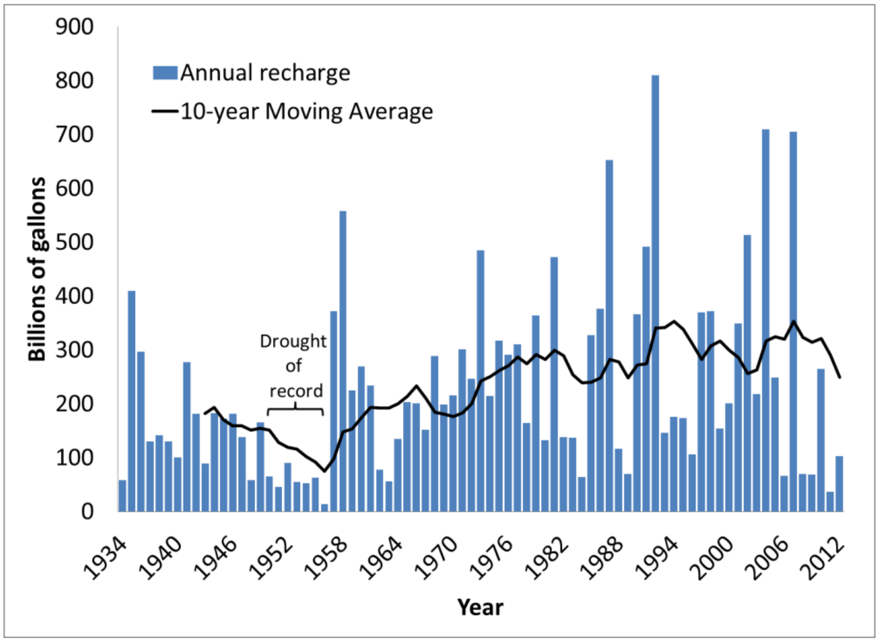


The EAPP is making steady progress toward meeting the City's goal of protecting water quantity and quality in the Edwards Aquifer. One way to measure progress is to compare the amount of annual aquifer recharge on protected land to the amount of water withdrawn for consumption by the City.

Annual recharge of Edwards Aquifer is highly variable. Figure 1-3 shows annual recharge amounts from 1934 to 2012.[3] During this period, annual recharge ranged from 14 to 810 billion gallons. Due to the high degree of interannual variability, we also show a 10-year moving average, a smoothed measure of recharge. This measure shows that average recharge rates have increased during the 20th century. However, recharge depends on a number of factors, including precipitation patterns (both quantity and temporal distribution) and the current aquifer level. The current aquifer level, in turn, depends on withdrawals and recharge in preceding years. For our analysis, we focus on recharge rates for 1980–2012, a period that corresponds most closely to recent rates of withdrawal and that is roughly consistent with World Meteorological Organization guidance for using 30-year averages for measuring "normal" precipitation levels.

[3] These data are for the San Antonio Segment of the Lower Balcones Fault Zone Edwards Aquifer and come from EAA. They are available in *Edwards Aquifer Authority Hydrologic Data Report for 2012 (Report No. 13-01)*, www.edwardsaquifer.org/scientific-research-and-reports/scientific-reports-document-library.

Figure 1-3. Annual Edwards Aquifer Recharge, 1934–2012



The average annual recharge rate in 1980–2012 was 279 billion gallons. The area of the Edwards Aquifer recharge zone is 779,566 acres. This implies an annual average of about 357,500 gallons of recharge per acre in the recharge zone.

Of the 116,683 acres currently protected by the EAPP, 101,098 acres (87 percent) are in the recharge zone. Using the average rate of recharge per acre in the recharge zone, the EAPP is currently "protecting" an average of 36 billion gallons of recharge annually. This represents about 51 percent of the 2012 Edwards Aquifer withdrawals by SAWS. In other words, under average conditions, the City of San Antonio is protecting about half what it currently withdraws from the aquifer.

Another way to analyze EAPP progress is to compare recharge protected to SAWS's total permitted withdrawals from the aquifer. SAWS currently holds permits to withdraw about 96 billion gallons per year from the aquifer (SAWS currently withdraws less from the Edwards Aquifer than its maximum permitted amount). Under average recharge conditions, the EAPP has protected 38 percent of the maximum permitted withdrawals.

However, if a prolonged drought were to occur, such as the drought of record that occurred in the 1950s, recharge would be much lower for a number of years. In recent history, the year 2011 was an extremely dry year that displayed the lowest recharge amount from 1980 to 2012: total recharge in 2011 was just 37 billion gallons, or 46,800 gallons per acre (13 percent of normal).

Under current regulations, the Edwards Aquifer Authority (EAA) can restrict withdrawals during dry conditions. Currently, the maximum restriction under extreme conditions can be as high as a 44 percent reduction of normal withdrawal rights, which would cap SAWS's Edwards withdrawals at 54 billion gallons a year—well below its 2012 Edwards withdrawal amount of 72 billion gallons. Therefore, in a drought of record scenario (using dry-weather recharge rates and assuming the full 44 percent withdrawal reduction is in place), the city's current conservation is protecting just 9 percent of its Edwards Aquifer withdrawals.

Chapter 2
Similar Municipal Programs

Table 2-1 summarizes the municipal programs we evaluated related to water, land, or voter-approved conservation initiatives. The sections that follow detail these programs.

Table 2-1. A Comparison of Municipal Conservation Initiatives

Municipality	Conservation initiative	Funding source	Expenditure	Acres protected
San Antonio	EAPP	Voter-approved sales tax (0.125%)	$225 million (through 2015)	116,683 (through 2013)
Austin	Water Quality Protection Land program	Voter-approved bonds, grants, donations	$153,494,925	26,663.25
El Paso	Water Rights Leasing Program	Information not available	Information not available	167
Travis County	Conservation Easement Program	Voter-approved bonds	$2,735,500	528
	Balcones Canyonlands Conservation Plan	Federal grants, county funds, donations	Information not available	30,438
	Land Water and Transportation Plan Parkland Acquisitions	Voter-approved bonds	$76,000,000	5,500
	Floodplain Buyout	FEMA and county funds	Information not available	Information not available
New York City	Land Acquisition Program and Watershed Agricultural Council	City funds	$301,382,714	97,704
State of Hawaii	None identified	N/A	N/A	N/A

Note: FEMA = Federal Emergency Management Agency.

City of Austin

The Austin area lies above the Barton Springs segment of the Edwards Aquifer. In 1998, voters approved a $65 million bond to purchase and manage land in this segment's watershed to protect water quality and quantity. Since 1998, several additional bond packages have been approved to protect water quality.

The result of these bond packages is the Water Quality Protection Land (WQPL) program, whose mission is to "acquire land in fee title and conservation easement in the Barton Springs contributing and recharge zones to conserve and maintain the safety of part of Austin's water supply." "The objective is to produce the optimum level of clean, high quality water from project lands to recharge the Barton Springs segment of the Edwards Aquifer."[1]

Since 1998, the City of Austin has acquired numerous parcels of land for the WQPL using primarily bond money, in addition to donations and grants provided for endangered species protection by the U.S. Fish and Wildlife Service (USFWS). Table 2-2 shows the amount of land acquired to date under Austin's WQPL program, which includes more than 26,000 acres—about 10,000 acres as fee simple and 17,000 acres as conservation easements.

Table 2-2. WQPL Land Acquisition

Land acquisition type	Total bond funds ($)	Other sources ($)	Total funding ($)	Protected acres
Fee simple tracts	104,866,686	5,101,461	109,968,147	9,882.28
Conservation easements	24,917,722	18,609,056	43,526,778	16,780.97
Total	129,784,408	23,710,517	153,494,925	26,663.25

The 26,663 acres of land were acquired for a total of $153,494,925, which equates to roughly $5,757 per acre. According to Ms. Junie Plummer, Program Manager for the City of Austin Office of Real Estate Services, all the WQPL property is purchased at or below fair market value as determined by an independent third-party appraiser. Information on the percentage of fair market value paid was not available.

According to the City of Austin, 13,688 acres of the protected land are within the Barton Springs recharge zone, about 21 percent of land within the recharge zone, and 11,869 acres of the protected land are within the Barton Springs contributing zone, about 7 percent of the total land within the contributing zone. The City of Austin also purchased 1,047 acres in the Blanco Watershed.

According to Dr. Brian Smith of the Barton Springs Edwards Aquifer Conservation District, an annual recharge rate for the Barton Springs segment of the Edwards Aquifer is not calculated as it is for the San Antonio segment. Therefore, we could not calculate the percentage of water recharge protected by conservation measures as we did for the City of San Antonio.

In addition to the WQPL program, the City of Austin has adopted eight main watershed ordinances since 1980 to protect its water supply and environmentally sensitive watersheds, several of which have been amended more than once. The ordinances include requirements related to impervious cover, density, transfer of

[1] Austin Water Utility, *Water Quality Protection Land*, austintexas.gov/department/water-quality-protection-land.

impervious cover or development rights, stormwater treatment and detention requirements, construction site management, and stream setbacks or buffer zones.[2]

Austin has also acquired conservation land as part of the Balcones Canyonlands Conservation Plan, which is discussed in the Travis County section.

CITY OF EL PASO

The Elephant Butte and Caballo Dams and Reservoirs and the associated canals and drains are collectively known as the Rio Grande Project. All waters in the reservoirs are appropriated for the downstream users of Elephant Butte Irrigation District, El Paso County Water Improvement District No. 1 (the district), and the Republic of Mexico.

In Texas, the Rio Grande Project provides water for 69,010 acres of water right lands, all of which are located within the boundaries of the district. The district contains 156 square miles, with more than 350 miles of canals and laterals in the distribution system, and more than 269 miles in the drainage system.

With an average rainfall of 8 inches per year, irrigation in the El Paso Valley depends on water received from the Rio Grande. Today, the district delivers water to more than 32,727 accounts. Although many property owners have chosen to subdivide their lands in response to the growth of the City of El Paso, the irrigation of farm land continues to account for the majority of the water used in the district.[3]

In 1962, El Paso Water Utilities (EPWU) entered into a contract with the district for leasing rights to irrigation water from property owners in the Upper Valley, Serial, and Ysleta Grants of El Paso County. While El Paso is not acquiring water rights to protect water quality, water rights acquisitions are a strategy it uses to ensure the availability of water resources into the future for city purposes, including waste water treatment, recycled water, and purple water.[4]

El Paso's Water Rights Leasing Program is available to property owners with water rights who own parcels 2.00 acres or smaller in size inside the city limits. EPWU pays the property owner a one-time lump sum of $2,500 per acre (payment is prorated for actual acreage) for a 75-year lease. EPWU pays all water rights taxes to the district (including any delinquent taxes) and cleans that portion of a community ditch associated with a leased property. All leases are carried with the property to successive owners, and the surface water rights revert back to the property owner of record at the end of the 75-year term, unless a lease is renewed. Landowners who participate in the leasing program receive a tax savings of

[2] City of Austin, *Watershed Protection Department, Watershed Ordinance History*, austintexas.gov/page/watershed-protection-ordinance.

[3] El Paso County Water Improvement District No. 1, *Our History*, www.epcwid1.org/AboutUs/About-Us.shtml.

[4] Purple water, often conveyed in purple pipes, is reclaimed water or treated sewage water.

approximately $30.00 per acre.[5] According to Ms. Lupe Cuellar, Real Estate Manager and Counsel for EPWU, El Paso currently leases approximately 167 acres.

In addition to leasing land, El Paso also owns more than 3,000 acres for the purposes of obtaining water rights. El Paso was unable to provide the amount paid for this land.

In terms of ground water quality protection, El Paso complies with the guidance and requirements from the Texas Commission on Environmental Quality (TCEQ) on aquifer protection and well contamination through its well-head protection program.

EPWU also completed a 50-year water resource management plan in 1991 (1991–2040). This plan recognizes the importance of water conservation and the increased use of surface water to meet future demands.[6]

TRAVIS COUNTY, TEXAS

Travis County has several programs related to land conservation initiatives. None are directly related to water conservation, but the overlapping or indirect benefits of these programs are water quality and quantity conservation.

Conservation Easement Program

Travis County initiated a program to conserve land (including prime farmland, cultural/historic sites, and natural resources) through conservation easement agreements with landowners. The first phase was implemented with $8.3 million of bond funds voters approved for this purpose in November 2011. In May 2012, Travis County Commissioners adopted the guidelines, applications, and a resolution supporting conservation of natural and cultural resources for this new program.[7] Table 2-3 shows the amount of land acquired to date for this program and the associated costs.

[5] EPWU, *Water Rights Leasing Program to Rio Grande Surface Water*, www.epwu.org/water/water_rights.html.

[6] EPWU, *Past and Present Water Supplies*, www.epwu.org/water/water_resources.html.

[7] Travis County, *Travis County Conservations Easement Program*, www.co.travis.tx.us/tnr/conservation_easement_program/.

Table 2-3. Travis County Land Acquisition

Year	Acres	Funding source ($)			Total ($)
		NRCS	Land trust	Travis Co.	
2011	284	1,025,000	262,500	250,000	1,537,500
2012	244	599,000	299,500	299,500	1,198,000
Totals	528	1,624,000	562,000	549,500	2,735,500

Note: NRCS = Natural Resources Conservation Service.

Travis County is also negotiating four additional conservation easements totaling 1,817 acres.

This conservation easement program is included in Travis County's Land, Water, and Transportation Plan (LWTP) discussed below as a strategy for protecting water quality and supply.

Balcones Canyonlands Conservation Plan

On May 2, 1996, USFWS issued Travis County and the City of Austin a regional permit that allows incidental "take" of eight locally occurring, federally listed endangered species, known as the Balcones Canyonlands Conservation Plan (BCCP).

To minimize and mitigate the impacts of take, the permit holders agreed to assemble and manage a minimum of 30,428 acres of endangered species habitat in western Travis County by 2016 known as the Balcones Canyonlands Preserve and secure protection for a series of karst (cave) features and rare plants throughout Travis County.[8]

The BCCP managing partners (Travis County, the City of Austin, and the Lower Colorado River Authority), in cooperation with nonprofit conservation organizations, Travis Audubon Society and the Nature Conservancy of Texas, and private landowners, have protected 30,438 acres of habitat as of FY12.[9] The total amount spent on all BCCP land acquisitions was not readily available as not all properties were "acquired." Many are owned and managed outright by the Management Agency; others were negotiated conservation easements, donated or directed to be donated by USFWS as terms and conditions of private 10(a) permits, so there was no purchase cost (grant or otherwise) to the Management Agency other than staff costs for negotiations, which Travis County does not track.

[8] Travis County, *The Balcones Canyonlands Conservation Plan*, www.co.travis.tx.us/TNR/bccp/default.asp.

[9] Travis County, *2012 Balcones Canyonlands Preserve Annual Report*, January 30, 2013, https://www.co.travis.tx.us/tnr/bccp/BCCP_Reports/2012_annual_report/2012_annual_report.asp.

According to the 2012 Balcones Canyonlands Preserve Annual Report, the permit holders and cooperating entities expended a combined total of $2,118,441 for operations and maintenance of BCCP lands in FY12.

While lands for the BCCP are conserved and managed primarily for endangered species' protection (birds, karst invertebrates), the overlapping benefit is water quality and quantity protection (to a degree) on surface with conduits (karst) to aquifer, springsheds, and surface waters.

Land, Water, and Transportation Plan

Travis County is preparing a LWTP that will include a set of long-term goals and policies the county will use to guide orderly development and the appropriate conservation of land and water resources within the unincorporated areas of Travis County. One of the growth guide principles of the LWTP is to protect uplands and riparian areas adjacent to Lake Travis, Colorado River, Pedernales River, and other significant waterways. To help do so, Travis County has begun acquiring land along waterways as parkland. Parkland acquisitions are funded through voter-approved bonds. According to Ms. Wendy Scaperotta, Planner for Travis County, the county has acquired approximately 5,500 acres for parkland for approximately $76,000,000 since 1997.

Travis County is also obtaining funds to acquire conservation easements. As another strategy for conserving land, it is trying to use a conservation development ordinance currently in place but not yet utilized.[10]

Floodplain Buyout

To reduce the loss of life and property as a result of floods, Travis County has been purchasing land in county floodplains. A corollary benefit of this program is improved water quality. According to Ms. Scaperotta, the county does not keep track of the amount spent on these buyouts. Travis County and FEMA both provide funding for this program.

NEW YORK CITY

New York City's Land Acquisition Program (LAP) seeks to prevent future degradation of water quality by acquiring sensitive watershed lands. In January 1997, New York City, New York State, the United States Environmental Protection Agency (EPA), watershed counties, towns, villages, and certain environmental and public interest groups signed the New York City Watershed Memorandum of Agreement (MOA). The MOA calls on New York City to dedicate up to $300 million to acquire 355,050 acres of eligible watershed land in the most sensitive areas of the Catskill/Delaware system. In 2007, EPA, in collaboration the New

[10] Travis County, *Draft Land Water, and Transportation Plan*, April 12, 2013, www.co.travis.tx.us/TNR/comprehensive/20130417/REPORT_ALL.pdf.

York State Department of Health and Department of Environmental Conservation, issued a 10-year filtration avoidance determination (FAD) that required the City to dedicate an additional $241 million for land acquisition in the Catskill/Delaware System. The acreage to be solicited was determined by estimating the eligible land and applying the requirements of MOA Paragraph 65, which reflects different intensities of solicitation according to the importance of each priority area.

New York City Department of Environmental Protection also funds the Watershed Agricultural Council (WAC) to support acquisition of conservation easements on operating farms in the watershed. Farms are eligible for consideration if they have a whole farm plan, a plan that circumscribes how agricultural uses can be undertaken while protecting water quality. This program also involves payment of fair market value.

As of July 1, 2009, LAP (including WAC) had acquired a total of 97,704 acres in the Catskill/Delaware System.[11] Table 2-4 shows the amount of land acquired as fee and conservation easements and the amount paid.

Table 2-4. LAP Land Acquisition

Type	Parcels	Acres	Average size (acres)	Purchase price ($)
Fee	963	62,426	65	242,505,795
Conservation easements	119	18,324	154	37,546,641
WAC conservation easements	90	16,954	188	21,330,278
Totals	1,172	97,704	83	301,382,714

State of Hawaii

The State of Hawaii has unique conservation and watershed responsibilities for almost half of the island's 1.5 million acres of forested lands.[12] At the turn of the 19th century, the then territorial government of Hawaii was forced to create and protect a large forest reserve system to protect its agricultural economy from destruction due to cattle and livestock.

Regretfully, this history of conservation and stewardship has not continued due mostly to the state's fiscal shortfalls. Despite having the 11th largest state forest reserve in the United States, the state's spending for conservation is ranked 48th, according to the Nature Conservancy.

[11] New York City Department of Environmental Protection, *Long Term Land Acquisition Plan: 2012 to 2022*, September 30, 2009, http://www.nyc.gov/html/dep/html/watershed_protection/land_acquisition.shtml.

[12] The Last Stand: The Vanishing Hawaiian Forest, The Nature Conservancy.

The state legislature passed Act 152 in 2000, establishing a watershed protection study group. The group created an extensive plan for watershed protection and funding, but it failed to receive any support or funding from the state legislature.

The one watershed conservation bright spot was the 2003 establishment of the Hawaii Association of Watershed Partnerships (HAWP), which brought together seven existing watershed partnership organizations and the State of Hawaii.[13] Since that time, four additional partnership organizations from other islands have joined the HAWP.

The HAWP works collaboratively with 71 private and public partners to protect more than 2.2 million acres of vital watershed lands. Since its formation, it has

- planted 100,000 native and endangered plants for forest restoration;
- engaged 7,000 volunteers, including community members, teachers, and school groups;
- built more than 40 miles of protective fence;
- leveraged $12 million in private and federal funds to support local jobs and businesses since 2006; and
- managed 300,000 acres for feral animals and destructive invasive plants.

The new governor, Neil Abercrombie, supports conservation programs and has slowly begun to increase state government spending to protect the watersheds and native species. He noted, “Protecting our mauka (mountain) forest area, which contain native plants and animals found nowhere else in the world, is essential to the future of agriculture, industry and our environment in Hawaii.”

The new budget for FY14 increases spending in this area and includes $3.5 million in general funds and $5 million in general obligation bond funding for watershed protection, as well as $2.5 million in bonds for the FY15.[14]

[13] *State of Hawaii Water Resources Protection Plan*, June 2008.
[14] John De Groote, *West Hawaii Today Press*, June 22, 2013.

Chapter 3
Water Quality

The karst geology of the Edwards aquifer strongly influences its water quality. The Edwards aquifer recharge zone contains faulted and fractured limestone that allows unrestricted downward movement of surface water and, potentially, contaminants into the ground water. In the confined zone, also known as the artesian zone, clay-rich, fine-grained layers create a buffer between the land surface and the Edwards aquifer, separating the aquifer from sources of vertical recharge. As a result, land use in the recharge zone influences water quality much more than in the confined zone.[1] Because most water enters the Edwards aquifer in the recharge zone, management of activities that might degrade water quality in this area (such as urban development, contaminant storage, and industrial activities) is essential for protecting water quality.

Equally important in protecting water quality in the recharge zone is the protection of stream-water quality in the contributing zone, as most of the Edwards aquifer water originates from streams in the contributing zone. Streams provide most of the recharge to the aquifer as they flow across the recharge zone. However, only 16 percent of the EAPP-protected land is in the contributing zone. As shown in Table 3-1, 809.6 linear miles of streams in the contributing zone are not located on or adjacent to conservation lands. Since the streams that provide much of the recharge to the aquifer originate in and flow through what is now presumably mostly undeveloped rangeland before reaching the recharge zone, the streams are not carrying urban or agricultural runoff in the recharge water.[2] If land use in the contributing zone changes from undeveloped rangeland to a less-water-quality-sensitive land use, it could negatively affect water quality. (We discuss industries that could have the largest impact on water quality in the following section.)

Table 3-1. Streams in Edwards Aquifer Recharge and Contributing Zones

	Stream length (miles)			% of column total		
Location[a]	Recharge zone	Contributing zone	Total	Recharge zone	Contributing zone	Total
Conservation lands on both sides	15.6	23.3	38.9	8.1	2.8	3.8
Conservation land on one side	19.9	3.2	23.1	10.3	0.4	2.2

[1] P.W. Bush et al., *Water Quality in South-Central Texas, Texas, 1996–98*: U.S. Geological Survey Circular 1212, 32 p., 2000, pubs.water.usgs.gov/circ1212/.

[2] U.S. Geological Survey (USGS), *Assessing the Vulnerability of Public-Supply Wells to Contamination: Edwards Aquifer Near San Antonio, Texas,* Fact Sheet 2011-3142, November 2011, pubs.usgs.gov/fs/2011/3142/.

Table 3-1. Streams in Edwards Aquifer Recharge and Contributing Zones

Location[a]	Stream length (miles)			% of column total		
	Recharge zone	Contributing zone	Total	Recharge zone	Contributing zone	Total
Unprotected	157.1	809.6	966.7	81.6	96.8	94.0
Total	192.6	836.1	1,028.7	100.0	100.0	100.0

[a] Conservation lands include those conserved by the City of San Antonio (EAPP, Parks, and SAWS), Nature Conservancy, Audubon Society, Texas Land Conservancy, Texas River Authority, and San Antonio River Authority; federal managed land; and private natural areas.

TCEQ and EAA have programs in place to protect water quality in the recharge and contributing zones, which include regulating the storage of certain substances and hazardous materials, regulating aboveground storage tanks and underground storage tanks located in, above, or on the recharge zone, recharge zone spill response requirements, and prohibiting the use of coal-tar-based pavement sealant products within areas on the recharge zone and on certain defined portions of the Edwards Aquifer contributing zone.[3] Other requirements include identification and protection of sensitive karst features, implementation of best management practices for mitigating stormwater quality, limitations for activities associated with potential pollutants, and requirements for well construction or plugging of abandoned wells.[4]

Current Water Quality Issues

Despite the programs in place to protect water quality, various land uses and industries impact water quality in the Edwards Aquifer. LMI investigated water quality data as well as impaired waters to understand the persistent water quality threats as well as the potential for future water quality impacts to the Edwards Aquifer.

Water Quality Studies

According to an EAA study that analyzed available water quality data collected by various agencies between 1913 and 2006 in the San Antonio segment of the Balcones Fault Zone Edwards Aquifer, concentrations of 27 parameters have exceeded protective concentration levels (PCLs) established by TCEQ.[5] EAA identified the parameters with these exceedances as constituents of concern (COCs)

[3] EAA, *Recharge Zone Protection & Management*, www.edwardsaquifer.org/recharge-zone-protection.

[4] USGS, *Assessing the Vulnerability of Public-Supply Wells to Contamination: Edwards Aquifer Near San Antonio, Texas*, Fact Sheet 2011-3142, November 2011, pubs.usgs.gov/fs/2011/3142/.

[5] EAA, *Water Quality Trends Analysis of the San Antonio Segment, Balcones Fault Zone Edwards Aquifer, Texas*, July 2009, Report No. 09-03.

because their concentrations exceeded the assimilative capacity of the aquifer.[6] The COCs include volatile organic compounds (VOCs), metals, herbicides, semi-volatile organic compounds (SVOCs), and nutrients, such as Nitrogen (N) and Phosphorus (P). This study also notes that detection of parameters that do not occur naturally in the aquifer demonstrates the aquifer's vulnerability to contamination.

Appendix A identifies the 27 COCs identified in the EAA study, as well as the potential sources of contamination as identified by TCEQ.[7] The potential sources of contamination include businesses and other activities that are known sources of surface water contamination for the COCs. Clearly, the City of San Antonio can't curtail all of these activities in the recharge area and along the feeder streams and waterways entering the recharge area from the contributing areas. However, awareness of the potential grave impacts of a fugitive emission from one of these businesses or activities should inform decision making with respect to permitted activities and long-range planning.

Metals occur naturally in surface waters and in the aquifer, but according to the EAA study, rarely exceed PCLs in the freshwater parts of the aquifer. Concentrations of metals such as arsenic, cadmium, iron, lithium, selenium, and strontium exceeded PCLs mostly in samples of saline water—more than 1,000 mg/L of total dissolved solids (TDS)—which have not traditionally been considered a suitable drinking-water source. Most of the organic contaminants (VOCs and SVOCs) do not occur naturally and are clearly the result of anthropogenic sources such as leaks or spills related to urban, agricultural, or industrial activities, especially on the recharge zone or near abandoned or poorly constructed wells.[8] Of the anthropogenic parameters, tetrachloroethene was detected most often, whereas of the naturally occurring parameters, N (in the form of nitrate) was detected most often in the freshwater part of the aquifer.[9]

Tetrachloroethylene—or tetrachloroethane, perchloroethylene, or PERC—is a chloro-carbon compound widely used in dry cleaning. It is locally abundant and exceeded the assimilative capacity near the Bandera Road Plume Superfund Site in Bexar County and in the east part of the city of Uvalde because several wells (approximately 4 in Bexar County and 14 in Uvalde County) have had consistent detections above the PCL. Tetrachloroethene was the most commonly detected anthropogenic contaminant in the EEA study.[10]

N in the form of nitrate is another consistently encountered contaminant. Although nitrate can be naturally occurring in soils, it is highly mobile in water and

[6] That is the ability of the aquifer to attenuate the concentrations of contaminants before they reach a well or spring.

[7] TCEQ, *Potential Source of Contamination Types and Subtypes: Detailed Listing, Descriptions, and Applied Contaminants*, July 23, 2010.

[8] See Note 3.

[9] See Note 3.

[10] See Note 3.

subject to bacterial remineralization to elemental N. Persistent presence in exceedance of the PCL in the wells indicates anthropogenic input. Potential sources of nitrates in the Edwards Aquifer region include fertilizers, precipitation, and human and animal waste. Along with lithium and strontium, it was the most commonly detected exceedance among parameters known to be naturally occurring.

The saline waters studied also showed the presence of selenium, lithium, arsenic, and cadmium. These elements are naturally occurring in the soils of this region. These saline waters were not considered to be a drinking water source by the study authors. However, SAWS plans to begin desalinization indicate that saline waters may well be considered part of the water supply in the future. Desalinization technologies have the ability to remove or attenuate the concentration of these elements, but requirements to remove these elements may change the technology requirement and therefore increase the cost of the technology solution chosen.

Impaired Surface Water

In addition to analyzing water testing data, we analyzed impaired waters listings in the recharge and contributing zones. The EPA maintains a database of impaired waters, those that fail to attain the quality required for their designated use. In other words, they are too polluted or otherwise degraded to meet the water quality standards set by states, territories, or authorized tribes. Table 3-2 shows the surface waters that impinge that have been identified as impaired in the Edwards Aquifer recharge zone and contributing area from which SAWS withdraws water.

Table 3-2. Impaired Waters in Edwards Aquifer Recharge Zone and Contributing Area

Watershed name	Water ID	Water name	Cause of impairment	Cause category	Designated use impairment	Probable source
Upper San Antonio	TX-1910_07	Salado Creek	Impaired macrobenthos community	Cause unknown—impaired biota	Aquatic life use	Unknown
Upper Frio	TX-2113_01	Upper Frio River	Impaired fish community Impaired macrobenthos community	Cause unknown—impaired biota	Aquatic life use	Unspecified nonpoint source Source unknown

Source: EPA, Water Quality Assessment and Total Maximum Daily Loads Information, www.epa.gov/waters/ir/index.html.

Two watersheds are identified in the EPA list of impaired waters, each with several impaired reaches. The reason given for the impairment is impaired biota. In other words, fauna are not present in the numbers and ratios expected of those waters. No specific contaminants are identified as causative agents for this impairment.

In our experience, impairments to aquatic life not associated with specific contaminants are usually attributed to issues with adjacent and upstream land use, particularly land disturbance. The land use contributes excess sediment or decreases dissolved oxygen content due to sedimentation, impacting the expected habitat.

The salient issue is that no contaminants are identified in these stream segments that could enter the aquifer and become a cause of concern for Edwards Aquifer water quality. The impairments are real and a concern with respect to the quality of the surface water, but not likely to become a concern for ground water in the aquifer or concern to SAWS.

HUMAN POPULATION IMPACTS ON WATER QUALITY

According to Texas State Data Center, the greater San Antonio metropolitan area is projected to grow by more than 60 percent from 2010 to 2050 (2.1 million to 3.4 million people).[11] Urban development has already been known to affect water quality in the Edwards Aquifer. In a 2011 study,[12] Mahler documents degradation to ground water quality after rapid urban development in areas supplying recharge to the Barton Springs segment of the Edwards Aquifer. The area contributing recharge to Barton Springs has rapidly grown since 2000, accompanied by increased generation of wastewater. The study found that nitrate, a major component of wastewater and a nutrient that can degrade water quality, has increased in Barton Springs and the creeks that provide its recharge. Key findings of the study are as follows:

- Nitrate concentrations in Barton Springs and the five streams that provide most of its recharge were much higher in 2008–10 than before 2008.
- Biogenic nitrogen (nitrogen from human or animal waste, or both) is a probable source of nitrate measured in the recharging streams in 2008–10.
- Septic systems and land-applied treated wastewater effluent are likely sources contributing nitrate to the recharging streams.

These findings imply that San Antonio should discourage permits for septic systems and land application of treated waste water in the recharge and contributing zones. The current approach of obtaining land in fee or through conservation easement can alleviate ground water contamination through nitrate nitrogen. Limitation or regulation and inspection of land alteration or installation of septic

[11] http://txsdc.utsa.edu/Data/TPEPP/Projections/Index.aspx.

[12] USGS, *Nitrate Concentrations and Potential Sources in the Barton Springs Segment of the Edwards Aquifer and its Contributing Zone, Central Texas*, Fact Sheet 2011-3035, May 2011, http://pubs.usgs.gov/fs/2011/3035/.

systems should remain a part of the controls placed on land obtained for the protection of recharge area.

Development in recharge areas has the potential to directly and indirectly impact surface and ground water quality. Direct impacts such as septic leachate to both surface and ground water can cause nitrate nitrogen contamination. Development that encourages lawns, confined animal feeding operations, or intensive agricultural will likewise have the potential to increase the amount of nitrate nitrogen in surface and ground water. Indirect impacts should also be considered. Clearing of land, disturbing land without a buffer strip adjacent to surface waters, and development of land all increase erosion and allow entrainment of contaminants associated with the dissolved solids to enter streams, rivers, and eventually ground water.

Chapter 4
Future Program Options

LMI analyzed three policy options for the EAPP future. For each, we projected the aquifer recharge protected and compared it with projections of the City's future water needs as estimated by SAWS. In this section, we define each policy option, describe our projection method and key assumptions, and present the results. Finally, we analyze each option for its relative effectiveness in meeting the City's future water needs by conserving Edwards Aquifer recharge.

We compared projected conservation under each option to the goals of protecting 100 percent of San Antonio's (1) projected 2060 Edwards Aquifer withdrawals, (2) current permitted Edwards Aquifer withdrawals, and (3) projected 2060 total water needs.

The three policy options were as follows:

1. *Continuation.* Assumes that the current funding level of $90 million every 5 years is reauthorized on an ongoing basis, with no adjustments for inflation.

2. *Reduced funding*. Assumes that, starting in 2015, funding levels are reduced to $45 million authorized every 5 years on an ongoing basis. This scenario will result in fewer acres conserved and therefore a slower rate of protection of the Edwards Aquifer recharge.

3. *Discontinuation*. Assumes that the program is not reauthorized and spending for conservation ceases after 2015. No additional conservation of Edwards Aquifer recharge will take place beyond 2015.

Projection Method

LMI projected the City's future water needs using a method developed by SAWS and estimated the Edwards Aquifer recharge that would be protected under each EAPP policy option. To estimate recharge protected, LMI projected future costs of land conservation by escalating recent EAPP land acquisition costs at average regional land price growth rates. Next, for each policy option we estimated the number of acres conserved every year by dividing the annual funding level by the projected land acquisition price. Finally, we expressed the acreage conserved in terms of Edwards Aquifer recharge conserved by multiplying the acreage conserved by average recharge rate per acre for the period 1980–2012. This allows a comparison of Edwards Aquifer recharge "protected" under each scenario to the City's future water needs. We used nominal prices (escalated over time) in our analysis to be consistent with the assumption that program reauthorization amounts would not be adjusted upward for inflation. The sections below describe each step of the method in greater detail.

SAWS Water Projections

Our analysis follows the water demand projection method SAWS used in its 2012 Water Management Plan.[1] This method projects the high end of future water needs by estimating consumption in a dry year. The SAWS projections assume an increase in total potable water demand proportional to population growth.[2]

We estimate demand for potable water from the Edwards Aquifer by subtracting current and total projected non-Edwards Aquifer potable water sources from the projected demand. Current non-Edwards Aquifer potable water sources include water from Medina Lake, Trinity Aquifer, Canyon Lake, Carrizo Aquifer (online in late 2013), Lake Dunlap, and Wells Ranch.[3] SAWS plans to develop the following additional resources (Table 4-1): brackish ground water desalination plant (10 billion gallons by 2026), expanded Carrizo Aquifer production (7 billion gallons by 2026), and a regional water supply project (16 billion gallons by 2018).[4] The capital investment needed to establish these sources is estimated at $557 million between 2012 and 2030.[5]

Table 4-1. SAWS Planned New Water Resources

Source and year online	Gallons (billions)	Total achieved
Ground water desalinization by		
2016	3.98	3.98
2021	3.98	7.96
2026	1.99	9.95
Carrizo, by		
2017	2.28	2.28
2022	2.28	4.56
2026	2.28	6.84
Regional water supply project, 2018		16.29

[1] SAWS, *2012 Water Management Plan*, www.saws.org/your_water/waterresources/2012_WMP/.

[2] The method employs assumptions regarding consumption measured in gallons per capita per day (GPCD), then uses population projections to estimate total consumption. The *2012 Water Management Plan* assumes that dry-year GPCD falls from 143 in 2011 to 135 in 2020, and then stays at 135. In contrast to the *2012 Water Management Plan*, we display this efficiency gain as decreased demand rather than another supply source.

[3] SAWS, *Current Water Supply Projects*, www.saws.org/your_water/waterresources/projects/.

[4] See Note 1. In addition, SAWS plans to purchase a small amount of additional Edwards Aquifer withdrawal permits (about 3.6 billion gallons). Our analysis does not incorporate these planned purchases.

[5] See Note 1.

If all these projects are realized, SAWS will expand potable water supplies available to San Antonio by 33 billion gallons by 2026 (Table 4-2), substantially decreasing the demands on the aquifer. (SAWS also delivers recycled water, but our analysis focuses on potable water only.) We assume these new resources are fully utilized in the future. In reality, this utilization and demand on the aquifer will vary, depending on a number of factors, so our projections only roughly approximate what future withdrawals will be.

Table 4-2. SAWS Planned New Water Resources

Year	Total new gallons (billions)
2016	3.98
2017	6.26
2018	22.55
2019	22.55
2020	22.55
2021	26.53
2022	28.81
2023	28.81
2024	28.81
2025	28.81
2026	33.08

Land Acquisition Costs

Land acquisition costs for the EAPP include the cost of appraisal, survey, environmental site assessments, baseline environmental documentation reports, land acquisition team, title and legal fees, and the conservation easement (or property deed) purchase. These costs vary on the basis of the number of acres or parcels acquired. Land acquisition costs for properties purchased in 2012 and 2013 averaged $1,520 per acre, 96 percent of which was for the purchase of the conservation easement.[6] In addition, the EAPP incurs capital administration costs averaging of $175,843 per year; this is a fixed cost incurred regardless of the number of acres or parcels purchased.

Rate of Land Acquisition Cost Inflation

To estimate future land acquisition costs for EAPP, we escalated the costs described above using historic rate of land price growth for the San Antonio region.

[6] According to an Interlocal Agreement, the EAA prepares and implements Conservation Easement Management and Monitoring Plans for each EAPP property. Under this agreement, the EAA bears all of its own program costs. All scenarios assume that the Interlocal Agreement continues throughout the timeframe analyzed.

According to data from the Real Estate Center at Texas A&M University, nominal rural land prices in the land market area that includes Uvalde and Medina counties (LMA 10) increased at average annual rate of 4.9 percent from 1980 to 2012 (the median year-over-year rate for the period was 5.0 percent). In the land market area including Bexar county and other parts of the San Antonio metropolitan area, rural land prices increased at an average annual rate of 6.1 percent (the median year-over-year rate was 6.0 percent).[7] For our analysis, we assume land acquisition costs will rise at a nominal rate of 5.5 percent annually. We assume capital administrative costs will increase at a nominal rate of 3 percent annually, a rate approximately equal to the long-run rate of inflation in the economy.[8] These assumptions allowed us to estimate the future cost of land conservation for each year of the analysis time period. For each year, we divided the assumed funding levels by the price of land, yielding an estimate of the total land conserved under each policy option.

Recharge Rates

Finally, we estimated the total recharge protected under each policy option by multiplying the estimated acreage conserved by the average recharge rate per acre. We performed our analysis using historic average recharge rates in 1980–2012, as obtained from EAA. As noted in Chapter 1, the average annual recharge rate in 1980–2012 was 279 billion gallons. The area of the Edwards Aquifer recharge zone is 779,566 acres. This implies an annual average of about 357,500 gallons of recharge per acre in the recharge zone. Primary projections reflect the average recharge rate for the period, but we also discuss the impact of a prolonged drought on the projections.

PROJECTIONS

Demand for potable water in the City of San Antonio is projected to increase by 61 percent from 2012 to 2060, reaching 128 billion gallons by 2060 (Figure 4-1). Total SAWS demand is projected to remain mostly flat through 2020 as projected efficiency gains decrease the amount of water used per capita and offset increased demand from population increases.[9] In addition, SAWS planned investments in new non-Edwards water resources between now and 2030 steadily decrease the amount needed from the aquifer. From current SAWS plans for alternative water resource development, we estimate that, under average conditions, about 67 percent of 2060 demand (85 billion gallons) will be met by the Edwards Aquifer, down from 90 percent in 2012. The projected 2060 demand from Edwards

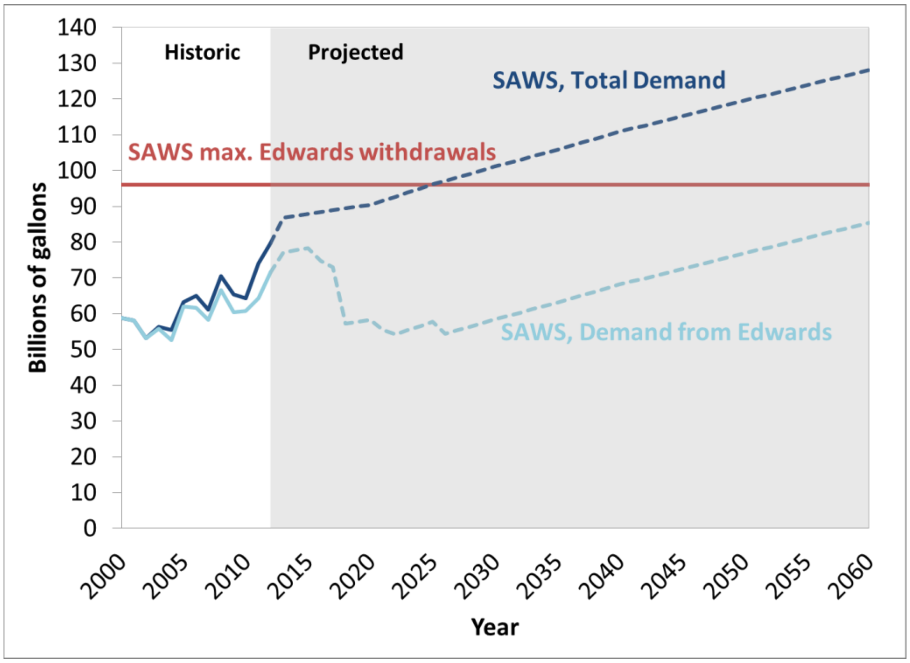
[7] Real Estate Center at Texas A&M University, *Texas Rural Land*, recenter.tamu.edu/data/rland/.

[8] Price escalation measured by the Bureau of Labor Statistics (BLS) for the 1913–2012 and 1980–2012 averaged 3.23 percent and 3.25 percent, respectively. BLS, *Consumer Price Index, All Urban Consumers (CPI-U), U.S. city average*, ftp.bls.gov/pub/special.requests/cpi/ cpiai.txt.

[9] See Note 1. Efficiency gains are expected due to decreased use of water for lawns and landscaping and more efficient toilets, washing machines, and industrial processes.

Aquifer is below the current maximum normal year withdrawals—96 billion gallons—permitted by SAWS.

Figure 4-1. Past and Projected SAWS Water Demand, 2000–60



Using the method described in the preceding section, we projected the acreage and recharge conserved in each year of the analysis period, under each policy option. Table 4-3 shows near-term projections for the total recharge protected by policy option. Based on recent land prices and previously authorized funding for EAPP, we estimate that about 137,100 acres will be conserved under the EAPP by 2015. At an average recharge rate of 357,000 billion gallons per acre, the program will be "protecting" about 49 billion gallons of recharge annually by 2015. Under a policy of discontinuation, no further acreage would be conserved beyond 2015, so the amount of recharge protected would remain fixed at 49 billion gallons between 2015 and 2020. At a reduced funding level ($45 million), additional acreage would be conserved leading to an increase of recharge conservation to 57 billion gallons by 2020. Under continuation ($90 million) conservation would reach 65 billion gallons by 2020.

Table 4-3. Estimated Recharge Protection in 2015 and 2020 (billions of gallons)

Year	Continuation ($90 million)	Reduced ($45 million)	Discontinuation
by 2015	49	49	49
by 2020	65	57	49

Figure 4-2 shows the projected path of conservation efforts under each policy option, assuming each option continues indefinitely into the future. As mentioned previously, under discontinuation, recharge protected remains fixed at 49 billion gallons beyond 2020. In contrast, under a policy of continuation, recharge conservation continues steadily to 111 billion gallons by 2060. At a reduced level of funding ($45 million), conservation increases but at a lower rate, reaching 79 billion gallons by 2060. The projected paths of continuation and reduced funding are not linear (the rate at which protected recharge increases falls over time) due to the assumption that the nominal 5-year funding level remains fixed while the nominal price of land acquisition costs continues to rise.

Figure 4-2. EAPP Recharge Protection Options, Average Recharge Rates

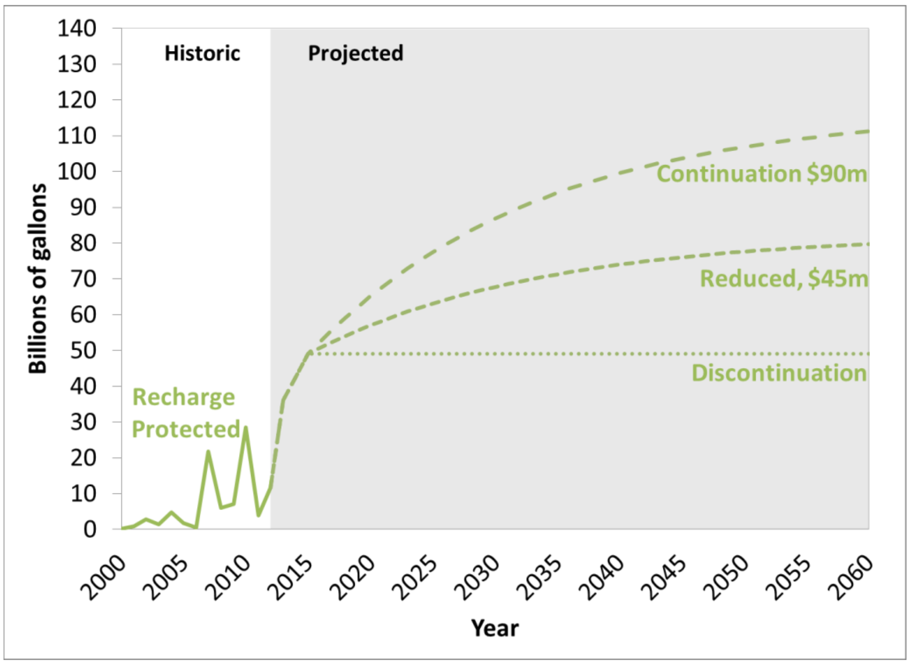
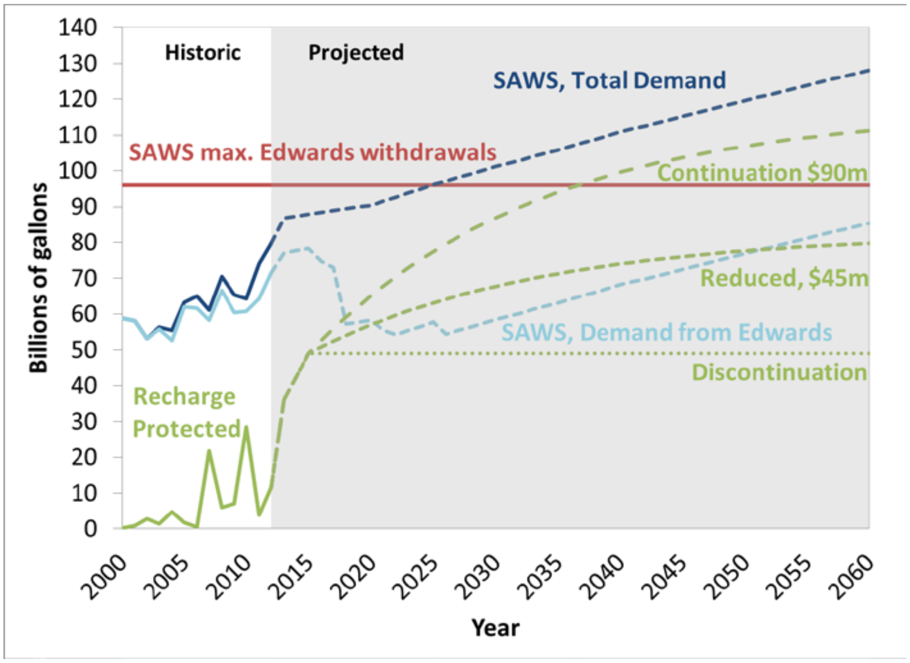


Figure 4-3 combines the data on projected future water needs (Figure 4-1) and projected recharge protection (Figure 4-2) on a single graph, allowing a comparison of future needs to the expected outcome of each policy option.

Figure 4-3. EAPP Recharge Protection Options Compared with Future Water Needs, Average Recharge Rates



Figures 4-4 through 4-6 show the projected path under each policy option in terms of its progress (in percent) toward meeting goals of protecting 2060 Edwards Aquifer withdrawals, protecting current total permitted Edwards Aquifer withdrawals, and protecting 2060 total water demand. Table 4-4 shows the exact percent progress against each of these goals expected to be met by 2020, and the year in which each goal would be completely achieved (100 percent completion).

Program continuation would achieve 76 percent protection of 2060 Edwards demand by 2020, but only 68 percent protection of total SAWS withdrawal permits. It would achieve 51 percent protection of total projected 2060 water demand (from both Edwards and non-Edwards sources).

By 2020, a policy of reduced funding ($45 million) would achieve 67 percent protection of 2060 Edwards demand, 59 percent protection of total SAWS withdrawal permits, and 44 percent protection of total projected 2060 water demand.

In contrast, a policy of program discontinuation would achieve lower levels of protection by 2020: 57 percent protection of 2060 Edwards demand, 51 percent protection of total SAWS withdrawal permits, and 38 percent protection of total projected 2060 water demand.

Figure 4-4. Share of 2060 Edwards Aquifer Withdrawals "Protected" by Policy Option

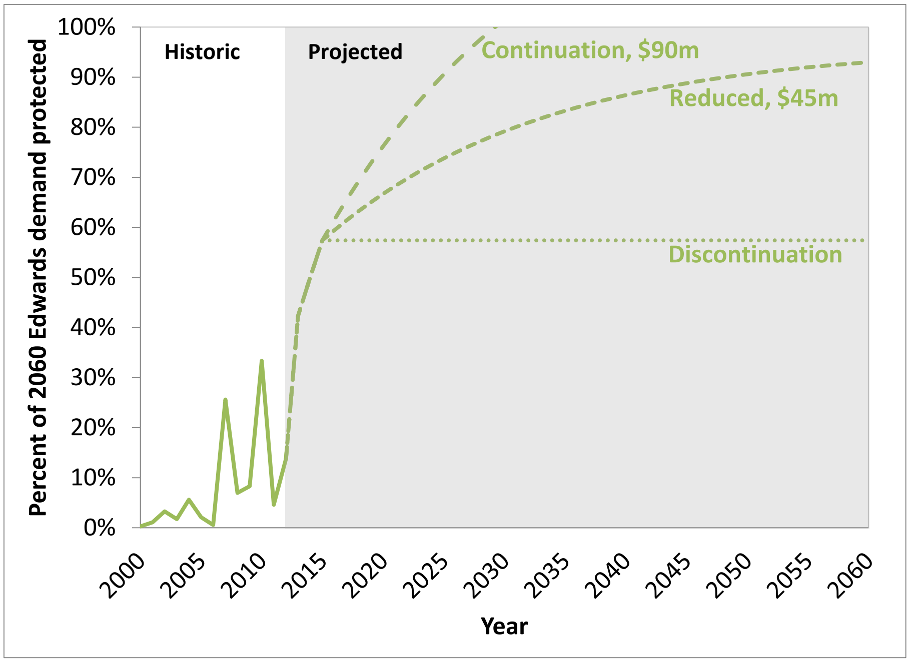


Figure 4-5. Share of SAWS Current Maximum Edwards Aquifer Withdrawals "Protected" by Policy Options

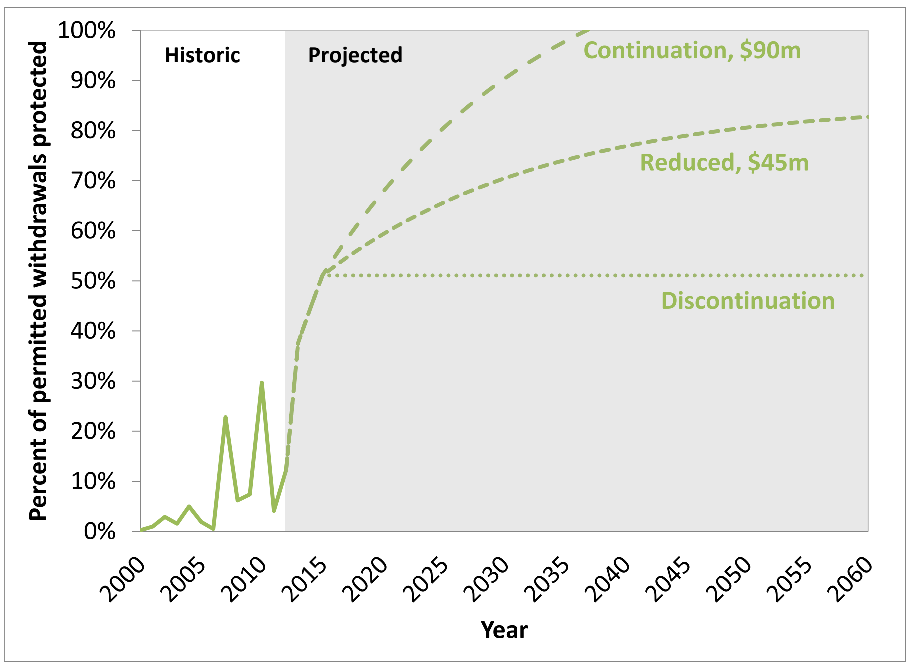


Figure 4-6. Share of 2060 Total Water Demand "Protected" by Policy Options

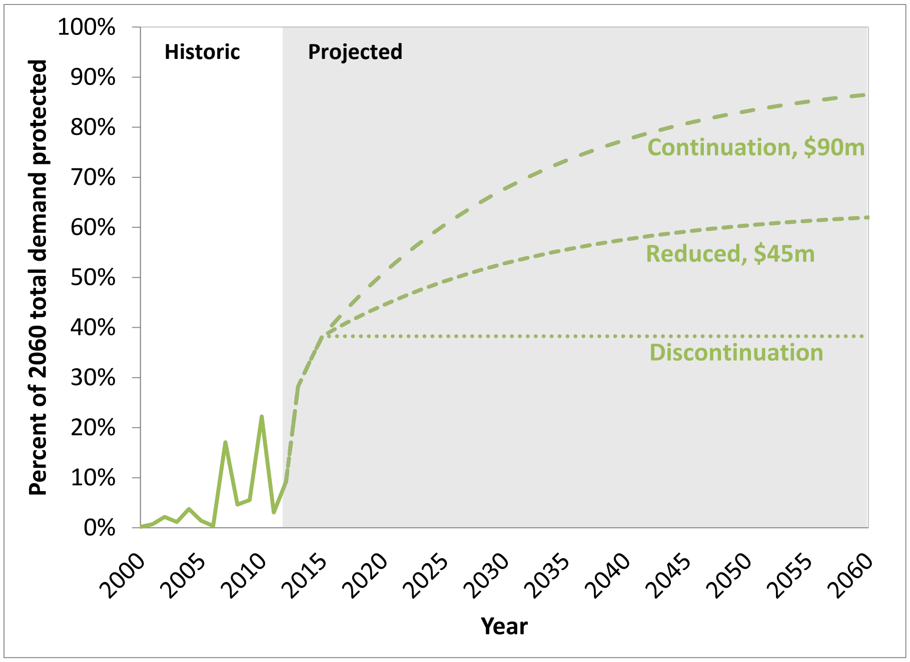


Table 4-4. Summary of Policy Options by Policy Goal

Goal	Continuation ($90 million)	Reduced ($45 million)	Discontinuation
In 2020, % achievement of goal:			
◆ Protection of 2060 Edwards demand	76%	67%	57%
◆ Protection of current permitted withdrawal	68%	59%	51%
◆ Protection of 2060 total demand	51%	44%	38%
Year achieving 100% of goal:			
◆ Protection of 2060 Edwards demand	2030	Never	Never
◆ Protection of current permitted withdrawal	2037	Never	Never
◆ Protection of 2060 total demand	Never	Never	Never

Based on the assumptions described above and summarized in the next section, only a policy of program continuation would ever achieve 100 percent achievement of the goals of protecting 2060 Edwards Aquifer withdrawals (by 2030) and protecting current total permitted Edwards Aquifer withdrawals (by 2037). A reduced funding level would never achieve these goals, and none of the policy options would achieve recharge protection equal to total 2060 projected water demand.

Sensitivities and Caveats

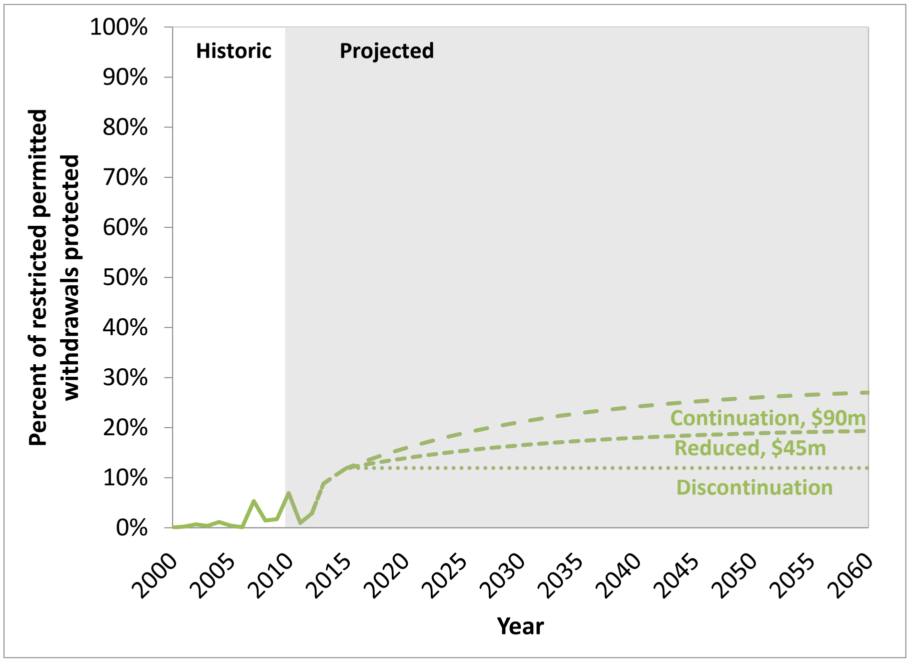
Our analysis and conclusions are based on the assumptions described above. Alternative assumptions would result in differing conclusions. We discuss the key assumptions briefly below.

In its *2012 Water Management Plan*, SAWS describes plans to secure alternative sources of water, thereby reducing reliance on the Edwards Aquifer. Should these alternative water sources not be realized, the City may find itself withdrawing more water from the aquifer in the future than reflected here. This would require the City to increase the amount of funding needed to protect future withdrawals.

The amount of land protected at a given funding level depends on assumptions of price inflation for land acquisition costs. If the fees required to obtain the easements increase more quickly (or slowly) than the assumed 5.5 percent per year, then a given level of funding would yield fewer (or more) acres of land protected. In addition, rural land prices in the areas near San Antonio have increased at rates well above the general rate of inflation. Assuming sales tax revenues increase at the rate of inflation implies that purchasing conservation easements in the near-term may present a greater value for the City than postponing conservation into the future. In other words, if historic trends continue, postponing conservation for another 20 or 30 years could result in the City’s paying substantially more for the same land, even after adjusting for inflation.

Our analysis of aquifer recharge “protected” is based on 30-year average annual recharge rates. However, as discussed earlier, recharge rates vary greatly. In a year as dry as 2011, recharge rates are just 13 percent of an average year’s rate. In addition, in a prolonged drought, current regulations can reduce Edwards Aquifer withdrawals by up to 44 percent. To illustrate the potential impact, Figure 4-7 shows progress toward meeting the goal of protecting 100 percent of current permitted withdrawals, assuming a full 44 percent restriction is in place and assuming dry-year recharge rates. Drought condition protection ranges from a maximum of 27 percent under program continuation to just 12 percent under discontinuation (in 2060).

Figure 4-7. Share of Current Permitted Withdrawals under Full 44 Percent Restriction Protected Using Dry-Year Recharge Rates

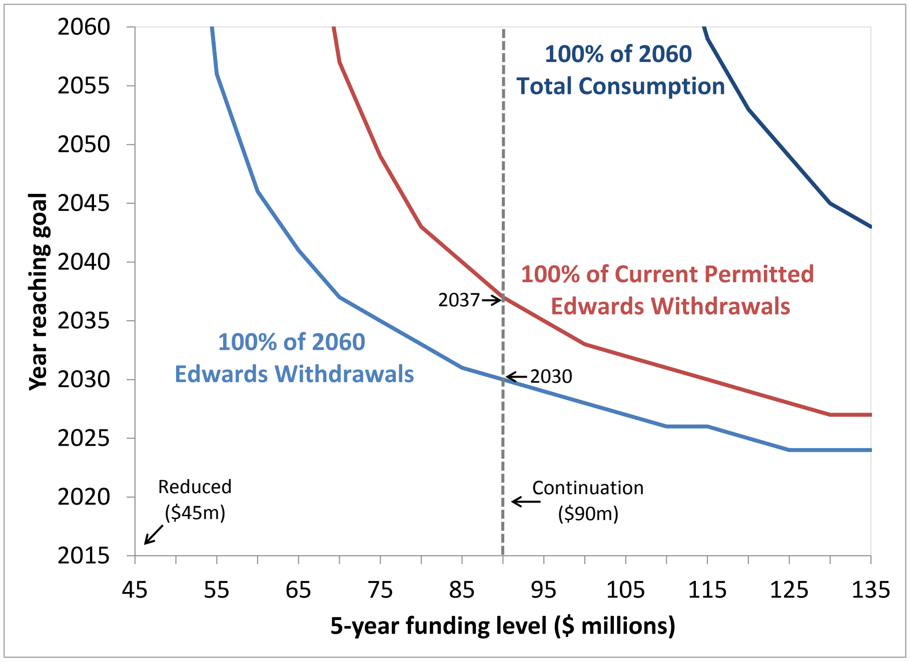


The water being withdrawn from the aquifer by SAWS for the City's use is not necessarily the recharge being protected by the EAPP. Water withdrawal rights are not currently connected to land conservation in the recharge zone. There is no guarantee that conserving land over the recharge zone will directly protect the City's water.

Finally, we present an analysis of how the year achieving policy goals varies by funding level. Figure 4-8 charts the year that each of the following goals are achieved (y-axis) for a giving funding level (x-axis): protecting 2060 Edwards Aquifer withdrawals, protecting current total permitted Edwards Aquifer with-drawals, and protecting 2060 total water demand.

The chart indicates the points at which a policy of continuation ($90 million fund-ing) would lead to meeting the goal of protecting 2060 Edwards demand (in year 2030), and protecting 100 percent protection of current permitted withdrawals (by 2037). It also shows the potential gains from increasing funding levels. For in-stance, increasing funding to $135 million every 5 years would lead to protecting 100 percent of 2060 Edwards withdrawals by 2024 and protect 100 percent of current permitted withdrawals by 2027. In addition, a funding level of $135 mil-lion would protect recharge amounts equal to 100 percent of total 2060 water de-mand.

Figure 4-8. Year Achieving Goals by 5-year Funding Level



Appendix A

Potential Sources of Contamination for Edwards Aquifer Constituents of Concern

Edwards Aquifer Constituent of Concern[a]	Potential Sources of Contamination[b]
1,2-Dibromoethane	None identified
1,2-Dichloroethane	GRAIN ELEVATOR
	METAL PLATING BUSINESS
1,2-Dichloropropane	ORGANIC CHEMICAL INDUSTRY
	PESTICIDE MFG, SALE, APPLICATION
	PESTICIDE, FERTILIZER MFG, SALE, APPLICATION
	PHOTO PROCESS BUSINESS
	PLASTIC MFG, SALE
	CLASS V INJECTION WELL: TRASH BURNING WELL
	WASTEWATER: INDUSTRIAL WASTEWATER OUTFALL
	WASTE: DOMESTIC TRASH OR BURN PILE
	WASTE: MUNICIPAL SOLID WASTE - ABANDONED, TCEQ
	WASTE: MUNICIPAL SOLID WASTE - ACTIVE, TCEQ
	WASTE: TRANSFER STATION
Antimony	AUTO PARTS BUSINESS (NEW, USED),
	AUTO REPAIR, SALES, SALVAGE, TOWING
	INORGANIC CHEMICAL INDUSTRY
	METAL PLATING BUSINESS
	ORGANIC CHEMICAL INDUSTRY
	PAINT SHOP
	PLASTIC MFG, SALE
	FIREWORKS BUSINESS (MFG OR RETAIL)
	CLASS V INJECTION WELL: UNTREATED SEWAGE
	CLASS V INJECTION WELL: STORM DRAINAGE
	CLASS V INJECTION WELL: TRASH BURNING WELL
	GUN RANGE: GUN RANGE
	GUN RANGE: PUBLIC OR PRIVATE
	GUN RANGE: MILITARY

Edwards Aquifer Constituent of Concern[a]	Potential Sources of Contamination[b]
	WASTEWATER: WASTEWATER
	WASTEWATER: HOLDING POND
	WASTEWATER: INDUSTRIAL WASTEWATER OUTFALL
	WASTEWATER: LAND APPLICATION SLUDGE
	WASTEWATER: LIFTSTATION
	WASTEWATER: PIPELINE
	WASTEWATER: MUNICIPAL WASTEWATER OUTFALL
	WASTEWATER: TREATMENT PLANT
	WASTEWATER: PRIVATE WASTEWATER OUTFALL
	WASTEWATER: WASTEWATER BIOSOLIDS PROCESSING PLANT
	TRANSPORTATION: HIGHWAY
	WASTE: DOMESTIC TRASH OR BURN PILE
	WASTE: MUNICIPAL SOLID WASTE - ABANDONED, TCEQ
	WASTE: MUNICIPAL SOLID WASTE - ACTIVE, TCEQ
	WASTE: TRANSFER STATION
	WASTE: COAL COMBUSTION PRODUCT DISPOSAL
Arsenic	AUTO PARTS BUSINESS (NEW, USED)
	AUTO REPAIR, SALES, SALVAGE, TOWING
	COTTON GIN
	GOLF COURSE
	INORGANIC CHEMICAL INDUSTRY
	METAL PLATING BUSINESS
	ORGANIC CHEMICAL INDUSTRY
	PAINT SHOP
	PESTICIDE MFG, SALE, APPLICATION
	PESTICIDE, FERTILIZER MFG, SALE, APPLICATION
	PETROLEUM CHEMICAL INDUSTRY
	PHOTO PROCESS BUSINESS
	PULP OR PAPER MILL
	WOOD PRESERVING
	FIREWORKS BUSINESS (MFG OR RETAIL)
	CLASS III INJECTION WELL: URANIUM
	CLASS V INJECTION WELL: UNTREATED SEWAGE
	CLASS V INJECTION WELL: CESSPOOL
	CLASS V INJECTION WELL: STORM DRAINAGE
	CLASS V INJECTION WELL: SEPTIC UNDIFFERENTIATED

Edwards Aquifer Constituent of Concern[a]	Potential Sources of Contamination[b]
	CLASS V INJECTION WELL: SEPTIC DRAINFIELD
	CLASS V INJECTION WELL: TRASH BURNING WELL
	WASTEWATER: WASTEWATER
	WASTEWATER: HOLDING POND
	WASTEWATER: INDUSTRIAL WASTEWATER OUTFALL
	WASTEWATER: LAND APPLICATION SLUDGE
	WASTEWATER: LIFTSTATION
	WASTEWATER: PIPELINE
	WASTEWATER: SEPTIC SYSTEM
	WASTEWATER: MUNICIPAL WASTEWATER OUTFALL
	WASTEWATER: TREATMENT PLANT
	WASTEWATER: PRIVATE WASTEWATER OUTFALL
	WASTEWATER: CESSPOOL
	WASTEWATER: WASTEWATER BIOSOLIDS PROCESSING PLANT
	TRANSPORTATION: AIRPORT
	TRANSPORTATION: HELIPORT
	TRANSPORTATION: HIGHWAY
	TRANSPORTATION: MILITARY AIR BASE
	WASTE: DOMESTIC TRASH OR BURN PILE
	WASTE: MUNICIPAL SOLID WASTE - ABANDONED, TCEQ
	WASTE: MUNICIPAL SOLID WASTE - ACTIVE, TCEQ
	WASTE: TRANSFER STATION
	WASTE: CATTLE DIPPING VAT
	WASTE: COAL COMBUSTION PRODUCT DISPOSAL
	ANIMAL FEEDING OPERATION: ANIMAL FEEDING OPERATION, NOT SPECIFIC
	ANIMAL FEEDING OPERATION: POULTRY
	ANIMAL FEEDING OPERATION: POULTRY: CHICKEN
	ANIMAL FEEDING OPERATION: POULTRY: CHICKEN, BROILER
	ANIMAL FEEDING OPERATION: SWINE
Atrazine	GOLF COURSE
	ORGANIC CHEMICAL INDUSTRY
	PESTICIDE MFG, SALE, APPLICATION
	PESTICIDE, FERTILIZER MFG, SALE, APPLICATION
	PETROLEUM CHEMICAL INDUSTRY
	CEMETERY: CEMETERY
	CLASS V INJECTION WELL: STORM DRAINAGE

Edwards Aquifer Constituent of Concern[a]	Potential Sources of Contamination[b]
	CLASS V INJECTION WELL: TRASH BURNING WELL
	WASTEWATER: INDUSTRIAL WASTEWATER OUTFALL
	TRANSPORTATION: HIGHWAY
	WASTE: DOMESTIC TRASH OR BURN PILE
	WASTE: MUNICIPAL SOLID WASTE - ABANDONED, TCEQ
	WASTE: MUNICIPAL SOLID WASTE - ACTIVE, TCEQ
	WASTE: TRANSFER STATION
Benzene	AUTO PARTS BUSINESS (NEW, USED)
	AUTO REPAIR, SALES, SALVAGE, TOWING
	DRY CLEANER
	GOLF COURSE
	INORGANIC CHEMICAL INDUSTRY
	METAL PLATING BUSINESS
	ORGANIC CHEMICAL INDUSTRY
	PAINT SHOP
	PETROLEUM CHEMICAL INDUSTRY
	PETROLEUM STORAGE TANK
	PHOTO PROCESS BUSINESS
	PLASTIC MFG, SALE
	PULP OR PAPER MILL
	NEW OR USED OIL SITE
	WOOD PRESERVING
	BOAT STORAGE
	OIL AND GAS PRODUCTION TANKS
	MILITARY ARMORY
	CHEMICAL PIPELINE: CRUDE OIL
	CHEMICAL PIPELINE: PRODUCT - GASOLINE, DIESEL, JET FUEL
	CHEMICAL PIPELINE: PETROLEUM PUMP STATION
	CLASS II INJECTION WELL: CLASS 2 INJECTION WELL
	CLASS V INJECTION WELL: UNTREATED SEWAGE
	CLASS V INJECTION WELL: STORM DRAINAGE
	CLASS V INJECTION WELL: TRASH BURNING WELL
	CLASS V INJECTION WELL: AUTO REPAIR FLOOR DRAIN
	NATURAL RESOURCE PRODUCTION: OIL OR GAS WELL - ABANDONED
	NATURAL RESOURCE PRODUCTION: OIL OR GAS WELL - PLUGGED
	NATURAL RESOURCE PRODUCTION: OIL OR GAS WELL - PRODUCTION

Edwards Aquifer Constituent of Concern[a]	Potential Sources of Contamination[b]
	NATURAL RESOURCE PRODUCTION: OIL OR GAS WELL - UNDERGROUND STORAGE
	NATURAL RESOURCE PRODUCTION: Service\Observation Wells Oil and Gas Operations
	WASTEWATER: WASTEWATER
	WASTEWATER: HOLDING POND
	WASTEWATER: INDUSTRIAL WASTEWATER OUTFALL
	WASTEWATER: LAND APPLICATION SLUDGE
	WASTEWATER: LIFTSTATION
	WASTEWATER: PIPELINE
	WASTEWATER: MUNICIPAL WASTEWATER OUTFALL
	WASTEWATER: TREATMENT PLANT
	WASTEWATER: PRIVATE WASTEWATER OUTFALL
	WASTEWATER: WASTEWATER BIOSOLIDS PROCESSING PLANT
	TRANSPORTATION: AIRPORT
	TRANSPORTATION: BOAT RAMP
	TRANSPORTATION: HELIPORT
	TRANSPORTATION: HIGHWAY
	TRANSPORTATION: LANDING STRIP
	TRANSPORTATION: MARINA
	TRANSPORTATION: MILITARY AIR BASE
	WASTE: DOMESTIC TRASH OR BURN PILE
	WASTE: MUNICIPAL SOLID WASTE - ABANDONED, TCEQ
	WASTE: MUNICIPAL SOLID WASTE - ACTIVE, TCEQ
	WASTE: TRANSFER STATIO
	WASTE: OILFIELD SLUDGE DISPOS
	WASTE: SALT WATER DISPOSAL PIT
Benzo(a)anthracene	None identified
Benzo(a)pyrene	ORGANIC CHEMICAL INDUSTRY
	OIL AND GAS PRODUCTION TANKS
	CHEMICAL PIPELINE: CRUDE OIL
	CHEMICAL PIPELINE: PETROLEUM PUMP STATION
	CLASS II INJECTION WELL: CLASS 2 INJECTION WELL
	CLASS V INJECTION WELL: STORM DRAINAGE
	CLASS V INJECTION WELL: TRASH BURNING WELL
	NATURAL RESOURCE PRODUCTION: OIL OR GAS WELL - ABANDONED
	NATURAL RESOURCE PRODUCTION: OIL OR GAS WELL - PLUGGED

Edwards Aquifer Constituent of Concern[a]	Potential Sources of Contamination[b]
	NATURAL RESOURCE PRODUCTION: OIL OR GAS WELL - PRODUCTION
	NATURAL RESOURCE PRODUCTION: OIL OR GAS WELL - UNDERGROUND STORAGE
	NATURAL RESOURCE PRODUCTION: Service\Observation Wells Oil and Gas Operations
	WASTEWATER: INDUSTRIAL WASTEWATER OUTFALL
	TRANSPORTATION: HIGHWAY
	WASTE: DOMESTIC TRASH OR BURN PILE
	WASTE: MUNICIPAL SOLID WASTE - ABANDONED, TCEQ
	WASTE: MUNICIPAL SOLID WASTE - ACTIVE, TCEQ
	WASTE: TRANSFER STATION
	WASTE: OILFIELD SLUDGE DISPOSAL
	WASTE: SALT WATER DISPOSAL PIT
Benzo(b)fluoranthene	None identified
Boron	INORGANIC CHEMICAL INDUSTRY
	METAL PLATING BUSINESS
	PAINT SHOP
	PHOTO PROCESS BUSINESS
	WOOD PRESERVING
	FIREWORKS BUSINESS (MFG OR RETAIL)
	CLASS V INJECTION WELL: UNTREATED SEWAGE
	CLASS V INJECTION WELL: AGRICULTURAL DRAINAGE
	CLASS V INJECTION WELL: TRASH BURNING WELL
	WASTEWATER: WASTEWATER
	WASTEWATER: HOLDING POND
	WASTEWATER: INDUSTRIAL WASTEWATER OUTFALL
	WASTEWATER: LAND APPLICATION SLUDGE
	WASTEWATER: LIFTSTATION
	WASTEWATER: PIPELINE
	WASTEWATER: MUNICIPAL WASTEWATER OUTFALL
	WASTEWATER: TREATMENT PLANT
	WASTEWATER: AGRICULTURAL WASTEWATER OUTFALL
	WASTEWATER: PRIVATE WASTEWATER OUTFALL
	WASTEWATER BIOSOLIDS PROCESSING PLANT
	WASTEWATER: DOMESTIC TRASH OR BURN PILE
	WASTE: MUNICIPAL SOLID WASTE - ABANDONED, TCEQ
	WASTE: MUNICIPAL SOLID WASTE - ACTIVE, TCEQ

Edwards Aquifer Constituent of Concern[a]	Potential Sources of Contamination[b]
	WASTE: TRANSFER STATION
	WASTE: COAL COMBUSTION PRODUCT DISPOSAL
Cadmium	AUTO PARTS BUSINESS (NEW, USED)
	AUTO REPAIR, SALES, SALVAGE, TOWING
	INORGANIC CHEMICAL INDUSTRY
	METAL PLATING BUSINESS
	ORGANIC CHEMICAL INDUSTRY
	PAINT SHOP
	PESTICIDE MFG, SALE, APPLICATION
	PESTICIDE, FERTILIZER MFG, SALE, APPLICATION
	PETROLEUM CHEMICAL INDUSTRY
	PHOTO PROCESS BUSINESS
	PLASTIC MFG, SALE
	PULP OR PAPER MILL
	NEW OR USED OIL SITE
	BATTERY MFG., SALES
	MILITARY ARMORY
	Machine Shop - Metal Working
	CLASS V INJECTION WELL: UNTREATED SEWAGE
	CLASS V INJECTION WELL: STORM DRAINAGE
	CLASS V INJECTION WELL: TRASH BURNING WELL
	WASTEWATER: WASTEWATER
	WASTEWATER: HOLDING POND
	WASTEWATER: INDUSTRIAL WASTEWATER OUTFALL
	WASTEWATER: LAND APPLICATION SLUDGE
	WASTEWATER: LIFTSTATION
	WASTEWATER: PIPELINE
	WASTEWATER: MUNICIPAL WASTEWATER OUTFALL
	WASTEWATER: TREATMENT PLANT
	WASTEWATER: PRIVATE WASTEWATER OUTFALL
	WASTEWATER: WASTEWATER BIOSOLIDS PROCESSING PLAN
	TRANSPORTATION: AIRPORT
	TRANSPORTATION: HELIPORT
	TRANSPORTATION: HIGHWAY
	TRANSPORTATION: MILITARY AIR BASE
	WASTE: DOMESTIC TRASH OR BURN PILE

Edwards Aquifer Constituent of Concern[a]	Potential Sources of Contamination[b]
	WASTE: MUNICIPAL SOLID WASTE - ABANDONED, TCEQ
	WASTE: MUNICIPAL SOLID WASTE - ACTIVE, TCEQ
	WASTE: TRANSFER STATION
	WASTE: RECYCLING FACILITY
	WASTE: COAL COMBUSTION PRODUCT DISPOSAL
Ethion	None identified
Indeno(1,2,3-cd) pyrene	None identified
Lead	AUTO PARTS BUSINESS (NEW, USED)
	AUTO REPAIR, SALES, SALVAGE, TOWING
	GOLF COURSE
	INORGANIC CHEMICAL INDUSTRY
	METAL PLATING BUSINESS
	ORGANIC CHEMICAL INDUSTRY
	PAINT SHOP
	PESTICIDE MFG, SALE, APPLICATION
	PESTICIDE, FERTILIZER MFG, SALE, APPLICATION
	PETROLEUM CHEMICAL INDUSTRY
	PETROLEUM STORAGE TANK
	PHOTO PROCESS BUSINESS
	PLASTIC MFG, SALE
	PULP OR PAPER MILL
	TIRE SALES, REPAIR BUSINESS
	NEW OR USED OIL SITE
	WOOD PRESERVING
	BATTERY MFG., SALES
	BOAT STORAGE
	FIREWORKS BUSINESS (MFG OR RETAIL)
	MILITARY ARMORY
	Machine Shop - Metal Working
	CHEMICAL PIPELINE: PRODUCT - GASOLINE, DIESEL, JET FUEL
	CLASS III INJECTION WELL: URANIUM
	CLASS V INJECTION WELL: UNTREATED SEWAGE
	CLASS V INJECTION WELL: STORM DRAINAGE
	CLASS V INJECTION WELL: TRASH BURNING WELL
	CLASS V INJECTION WELL: AUTO REPAIR FLOOR DRAIN
	GUN RANGE: GUN RANGE

Edwards Aquifer Constituent of Concern[a]	Potential Sources of Contamination[b]
	GUN RANGE: PUBLIC OR PRIVATE
	GUN RANGE: MILITARY
	WASTEWATER: WASTEWATER
	WASTEWATER: HOLDING POND
	WASTEWATER: INDUSTRIAL WASTEWATER OUTFALL
	WASTEWATER: LAND APPLICATION SLUDGE
	WASTEWATER: LIFTSTATION
	WASTEWATER: PIPELINE
	WASTEWATER: MUNICIPAL WASTEWATER OUTFALL
	WASTEWATER: TREATMENT PLANT
	WASTEWATER: PRIVATE WASTEWATER OUTFALL
	WASTEWATER: WASTEWATER BIOSOLIDS PROCESSING PLANT
	TRANSPORTATION: HIGHWAY
	TRANSPORTATION: LANDING STRIP
	TRANSPORTATION: MARINA
	WASTE: DOMESTIC TRASH OR BURN PILE
	WASTE: MUNICIPAL SOLID WASTE - ABANDONED, TCEQ
	WASTE: MUNICIPAL SOLID WASTE - ACTIVE, TCEQ
	WASTE: TRANSFER STATION
	WASTE: RECYCLING FACILITY
	WASTE: COAL COMBUSTION PRODUCT DISPOSAL
Lithium	None identified
Mercury	AUTO PARTS BUSINESS (NEW, USED)
	AUTO REPAIR, SALES, SALVAGE, TOWING
	INORGANIC CHEMICAL INDUSTRY
	METAL PLATING BUSINESS
	ORGANIC CHEMICAL INDUSTRY
	PAINT SHOP
	PETROLEUM CHEMICAL INDUSTRY
	PHOTO PROCESS BUSINESS
	PLASTIC MFG, SALE
	PULP OR PAPER MILL
	WOOD PRESERVING
	BATTERY MFG., SALES
	Dental Clinic
	Machine Shop - Metal Working

Edwards Aquifer Constituent of Concern[a]	Potential Sources of Contamination[b]
	CLASS V INJECTION WELL: UNTREATED SEWAGE
	CLASS V INJECTION WELL: STORM DRAINAGE
	CLASS V INJECTION WELL: TRASH BURNING WELL
	WASTEWATER: WASTEWATER
	WASTEWATER: HOLDING POND
	WASTEWATER: INDUSTRIAL WASTEWATER OUTFALL
	WASTEWATER: LAND APPLICATION SLUDGE
	WASTEWATER: LIFTSTATION
	WASTEWATER: PIPELINE
	WASTEWATER: MUNICIPAL WASTEWATER OUTFALL
	WASTEWATER: TREATMENT PLANT
	WASTEWATER: PRIVATE WASTEWATER OUTFALL
	WASTEWATER: WASTEWATER BIOSOLIDS PROCESSING PLANT
	TRANSPORTATION: AIRPORT
	TRANSPORTATION: HELIPORT
	TRANSPORTATION: HIGHWAY
	TRANSPORTATION: MILITARY AIR BASE
	WASTE: DOMESTIC TRASH OR BURN PILE
	WASTE: MUNICIPAL SOLID WASTE - ABANDONED, TCEQ
	WASTE: MUNICIPAL SOLID WASTE - ACTIVE, TCEQ
	WASTE: TRANSFER STATION
	WASTE: RECYCLING FACILITY
	WASTE: COAL COMBUSTION PRODUCT DISPOSAL
Metribuzin	ORGANIC CHEMICAL INDUSTRY
	PESTICIDE MFG, SALE, APPLICATION
	PESTICIDE, FERTILIZER MFG, SALE, APPLICATION
	CLASS V INJECTION WELL: TRASH BURNING WELL
	WASTEWATER: INDUSTRIAL WASTEWATER OUTFALL
	WASTE: DOMESTIC TRASH OR BURN PILE
	WASTE: MUNICIPAL SOLID WASTE - ABANDONED, TCEQ
	WASTE: MUNICIPAL SOLID WASTE - ACTIVE, TCEQ
	WASTE: TRANSFER STATION
Molybdenum	None identified
Nitrate	FERTILIZER MFG, SALE, APPLICATION
	GOLF COURSE
	INORGANIC CHEMICAL INDUSTRY

Edwards Aquifer Constituent of Concern[a]	Potential Sources of Contamination[b]
	METAL PLATING BUSINESS
	PESTICIDE, FERTILIZER MFG, SALE, APPLICATION
	PHOTO PROCESS BUSINESS
	FIREWORKS BUSINESS (MFG OR RETAIL)
	Hospital or Clinic
	Veterinary Hospital or Clinic
	Meat Processing Facility
	Composting Facility
	CEMETERY: CEMETERY
	CEMETERY: Forensic Body Site
	CEMETERY: Pet Cemetery
	CEMETERY: Agricultural Animal Burial Site
	CLASS III INJECTION WELL: BRINE
	CLASS V INJECTION WELL: UNTREATED SEWAGE
	CLASS V INJECTION WELL: AGRICULTURAL DRAINAGE
	CLASS V INJECTION WELL: CESSPOOL
	CLASS V INJECTION WELL: STORM DRAINAGE
	CLASS V INJECTION WELL: SEPTIC UNDIFFERENTIATED
	CLASS V INJECTION WELL: SEPTIC DRAINFIELD
	CLASS V INJECTION WELL: TRASH BURNING WELL
	NATURAL RESOURCE PRODUCTION: Oil and Gas Dry Exploration Hole
	WASTEWATER: WASTEWATER
	WASTEWATER: HOLDING POND
	WASTEWATER: HOLDING TANK
	WASTEWATER: INDUSTRIAL WASTEWATER OUTFALL
	WASTEWATER: LAND APPLICATION SLUDGE
	WASTEWATER: LIFTSTATION
	WASTEWATER: PIPELINE
	WASTEWATER: SEPTIC SYSTEM
	WASTEWATER: MUNICIPAL WASTEWATER OUTFALL
	WASTEWATER: TREATMENT PLANT
	WASTEWATER: AGRICULTURAL WASTEWATER OUTFALL
	WASTEWATER: PRIVATE WASTEWATER OUTFALL
	WASTEWATER: CESSPOOL
	WASTEWATER: WASTEWATER BIOSOLIDS PROCESSING PLANT
	TRANSPORTATION: HIGHWAY

Edwards Aquifer Constituent of Concern[a]	Potential Sources of Contamination[b]
	WASTE: DOMESTIC TRASH OR BURN PIL
	WASTE: MUNICIPAL SOLID WASTE - ABANDONED, TCEQ
	WASTE: MUNICIPAL SOLID WASTE - ACTIVE, TCEQ
	WASTE: TRANSFER STATION
	ANIMAL FEEDING OPERATION: ANIMAL FEEDING OPERATION, NOT SPECIFIC
	ANIMAL FEEDING OPERATION: POULTRY
	ANIMAL FEEDING OPERATION: POULTRY: CHICKEN
	ANIMAL FEEDING OPERATION: POULTRY: CHICKEN, BREEDER
	ANIMAL FEEDING OPERATION: POULTRY: CHICKEN, BROILER
	ANIMAL FEEDING OPERATION: POULTRY: CHICKEN, LAYER (EGG)
	ANIMAL FEEDING OPERATION: POULTRY: CHICKEN, PULLET
	ANIMAL FEEDING OPERATION: POULTRY: TURKEY
	ANIMAL FEEDING OPERATION: BEEF
	ANIMAL FEEDING OPERATION: BEEF: CATTLE
	ANIMAL FEEDING OPERATION: BEEF: DAIRY
	ANIMAL FEEDING OPERATION: GOAT
	ANIMAL FEEDING OPERATION: SHEEP
	ANIMAL FEEDING OPERATION: SHEEP: LAMB
	ANIMAL FEEDING OPERATION: SWINE
	ANIMAL FEEDING OPERATION: Horses
	ANIMAL FEEDING OPERATION: AQUACULTURE ANIMAL PRODUCTION, NOT SPECIFI
	ANIMAL FEEDING OPERATION: FISH
	ANIMAL FEEDING OPERATION: CATFISH
	ANIMAL FEEDING OPERATION: TILAPIA
	ANIMAL FEEDING OPERATION: BASS
	ANIMAL FEEDING OPERATION: RED DRUM
	ANIMAL FEEDING OPERATION: KOI
	ANIMAL FEEDING OPERATION: CRUSTACEAN
	ANIMAL FEEDING OPERATION: SHRIMP
	ANIMAL FEEDING OPERATION:
	ANIMAL FEEDING OPERATION: ALLIGATOR
	ANIMAL FEEDING OPERATION: Large concentrations of natural animals
	ANIMAL FEEDING OPERATION: Mexican Free-tailed Bats
Pentachlorophenol	METAL PLATING BUSINESS
	ORGANIC CHEMICAL INDUSTRY

Edwards Aquifer Constituent of Concern[a]	Potential Sources of Contamination[b]
	PLASTIC MFG, SALE
	WOOD PRESERVING
	CLASS V INJECTION WELL: STORM DRAINAGE
	CLASS V INJECTION WELL: TRASH BURNING WELL
	WASTEWATER: INDUSTRIAL WASTEWATER OUTFALL
	TRANSPORTATION: HIGHWAY
	WASTE: DOMESTIC TRASH OR BURN PILE
	WASTE: MUNICIPAL SOLID WASTE - ABANDONED, TCEQ
	WASTE: MUNICIPAL SOLID WASTE - ACTIVE, TCEQ
	WASTE: TRANSFER STATION
Selenium	INORGANIC CHEMICAL INDUSTRY
	METAL PLATING BUSINESS
	ORGANIC CHEMICAL INDUSTRY
	PETROLEUM CHEMICAL INDUSTRY
	PHOTO PROCESS BUSINESS
	PLASTIC MFG, SALE
	PULP OR PAPER MILL
	WOOD PRESERVING
	Machine Shop - Metal Working
	CLASS III INJECTION WELL: URANIUM
	CLASS V INJECTION WELL: UNTREATED SEWAGE
	CLASS V INJECTION WELL: STORM DRAINAGE
	CLASS V INJECTION WELL: TRASH BURNING WELL
	WASTEWATER: WASTEWATER
	WASTEWATER: HOLDING POND
	WASTEWATER: INDUSTRIAL WASTEWATER OUTFALL
	WASTEWATER: LAND APPLICATION SLUDGE
	WASTEWATER: LIFTSTATION
	WASTEWATER: PIPELINE
	WASTEWATER: MUNICIPAL WASTEWATER OUTFALL
	WASTEWATER: TREATMENT PLANT
	WASTEWATER: PRIVATE WASTEWATER OUTFALL
	WASTEWATER: WASTEWATER BIOSOLIDS PROCESSING PLANT
	TRANSPORTATION: AIRPORT
	TRANSPORTATION: HELIPORT
	TRANSPORTATION: HIGHWAY

Edwards Aquifer Constituent of Concern[a]	Potential Sources of Contamination[b]
	TRANSPORTATION: MILITARY AIR BASE
	WASTE: DOMESTIC TRASH OR BURN PILE
	WASTE:MUNICIPAL SOLID WASTE - ABANDONED, TCEQ
	WASTE:MUNICIPAL SOLID WASTE - ACTIVE, TCEQ
	WASTE:TRANSFER STATION
	WASTE:RECYCLING FACILITY
	WASTE:COAL COMBUSTION PRODUCT DISPOSAL
Silver	AUTO PARTS BUSINESS (NEW, USED)
	AUTO REPAIR, SALES, SALVAGE, TOWING
	INORGANIC CHEMICAL INDUSTRY
	METAL PLATING BUSINESS
	ORGANIC CHEMICAL INDUSTRY
	PHOTO PROCESS BUSINESS
	Dental Clinic
	Machine Shop - Metal Working
	CLASS V INJECTION WELL: TRASH BURNING WELL
	WASTEWATER: INDUSTRIAL WASTEWATER OUTFALL
	WASTE: DOMESTIC TRASH OR BURN PILE
	WASTE: MUNICIPAL SOLID WASTE - ABANDONED, TCEQ
	WASTE: MUNICIPAL SOLID WASTE - ACTIVE, TCEQ
	WASTE: TRANSFER STATION
	WASTE: RECYCLING FACILITY
	WASTE: COAL COMBUSTION PRODUCT DISPOSAL
Strontium	NUCLEAR POWER PLANT
	CLASS III INJECTION WELL: URANIUM
	WASTE: MUNICIPAL SOLID WASTE - ABANDONED, TCEQ
	WASTE: MUNICIPAL SOLID WASTE - ACTIVE, TCEQ
	WASTE: TRANSFER STATION
Tetrachloroethylene	AUTO PARTS BUSINESS (NEW, USED)
	AUTO REPAIR, SALES, SALVAGE, TOWING
	DRY CLEANER
	METAL PLATING BUSINESS
	ORGANIC CHEMICAL INDUSTRY
	PAINT SHOP
	PESTICIDE MFG, SALE, APPLICATION
	PESTICIDE, FERTILIZER MFG, SALE, APPLICATION

Edwards Aquifer Constituent of Concern[a]	Potential Sources of Contamination[b]
	PETROLEUM CHEMICAL INDUSTRY
	PHOTO PROCESS BUSINESS
	PLASTIC MFG, SALE
	PULP OR PAPER MILL
	NEW OR USED OIL SITE
	MILITARY ARMORY
	CLASS V INJECTION WELL: STORM DRAINAGE
	CLASS V INJECTION WELL: TRASH BURNING WELL
	CLASS V INJECTION WELL: AUTO REPAIR FLOOR DRAIN
	WASTEWATER: INDUSTRIAL WASTEWATER OUTFALL
	TRANSPORTATION: AIRPORT
	TRANSPORTATION: HELIPORT
	TRANSPORTATION: HIGHWAY
	TRANSPORTATION: MILITARY AIR BASE
	WASTE: DOMESTIC TRASH OR BURN PILE
	WASTE: MUNICIPAL SOLID WASTE - ABANDONED, TCEQ
	WASTE: MUNICIPAL SOLID WASTE - ACTIVE, TCEQ
	WASTE: TRANSFER STATION
Trichloroethylene	AUTO PARTS BUSINESS (NEW, USED)
	AUTO REPAIR, SALES, SALVAGE, TOWING
	DRY CLEANER
	METAL PLATING BUSINESS
	ORGANIC CHEMICAL INDUSTRY
	PAINT SHOP
	PESTICIDE MFG, SALE, APPLICATION
	PESTICIDE, FERTILIZER MFG, SALE, APPLICATION
	PESTICIDE, FERTILIZER MFG, SALE, APPLICATION
	PETROLEUM CHEMICAL INDUSTRY
	PHOTO PROCESS BUSINESS
	PLASTIC MFG, SALE
	PULP OR PAPER MILL
	NEW OR USED OIL SITE
	MILITARY ARMORY
	CLASS V INJECTION WELL: UNTREATED SEWAGE
	CLASS V INJECTION WELL: STORM DRAINAGE
	CLASS V INJECTION WELL: TRASH BURNING WELL

Edwards Aquifer Constituent of Concern[a]	Potential Sources of Contamination[b]
	CLASS V INJECTION WELL:AUTO REPAIR FLOOR DRAIN
	WASTEWATER: WASTEWATER
	WASTEWATER: HOLDING POND
	WASTEWATER: INDUSTRIAL WASTEWATER OUTFALL
	WASTEWATER: LAND APPLICATION SLUDGE
	WASTEWATER: LIFTSTATION
	WASTEWATER: PIPELINE
	WASTEWATER: MUNICIPAL WASTEWATER OUTFALL
	WASTEWATER: TREATMENT PLANT
	WASTEWATER: PRIVATE WASTEWATER OUTFALL
	WASTEWATER: WASTEWATER BIOSOLIDS PROCESSING PLANT
	TRANSPORTATION: AIRPORT
	TRANSPORTATION: HELIPORT
	TRANSPORTATION: HIGHWAY
	TRANSPORTATION: MILITARY AIR BASE
	WASTE: DOMESTIC TRASH OR BURN PILE
	WASTE: MUNICIPAL SOLID WASTE - ABANDONED, TCEQ
	WASTE: MUNICIPAL SOLID WASTE - ACTIVE, TCEQ
	WASTE: TRANSFER STATION
Vinyl chloride	AUTO PARTS BUSINESS (NEW, USED)
	AUTO REPAIR, SALES, SALVAGE, TOWING
	DRY CLEANER
	METAL PLATING BUSINESS
	ORGANIC CHEMICAL INDUSTRY
	PAINT SHOP
	PETROLEUM CHEMICAL INDUSTRY
	PHOTO PROCESS BUSINESS
	PLASTIC MFG, SALE
	PULP OR PAPER MILL
	NEW OR USED OIL SITE
	MILITARY ARMORY
	CLASS V INJECTION WELL: TRASH BURNING WELL
	WASTEWATER: INDUSTRIAL WASTEWATER OUTFALL
	TRANSPORTATION: AIRPORT
	TRANSPORTATION: HELIPORT
	TRANSPORTATION: MILITARY AIR BASE

Edwards Aquifer Constituent of Concern[a]	Potential Sources of Contamination[b]
	WASTE: DOMESTIC TRASH OR BURN PILE
	WASTE: MUNICIPAL SOLID WASTE - ABANDONED, TCEQ
	WASTE: MUNICIPAL SOLID WASTE - ACTIVE, TCEQ
	WASTE: TRANSFER STATION

[a] Source: EAA, *Water Quality Trends Analysis of the San Antonio Segment, Balcones Fault Zone Edwards Aquifer, Texas*, July 2009, Report No. 09-03.

[b] Source: TCEQ, *Potential Source of Contamination Types and Subtypes: Detailed Listing, Descriptions, and Applied Contaminants*, July 23, 2010.

Appendix B
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