RECLAMATION
Managing Water in the West

2017 Groundwater Status Report Yuma Area Arizona and California

Yuma Area Office
Lower Colorado Region

U.S. Department of the Interior
Bureau of Reclamation

September 2018

2017 Groundwater Status Report Yuma Area

Arizona and California

Yuma Area Office
Lower Colorado Region

Mission Statements

The Department of the Interior conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Acronyms and Abbreviations

acre-ft	acre-feet
AAC	All-American Canal
cfs	cubic feet per second
ft	feet
bgs	below ground surface
amsl	above mean sea level
DPOC	Drainage Pump Outlet Channel
GGMC	Gila Gravity Main Canal
ID	Irrigation District
IDD	Irrigation and Drainage District
IBWC	International Boundary and Water Commission
meq/l	milliequivalents per liter
MODE	Main Outlet Drain Extension
NGVD-29	National Geodetic Vertical Datum 1929
NIB	Northerly International Border
P.L.	Public Law
SIB	Southerly International Boundary
Tape reading	Depth measurement from a reference point at the top of a well casing to the water surface
USGS	United States Geological Survey
YAO	Yuma Area Office
YCWUA	Yuma County Water Users' Association
YDP	Yuma Desalting Plant
YM	Yuma Mesa
YV	Yuma Valley

Author/Peer Reviewer Signature Page

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Review Certification

This document has been reviewed and is believed to be in accordance with Reclamation policy and the standards of this profession.

Jay P. Nemeth, P.E. Supervisory Civil Engineer — Date 9/24/18

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INTRODUCTION

Purpose and Scope

This report presents a summary description of the groundwater conditions in the Yuma area during 2017. The area includes the Yuma groundwater basin which incorporates the North Gila Valley, Reservation Division, Bard Valley, South Gila Valley, Yuma Valley, and Yuma Mesa. Although not part of the Yuma groundwater basin, the report also includes information about the nearby Wellton-Mohawk Valley located east of the Gila Mountains. Results of previous Bureau of Reclamation (Reclamation) summaries of groundwater conditions in the Yuma area are contained in annual Ground Water Status Reports dating from 1967 through 1995 and 2016. The purpose of this report is to present groundwater and related hydrologic data that influence groundwater conditions for the area. Included are data on water resource use and groundwater conditions including depth to groundwater (DTW). DTW data are compiled and presented in this report as contour maps of depth and groundwater elevation for specific areas. Comparisons between this report and previous status reports allows for assessment of changes in groundwater conditions over time.

Work conducted for this groundwater program is based on the following authorizations:

- Reclamation Act of 1902, June 17, 1902 (Yuma Project approved by the Secretary of the Interior on May 10, 1904)
- P.L. 64-293, Yuma Auxiliary Project, January 25, 1917, as amended
- P.L. 68-292, Second Deficiency Appropriation Act for 1924, Section 4 (The Fact Finders Act), December 5, 1924 (Gila Project approved by the President on June 21, 1937)
- P.L. 68-585, Colorado River Front Work and Levee System, March 3, 1925 P.L. 70-642, Boulder Canyon Project Act, December 21, 1928
- P.L. 80-247, Interior Department Appropriation Act of 1948, July 30, 1947
- P.L. 88-25, Delivery of Water to Mexico, May 17, 1963
- P.L. 106-221, Wellton Mohawk Transfer Act, June 21, 2000
- P.L. 106-566, Conveyance to Yuma Port Authority, December 23, 2000

Reclamation intends to prepare groundwater status reports on an annual basis to document data collection and to assess changes in aquifer conditions over time. This report, and future annual status reports will be posted on Reclamation's website to provide access by water managers and interested parties.

Location and General Description

The Yuma area includes approximately 675 square miles of land located near the apex of the Colorado River delta in southwestern Arizona and southeastern California. The area generally extends from the north at Laguna Dam to 30 miles south at the Southerly International Border (SIB) and from the Gila Mountains in the east to 35 miles west at the Coachella Canal which diverts water from the All American Canal (ACC). Notable physiographic features include the Cargo Muchacho and Chocolate Mountains to the north, and the Gila Mountains to the east. The Colorado River bisects the area and defines the international boundary between the United States and Mexico in the area west of Yuma Valley (Figure 1). The Wellton-Mohawk Valley, which lies east of the Gila Mountains, is technically not a part of the Yuma area, but is included in this report because of its close association.

The landscape in the Yuma area is characterized by the Colorado and Gila River valleys, river terraces or mesas, desert plains, and rugged mountains. Land surface elevations range from 75 ft above mean sea level (amsl) at the Colorado River near San Luis, AZ, to a high point of 3,156 ft amsl at Sheep Mountain in the Gila Mountains. The climate is extremely arid, and is classified as BWh on the Köppen Climate Classification Scale. Average rainfall is about 3 inches per year.

Agriculture is by far the single largest industry in Yuma County generating approximately $2.8 billion in economic output in 2014.[1] The thriving agricultural economy is made possible by a steady supply of water from the Colorado River.

History of Development in the Yuma Area

Numerous significant events have contributed to the development of water resources to support agriculture in the Yuma area. Initial efforts began in 1857 with the building of the first canals to deliver agricultural irrigation water to Yuma Valley. Over time, additional infrastructure was added to manage water supplies, including the Laguna Diversion Dam completed in 1909, the Imperial Dam in 1938, and the AAC in 1940. Beginning in the 1950s, a system of high-capacity drainage wells was developed and maintained to help keep groundwater at acceptable levels for agriculture and other purposes in eastern Yuma Valley and later in South Gila Valley. In recent years, efforts have been made to use the pumped drainage water for supply. Appendix A provides a table that lists the chronology of significant events related to the development and management of water supplies in the Yuma area.

The Groundwater System

The following provides a summary of the hydrogeologic characteristics for the Yuma area including the Wellton-Mohawk Valley. The information that is presented here is largely derived

[1] Yuma County Agriculture Coalition. 2015. “A Case Study in Efficiency – Agriculture and Water Use in the Yuma, Arizona Area.” [http://www.agwateryuma.com/]

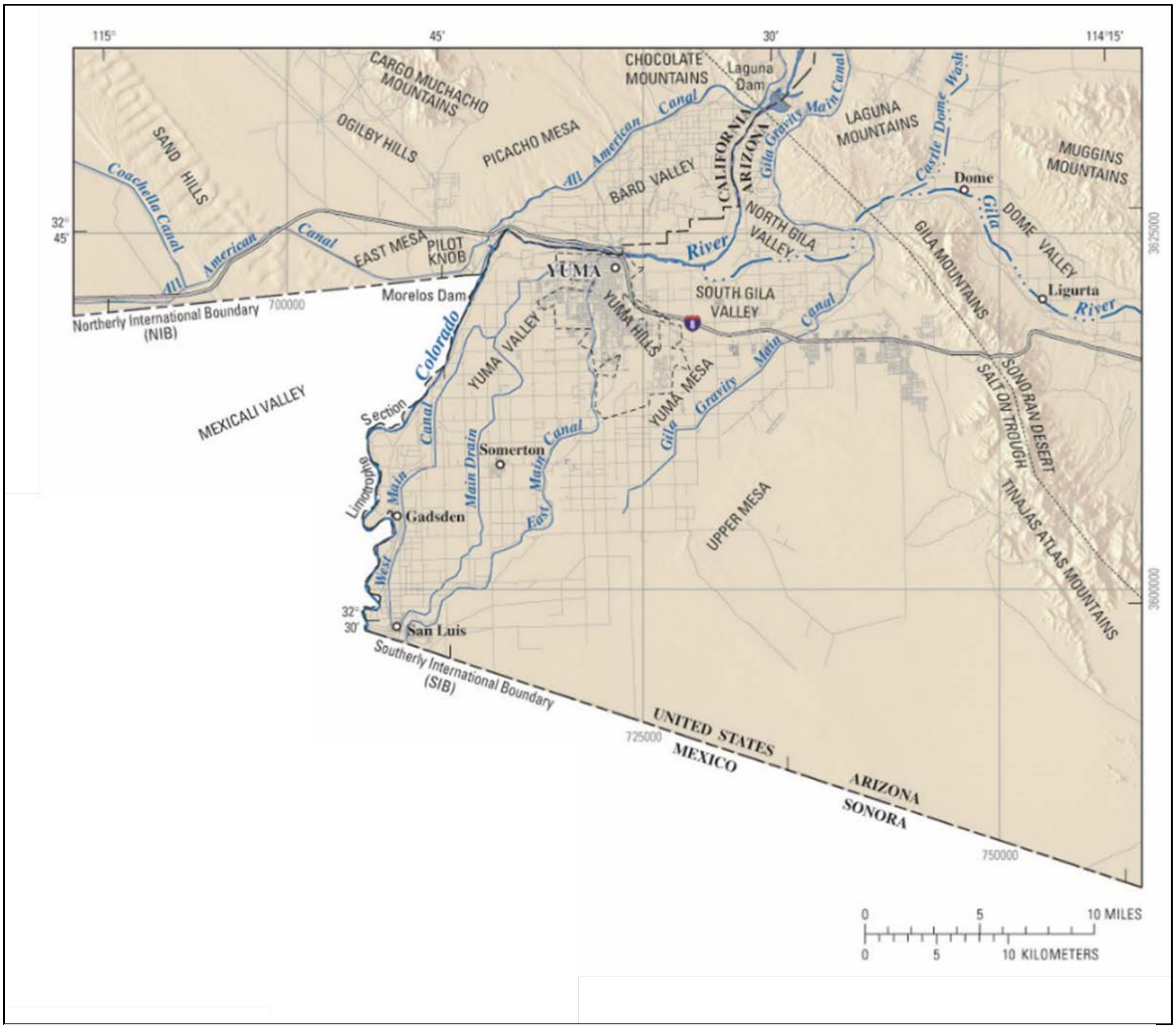

Figure 1. General map of the Yuma area.
(Data source: U.S. Geological Survey, Scientific Investigations Report 2006-5135)

from two U.S. Geological Survey publications: Professional Paper 486-H[2] and Scientific Investigations Report 2006-5135[3].

These documents provide a comprehensive summary of the hydrogeologic conditions in the area. The Yuma area groundwater basin, also called the Yuma Groundwater Reservoir, is an unconfined aquifer system located in the upstream end of the Colorado River delta that includes alluvial deposits of the Yuma area and parts of the states of Baja California and Sonora, Mexico. The aquifer system, developed in a sedimentary basin, is formed by the interaction of Basin and Range

[2] Olmsted, F.H., Loeltz, O.J., and Irelan, B. 1973. Geohydrology of the Yuma Area, Arizona and California: U.S. Geological Survey Professional Paper 486-H, 227 pp.
[3] U.S. Geological Survey, Scientific Investigations Report 2006-5135. Hydrogeologic Framework Refinement, Ground-Water Flow and Storage, Water-Chemistry Analyses, and Water-Budget Components of the Yuma Area, Southwestern Arizona and Southeastern California: Geological Survey Scientific Investigations Report 2006-5135, 62 pp.

tectonics and the Salton Trough. The basin is bounded on the north and east by impermeable bedrock outcrops. The western and southern boundaries of the system have not been defined, but it is believed that the aquifer extends for considerable distances west and south of the Yuma area into northern Mexico.

The mostly unconfined alluvial aquifer system is generally divided into two transmissive water bearing units that overlie Pliocene and older marine sediments, volcanic units, or crystalline bedrock. The alluvium consists of stratified, heterogeneous sediments of the Colorado and Gila Rivers. Total thickness of the river sediments ranges from 0 ft near the mountain margins to over 2,500 ft in the southwestern parts of the Yuma area.

Figure 2 shows the major geologic structures that tend to affect the movement and direction of groundwater flow in the Yuma area. The Algodones Fault trends northwest to southeast through the area along with other parallel faults that offset the (Pliocene) marine Bouse Formation. The map shows the alignment of three geologic sections A-A’, B-B’ and C-C’, two of which are also shown in Figure 3 and used in this report to illustrate the subsurface conditions that are described below.

The lower aquifer unit or transmissive layer, commonly referred to as the "wedge zone," (Olmsted and others, 1973, p. 66) consists of a series of fine to coarse grained alluvial deposits reaching a total thickness of over 2,000 ft. The wedge zone is typically encountered at depths of 200 ft or more below land surface and is labeled in Figure 3 as ‘undifferentiated lower units’. Because the lower transmissive layer accounts for about half of the transmissivity of the total alluvial thickness, it is considered to be a significant component of the groundwater system.

The upper aquifer unit, or transmissive layer, consists of fine to coarse-grained sediments ranging in thickness from 0 to more than 200 ft, and is labeled in Figure 3 as the ‘Upper Fine-Grained Unit’. In the river valleys and in parts of the adjacent terraces, or mesas, the basal member of the upper transmissive layer is composed largely of highly permeable Colorado and Gila River gravels with lesser amounts of interbedded sands. Commonly referred to as the ‘coarse gravel zone’, these gravels often exceed 100 ft in thickness. However, this zone tends to be absent in mesa areas that are distal from the river valleys. In these mesa areas, the upper and lower transmissive layers are stratigraphically indistinguishable and the division between them is rather arbitrary. The gravel beds of the upper transmissive layer are the most permeable of the sediments in the greater Yuma area and, because the layer is relatively shallow, most groundwater wells are completed in it.

The coarse gravel zone of the upper transmissive layer is overlain by finer-grained sediments ranging in thickness from 0 to more than 100 ft. These sediments include two localized clay layers, which are labeled as ‘Clay A’ and ‘Clay B’ in Figure 3.

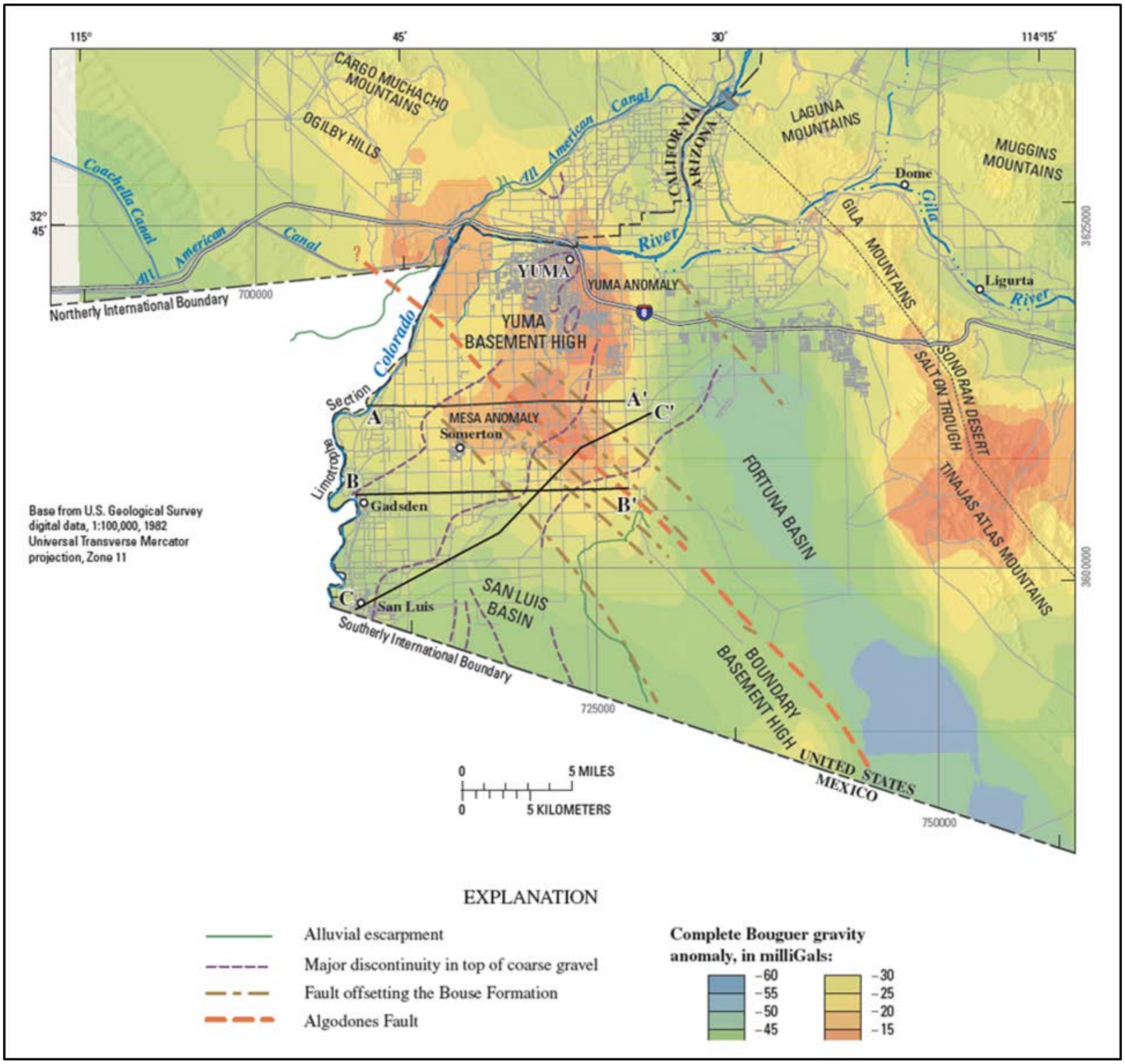

Figure 2. Major geologic structures affecting groundwater flow in the Yuma Area. (Data source: U.S. Geological Survey, Scientific Investigations Report 2006-5135)

In the river valley areas these sediments form semi-confining layers, which tend to impede the vertical movement of groundwater. Near the mountain ranges, the upper sediments grade into coarse-grained alluvial fans and piedmonts, which have not been developed for water supply due to the greater depth to groundwater and remote location. Some domestic wells have been completed in the upper fine-grained sediments, however, they produce relatively small quantities of water. The majority of groundwater discharge from the upper fine-grained sediments above the coarse gravel zone occurs through evapotranspiration or via surface drains.

The basin sediments are largely saturated and depth to groundwater ranges from land surface to over 500 ft. The regional groundwater gradient is to the southwest towards Mexico, but is locally

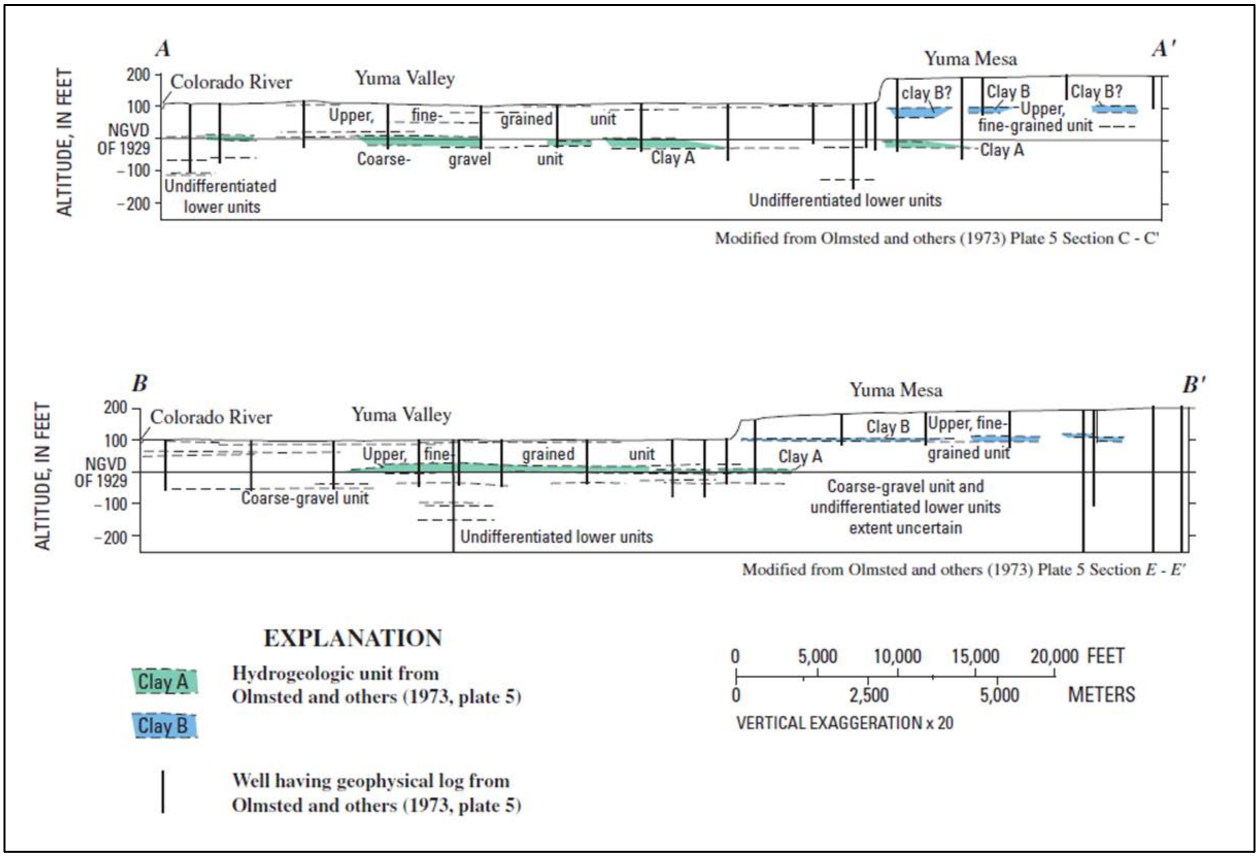

Figure 3. Cross-sections showing hydrogeological conditions in the Yuma Valley and Adjacent Yuma Mesa areas. (Data source: U.S. Geological Survey, Scientific Investigations Report 2006-5135)

controlled by vertical offsets associated with faulting and possibly shallow bedrock, and irrigation activities that have caused groundwater mounding on Yuma Mesa. Except for the Colorado and Gila River channels, the sedimentary basin is closed to the north and east, causing subsurface inflows to be restricted. Virtually all recharge to the basin is the result of application of Colorado River water to agricultural fields.

GENERAL AREA

Distribution of Developed Land

The Yuma area is divided into six subareas distinguished by natural geographic boundaries, irrigation districts, and hydrogeologic characteristics. The subareas include the North Gila Valley, Reservation Division, South Gila Valley, Yuma Mesa, Yuma Valley, and the Wellton-Mohawk Valley, which lies to the east of the Gila Mountains along the Gila River. A map showing the locations of the subareas is presented in Figure 4.

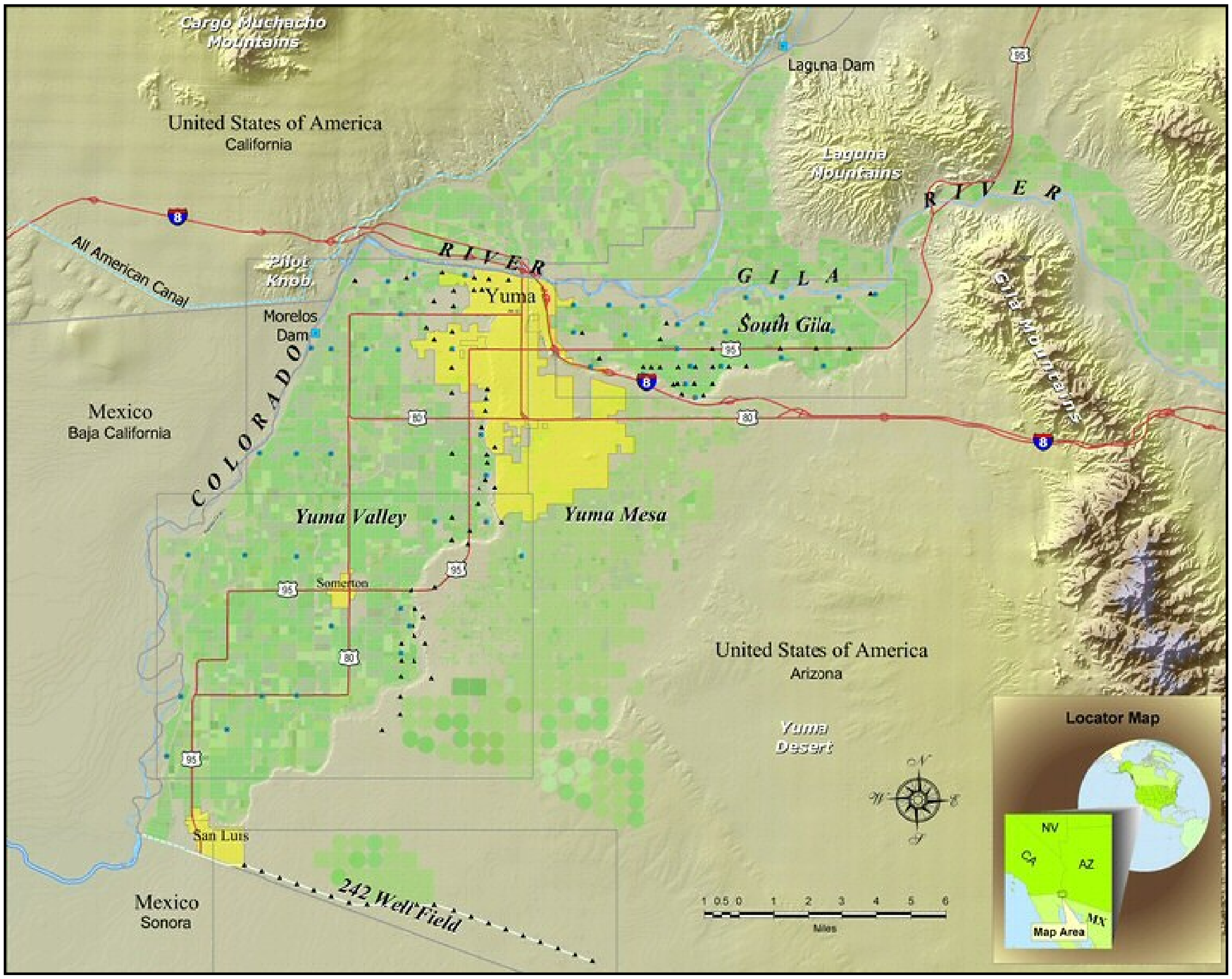

Figure 4. Map showing locations of groundwater basin subareas near Yuma, AZ.

Agricultural development in the Yuma area has occurred principally on the flood plains of the Colorado and Gila Rivers. However, a smaller but sizeable area is also farmed on Yuma Mesa. In total, about 163,000 acres of agricultural lands were operated under irrigation in the Yuma area during 2017.

Water Supply

Most of the water used in the Yuma area is diverted from the Colorado River. The diversion point for surface water supplied to all Yuma area Reclamation projects is Imperial Dam. The distribution infrastructure that conveys surface water diversions from Imperial Dam is shown in Figure 5. The extreme downstream reach of the Gila River which enters the Yuma area is not considered a significant source of surface water. Owing to the small amount of rain that the area receives annually, recharge from precipitation is insignificant. Additional water supplies are also pumped from private wells or off-stream ponds, and small amounts are also diverted from drains and conveyance channels. However, individual well records and private surface water diversions are not reported to the Yuma Area Office (YAO). Wells are the primary source of water in non-project areas and are also used to supplement surface water supplies within the in Yuma and South Gila Valleys.

Mexico diverts Colorado River water at Morelos Dam (NIB) for use in the Mexicali Valley and also receives irrigation water from the 242 Wellfield, and drainage and wasteway flows at the SIB. Total surface water flows to Mexico in 2017 were 1,516,668 acre-ft. This includes 1,365,369 acre-ft of diversion at the NIB[4] and 130,554 acre-ft of flows crossing the SIB, but does not include 126,701 acre-ft that was discharged to the Cienega de Santa Clara via the bypass drain pursuant to IBWC Minute 242.

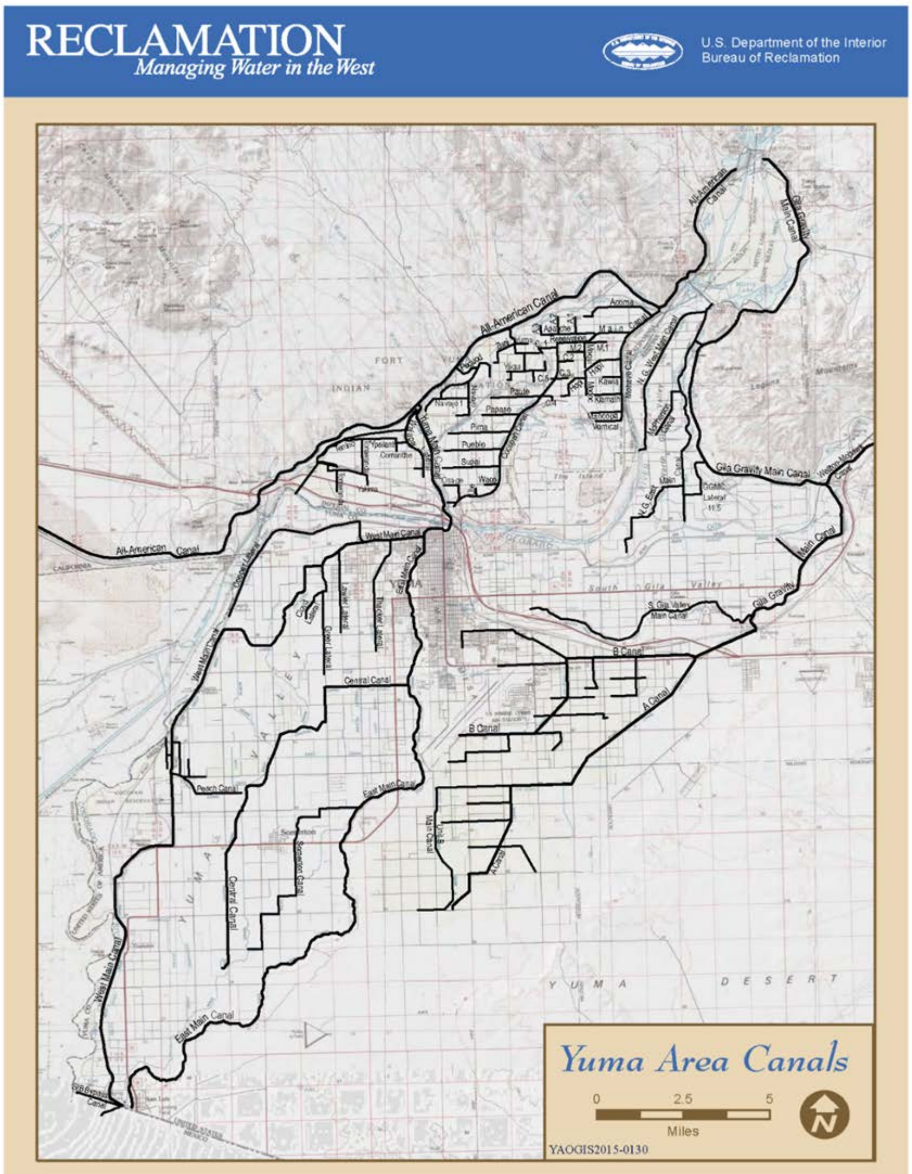

Figure 5. Map showing principal surface water supply canal infrastructure for the Yuma area.

[4] Bureau of Reclamation, 2017. Colorado River Accounting and Water Use Report: Arizona, California, and Nevada.

Drainage

In 2017, drainage infrastructure in the Yuma area included 77 operating drainage wells and approximately 90 miles of open gravity drains for capture and conveyance. A map showing the locations of the drainage wells and conveyance infrastructure is shown in Figure 6. Table 1 below provides a summary of drainage and drainage export by subarea.

Table 1. Summary of drainage and drainage export by sub-area.

Subarea	Acre-Feet	Remarks
South Gila Valley		
Total Diverted to Gila River	41,646	
Total Diverted to MODE	26,636	
Total Diverted to South Gila Canal	423	Not included in export - returned for irrigation
Fortuna Well	1,230	Discharged into pond - some to Gila River
Drainage Exported	**69,330**	
North Gila Valley		
North Gila Valley	3,529	
Drainage Exported	**3,529**	
Reservation		
Main Drain	38,237	
Araz Drain	8,595	
Drainage Exported	**46,832**	
Yuma Mesa and Yuma Valley Drainage Wells		
Discharged to Drains	52,513	This includes both YM and YV drainage wells
Discharged to MODE	7,245	
Discharged to River	7,240	
Drainage Exported	**14,485**	
Yuma Valley		
Measured at Boundary Pumping Plant	102,485	This does not include contributions for 242 Lateral
Drainage Exported	**49,972**	Less contribution for drainage wells that discharged to drains
Total Drainage Exported - 2017	**184,148**	

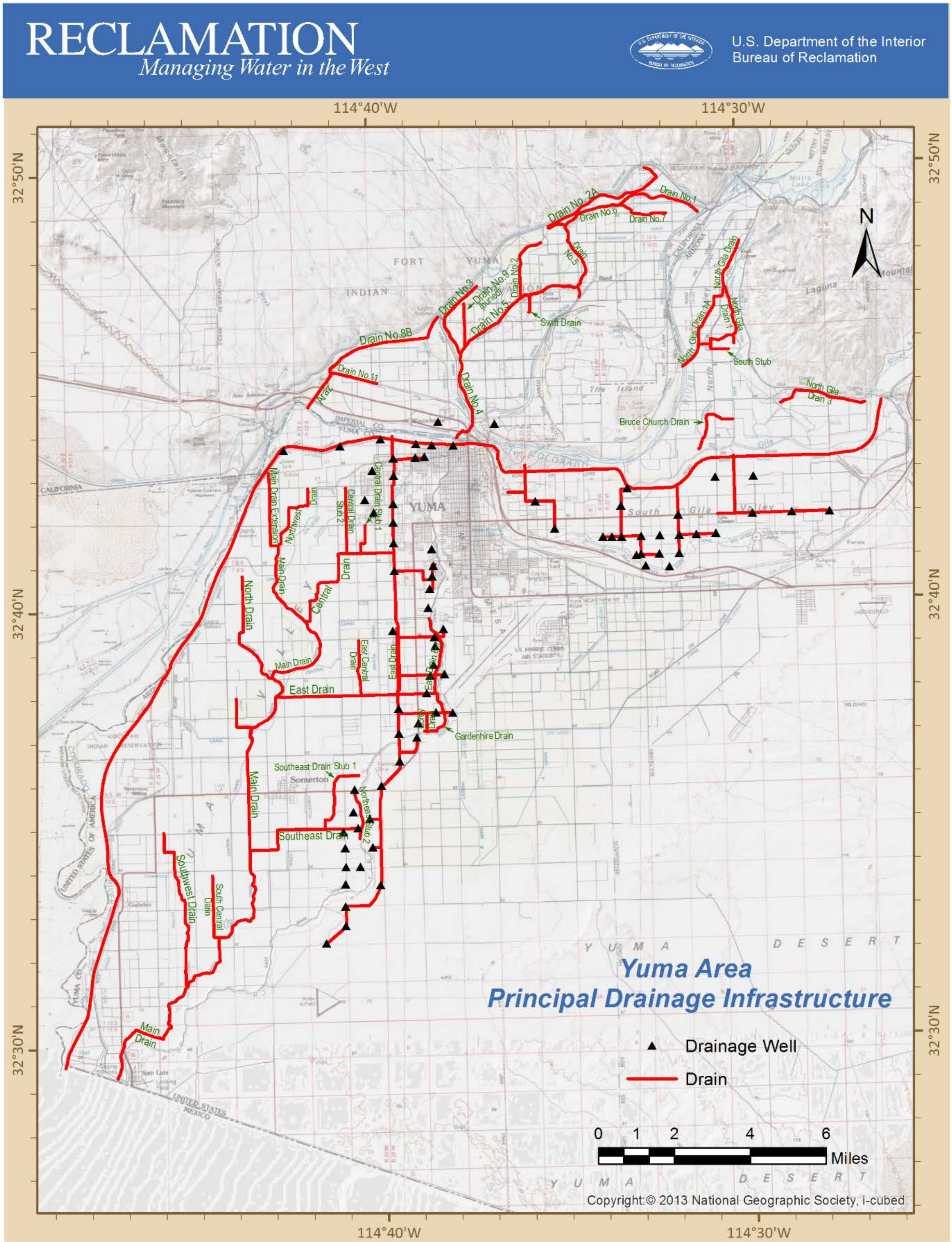

Figure 6. Map showing principal drainage infrastructure in the Yuma area.

Groundwater Monitoring

Depth to Groundwater Measurements

The YAO operates and maintains an extensive groundwater monitoring program employing a network of more than 500 observation wells distributed throughout the Yuma area (Figure 7). As part of this monitoring program, YAO personnel, in collaboration with several water districts, make measurements of groundwater depth in the observation well network on a set schedule. Collaborating agencies involved with the program include Yuma County Water Users' Association (YCWUA), Wellton-Mohawk Irrigation and Drainage District (WMIDD), and the Yuma Mesa Irrigation and Drainage District (YMIDD). Water level data are used to generate contour maps of depth to groundwater and groundwater surface elevation and assess changes in groundwater storage, the influences of pumping and irrigation, and seepage from rivers, canals, and drains. A description of the methods, equipment, and procedures used in the groundwater monitoring program can be found in Appendix B.

Groundwater Contour Maps

Groundwater maps provide a useful means of visually assessing groundwater conditions and identifying how groundwater conditions may be changing over time. Three types of contour maps are generated. These include depth to groundwater, groundwater elevation, and change in depth to groundwater. All the maps prepared for the groundwater monitoring program can be located at the Reclamation website:

http://www.usbr.gov/lc/yuma/programs/YAWMS/GROUNDWATER_maps.cfm

Depth to Groundwater Maps

Depth to groundwater maps show a contoured surface depicting the depth to groundwater relative to the land surface. Throughout most of the Yuma area, the ground surface is relatedly flat and the contours provide a smoothed approximation of the shape of the groundwater surface (water table). Depths are reported in units of feet below the ground surface (ft bgs) where larger values indicate greater depth to groundwater and smaller values indicate shallower groundwater. Depth to groundwater contour maps are prepared by the YAO for the following areas:

- **South Gila Valley and Yuma Valley –** maps prepared on a monthly basis.
- **Reservation Division –** maps prepared on a quarterly basis using data collected in March, June, September, and December.
- **Wellton-Mohawk area** - maps prepared on a quarterly basis using data collected in January, April, July, and October.

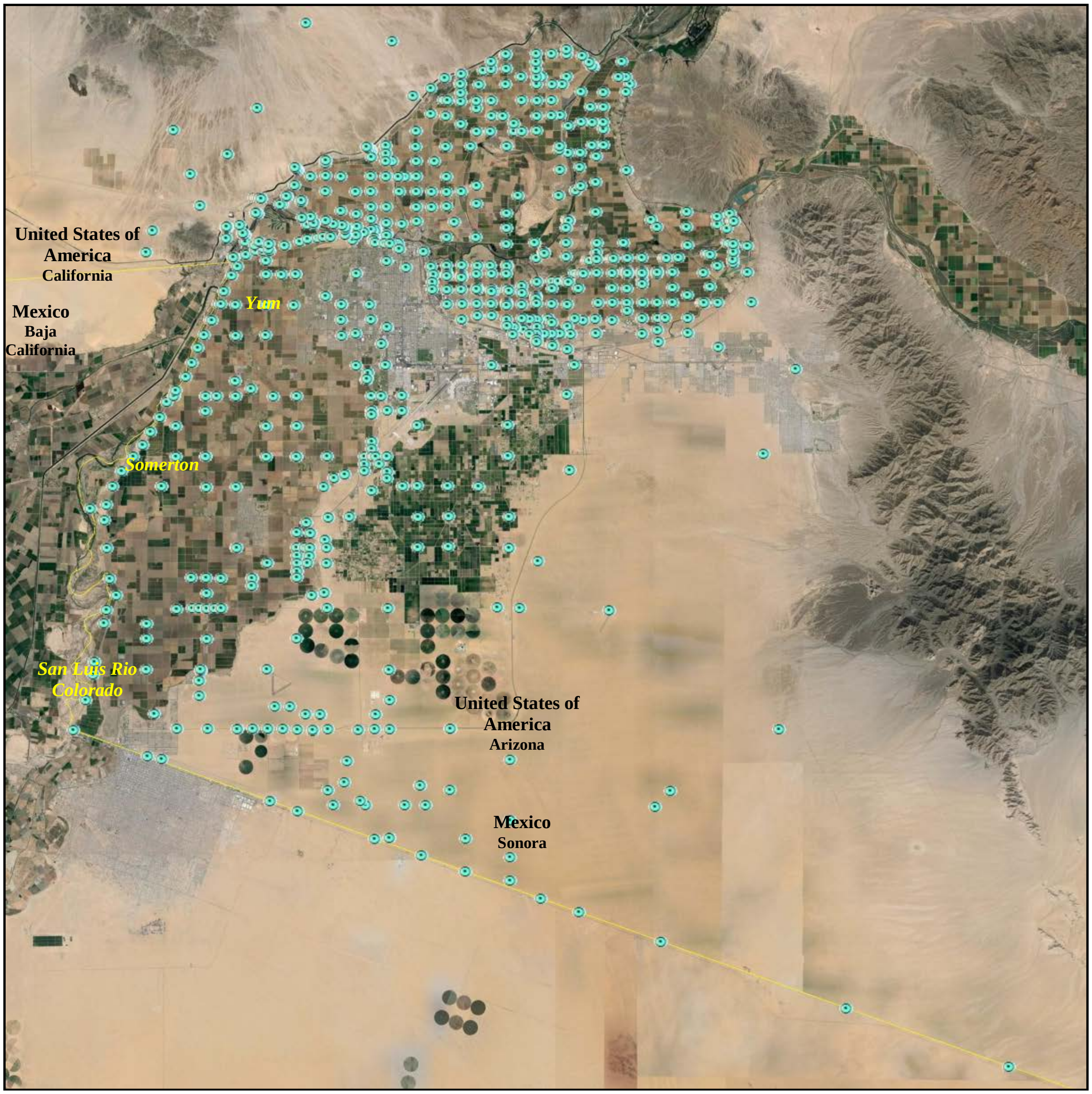

Figure 7. Map showing locations of YAO groundwater observation wells (blue dots) in the Yuma area exclusive of the Wellton-Mohawk Valley.

North Gila Valley

The North Gila Valley is located northeast of the City of Yuma. The valley is situated east of the Colorado River, west of the Laguna and Gila Mountains, south of Laguna Dam, and north of the Gila River. Irrigation water for the North Gila Valley is delivered through the GGMC, which traverses the base of the mountains at the eastern edge of the valley. Land surface elevations range from 180 ft amsl along the GGMC to 130 ft amsl near the Colorado River at the southwestern corner of the valley.

In the North Gila Valley, a total of 45 observation wells were used for groundwater monitoring in 2017, including 4 well clusters, each having a shallow, medium, and deep piezometer. Groundwater levels were measured quarterly (March, June, September, and December). DTW contour maps are not routinely prepared for this sub-area, but groundwater elevations for this area are included within the regional groundwater elevation contour maps prepared in June and December. These maps can be found in Appendix C (Figures C-1 and C-2, respectively) at the back of this report.

Table 3. 2017 Groundwater Depth and Elevation Summary, North Gila Valley.

	Depth to Water (ft bgs)			Elevation (ft amsl)		
	Average	Maximum	Minimum	Average	Maximum	Minimum
March	14.6	26.2	5.1	130.7	153.1	119.1
June	14.1	26.3	4.5	131.3	155.0	119.0
September	13.6	23.4	5.2	131.8	154.8	120.6
December	13.5	23.4	5.1	131.9	154.2	120.9
Summary for 2017	**13.9**	**26.3**	**4.5**	**131.4**	**155.0**	**119.0**

As summarized in Table 3, DTW measurements in 2017 ranged from 4.5 to 26.3 ft bgs with an average depth of 13.9 ft bgs. Groundwater elevations ranged from 119.0 to 155.0 ft amsl, with an average of 131.4 ft.

Reservation Division

The Reservation Division is an agricultural valley located north of the City of Yuma situated to the west and north of the Colorado River below Laguna Dam. The Division includes the Indian Unit, the Bard Water District, and for purposes of this report, the ‘Island’. The AAC flows south along the northwestern edge of the valley and delivers water to the various smaller canals and laterals of the Division.

The Reservation Division has a long history of water level monitoring with the first record of measurements taken in September 1911 using 12 observation wells. This early monitoring program was implemented to assess the hydrologic effects associated with the (then) newly operational High Line Canal which transported irrigation diversions from Laguna Dam to the Colorado River Siphon. By 1915, there were 74 observation wells in the Reservation Division.

On June 7, 1920, flooding from the Colorado River breached the narrow meander neck near County Avenue 4E and the Reservation Levee Road. The avulsive flood event created what is now called the Island portion of the Reservation Division. As a result, two oxbow lakes formed in the abandoned river channel, Bard Lake and Haughtelin Lake. The larger Haughtelin Lake has been used as a source of off-stream pumping for irrigation in the Island. Observation wells were not established in the Island until the mid-1950s.

By 1937, water level measurements were being taken monthly in about 90 to 95 wells in the Reservation Division. Later that year, 44 additional wells were installed to monitor the eventual operation of the AAC. By 1940, when the AAC became operational, the measurement frequency increased to three or four times per month (until late 1943) and included 25 staff gages to measure flow (stage height) throughout the open-ditch drain network. The data during this time period were primarily presented as half-mile spaced north-south cross-sections starting at the AAC. By December 1962, monthly water level measurements were being taken in about 175 wells.

Table 4. 2017 Groundwater Depth and Elevation Summary, Reservation Division.

	Depth to Water (ft bgs)			Elevation (ft amsl)		
	Average	Maximum	Minimum	Average	Maximum	Minimum
March	122.6	137.5	110.0	10.2	26.4	1.6
June	124.0	149.9	109.9	12.2	45.8	1.5
September	124.0	152.2	109.9	11.2	45.8	1.5
December	123.6	147.9	109.8	12.7	45.1	2.1
Summary for 2017	**123.6**	**152.2**	**109.8**	**11.7**	**48.1**	**1.5**

For the 2017 monitoring period, there were a total of 124 observation wells available for monitoring in the Reservation Division. Measurements were obtained quarterly (March, June, September, and December). As shown in Table 4, the 2017 depth-to-groundwater measurements ranged from 1.5 to 48.1 ft bgs with an average depth of 11.7 ft bgs and groundwater elevations ranged from 109.8 to 152.2 ft amsl with an average elevation of 123.6 ft.

Figure C- Appendix C provides the December 2017 depth to groundwater contour map for the Reservation Division. This map shows that the depth to the water table in 2017 was generally about 6 to 18 ft bgs in most areas. Some undulations in the water depth contours occur due to the relatively flat gradient of the water surface. Subtle changes in the DTW contours are visible from quarter to quarter where shallow areas of groundwater expand and contract slightly or change shape. Groundwater depths, however, appear to be generally consistent throughout the year.

South Gila Valley

The South Gila Valley is located immediately east of the City of Yuma. The valley is situated south of the Colorado and Gila Rivers, west of the Gila Mountains, and north of the Yuma Mesa. Land surface elevations range from 180 ft amsl at the eastern edge of the valley to 120 ft amsl near the Colorado River at the Yuma East Wetlands. Irrigation water is conveyed southward to the area through the GGMC to the South Gila Main Canal, which traverses near the base of the Yuma Mesa. Drainage of excess irrigation water in South Gila Valley and groundwater inflow from the Yuma Mesa mound is achieved by extensive drainage pumping.

For 2017 there were a total of 111 observation wells available for groundwater monitoring. These wells were measured during the first week of every month. As shown in Table 5, depth-to-groundwater measurements during 2017 ranged from 3.1 to 77.3 ft bgs with an average groundwater depth of 14.3 ft bgs. Groundwater elevations ranged from 115.6 to 150.9 ft amsl, with an average of 129.4 ft amsl.

Depth to groundwater contour maps for South Gila Valley are produced by the YAO on a monthly basis. For practicality however, this report includes only the December depth to groundwater contour map which is provided in Appendix C as Figure C-2. The December map shows that the depth to the water table in 2017 was generally about 12 to 16 ft bgs in most areas. Some undulation

Table 5. 2017 Groundwater Depth and Elevation Summary, South Gila Valley.

	Depth to Water (ft bgs)			Elevation (ft amsl)		
	Average	Maximum	Minimum	Average	Maximum	Minimum
January	14.0	38.5	5.4	129.4	150.1	116.9
February	14.1	38.7	5.5	129.3	150.4	116.5
March	15.0	76.7	5.8	129.1	149.6	116.6
April	14.2	38.9	5.7	129.3	150.1	116.7
May	13.9	39.0	3.1	129.6	150.5	116.4
June	14.4	76.8	4.8	129.7	150.8	116.2
July	14.1	39.3	4.2	129.3	150.7	115.6
August	14.7	39.3	5.3	129.3	150.7	115.6
September	14.5	77.0	3.3	129.5	150.9	115.8
October	13.8	39.7	5.3	129.6	150.7	116.5
November	14.1	39.8	4.8	129.3	150.8	116.1
December	14.8	77.3	5.5	129.1	150.6	115.8
Summary for 2017	**14.3**	**77.3**	**3.1**	**129.4**	**150.9**	**115.6**

in the contours is apparent due to the relatively flat gradient of the water surface. Offsets in the contours occur in some areas where the land surface abruptly changes by several feet at field breaks. Subtle changes in the contours are visible from quarter to quarter, however, groundwater depths appear to be generally consistent throughout the year.

Wellton-Mohawk Valley

The Wellton-Mohawk Valley is located along the Gila River floodplain. The town of Wellton is located approximately 30 miles east of Yuma near the middle of the valley, Land surface elevations in this area range from 160 ft amsl near the western end of the agricultural area to about 330 ft amsl near the eastern end of the area.

Irrigation water is delivered by the GGMC via the Gila River Siphon to the Wellton-Mohawk Main Canal. Irrigation water is then lifted through a series of pump stations to reach the higher elevations at the eastern end of the agricultural area.

The WMIDD measures depth-to-groundwater on a monthly basis in about 300 observation wells throughout the area and provides the measurement data to YAO. These data are used to generate quarterly depth-to-groundwater contour maps. As shown in Table 6, quarterly measured depth to groundwater for 2017 in the Wellton-Mohawk Valley ranged from a minimum of 1.6 ft bgs to a maximum of 238.9 ft bgs. The average DTW for the area was 18.3 ft bgs. Groundwater elevations ranged from 109.2 to 335.8 ft amsl, with an average of 234.6 ft amsl.

The October 2017 depth to groundwater map for the Wellton-Mohawk area is presented as Figure C-3 in Appendix C. This map shows that the depth to groundwater is generally about 6 to 18 ft bgs in most areas. Some undulations in the water depth contours occur due to the relatively flat gradient of the water surface. In the eastern portion of the valley, narrowly-spaced groundwater depth contours indicate relative deepening of the water table away from the agricultural fields

Table 6. 2017 Quarterly Groundwater Depth and Elevation Summary, Wellton Mohawk Area.

	Depth to Water (ft bgs)			Elevation (ft amsl)		
	Average	Maximum	Minimum	Average	Maximum	Minimum
January	18.6	238.1	1.6	234.7	335.6	110.0
April	18.5	237.9	1.9	234.9	335.5	110.2
July	18.0	238.6	2.2	234.6	335.8	109.5
October	18.2	238.9	1.9	234.1	335.0	109.2
Summary for 2017	**18.3**	**238.9**	**1.6**	**234.6**	**335.8**	**109.2**

*Not measured

towards areas of elevated ground. Subtle changes in the depth to groundwater contours are visible from quarter to quarter, but the overall shape tends to be rather consistent.

Yuma Mesa and 242 Wellfield

Yuma Mesa is located south and east of the City of Yuma and occupies the area that extends from the west side of the Gila Mountains, to the east side of Yuma Valley, and south to the U.S.-Mexico international border. The mesa is the largest subarea in the Yuma Area Groundwater Basin and is topographically higher than the nearby valleys. Land surface elevations range from about 150 ft amsl near the 242 Wellfield to about 500 ft amsl near the base of the Gila Mountains.

Beneath a large portion of the Yuma Mesa, a sizable groundwater mound has developed primarily as a result of deep percolation of irrigation water that is applied to support citrus and date production. Although estimates vary, it is thought that groundwater stored within the mound may be as much as 600,000 acre-ft above the predevelopment storage.[5] Groundwater from the mound flows radially outward to areas of lower groundwater elevation, especially in Yuma Valley and South Gila Valley.

In 2017, a total of 101 observation wells were available for groundwater monitoring on the Yuma Mesa and quarterly depth to groundwater measurements were made in March, June, September, and December. Depth to groundwater measurements for 22 of the 101 observation wells were provided by YMIDD. Stand-alone groundwater elevation maps for the Yuma Mesa area are typically not prepared by YAO. However groundwater elevation information for this area is included in the groundwater elevation contour map for the entire Yuma area that YAO prepares on a semi-annual basis. The December 2017 map is provided in Appendix C as Figure C-6.

For the Yuma Mesa area, the YMIDD measures 22 wells and YAO measures 79 wells. As shown in Table 7, depth-to-groundwater measurements in the Yuma Mesa area varied greatly from a minimum of 13.7 ft bgs in agricultural areas to a maximum of 498.5 ft bgs along the U.S.-Mexico border about 30 miles east of San Luis, AZ. The average depth-to-groundwater on the Yuma Mesa

[5] Dickinson, et al. 2006. Hydrogeologic Framework Refinement, Ground-Water Flow and Storage, Water-Chemistry Analyses, and Water-Budget Components of the Yuma Area, Southwestern Arizona and Southeastern California: U.S. Geological Survey Scientific Investigations Report 2006-5135, 90 pp.

Table 7. 2017 Quarterly Groundwater Depth end Elevation Summary, Yuma Mesa Area.

	Depth to Water (ft bgs)			Elevation (ft amsl)		
Month	Average	Maximum	Minimum	Average	Maximum	Minimum
March	112.0	331.1	13.8	84.0	172.9	23.3
June	119.6	498.5	13.7	81.2	173.6	22.0
September	111.9	331.5	13.9	84.3	177.2	17.1
December	115.6	363.4	13.9	81.1	177.5	20.9
Summary for 2017	**114.9**	**498.5**	**13.7**	**82.6**	**177.5**	**17.1**

was 114.9 ft bgs in 2017. Groundwater elevations ranged from 17.1 to 177.5 ft amsl, and averaged 82.6 ft amsl.

The 242-Wellfield, otherwise known as the Protective and Regulatory Pumping Unit, is situated near the SIB. The wellfield consists of 21 groundwater pumping wells that are used to intercept groundwater underflow that moves into Mexico. The pumped groundwater is conveyed to Mexico at the Sanchez Mejorada Canal to meet a portion of the treaty obligations associated with managing the Colorado River. Depth to groundwater measurements for wells in the 242-Wellfield were not made in 2017.

Yuma Valley

The Yuma Valley is situated to the west and southwest of the City of Yuma in the historic, predevelopment Colorado River floodplain. The valley is bounded on the north and west by the Colorado River, on the east by Yuma Mesa, and to the south by the U.S.-Mexico international border. Land surface elevations in the Yuma Valley range from about 90 ft amsl near the City of San Luis to 130 ft amsl near the City of Yuma. Colorado River water is provided to the Yuma Valley by diversion from the AAC to the Yuma Main Canal. Irrigation water deliveries in Yuma Valley are managed by the YCWUA through a system of canals and laterals.

The water table in Yuma Valley is relatively shallow throughout all but the southernmost part of the valley. The shallow water table is the result of extensive irrigation, abundant discontinuous clay layers in the shallow subsurface, and westward groundwater flow from Yuma Mesa. To aid in controlling the water table depth, drainage wells and deep-cut drainage ditches are typically used to capture and convey shallow groundwater away from irrigated areas throughout the valley. The drains generally flow from north to south and terminate at the Boundary Pumping Plant at the SIB near San Luis, AZ. The drainage water is then pumped into the Sanchez Mejorada Canal and delivered to Mexico for agricultural use.

During 2017, a total of 141 observation wells were available for monthly groundwater monitoring in the Yuma Valley. For the Yuma Valley area, the YCWUA measured water levels in 63 wells and YAO measured water levels in 78 wells. Measurements were normally made at the beginning of each month. A statistical summary of the measurement data is presented in Table 9.

In 2017, depth-to-groundwater measurements in Yuma Valley ranged from a minimum of 29.6 ft to a maximum depth of 115.0 ft bgs in the Colorado River limitrophe near the SIB. In 2017, the average depth-to-groundwater for the Yuma Valley was 94.4 ft bgs. Groundwater depths ranged

Table 9. 2017 Monthly Groundwater Depth and Elevation Summary, Yuma Valley.

	Depth to Water (ft bgs)			Elevation (ft amsl)		
	Average	Maximum	Minimum	Average	Maximum	Minimum
January	95.4	115.0	32.3	15.9	58.6	4.4
February	93.9	114.0	32.1	17.1	58.9	5.8
March	94.2	114.3	32.1	16.9	58.8	4.3
April	94.9	114.3	30.6	16.2	60.3	3.6
May	94.6	114.1	31.0	16.4	59.9	1.5
June	95.6	114.3	31.1	15.8	59.8	4.0
July	95.4	114.2	30.4	16.0	60.5	4.2
August	95.3	114.3	29.6	15.9	61.3	3.2
September	91.5	114.7	29.6	18.5	61.3	3.5
October	91.5	114.4	29.7	18.7	61.2	4.5
November	95.1	114.1	30.0	16.4	60.9	4.0
December	95.4	114.0	29.9	16.3	61.0	4.3
Summary for 2017	**94.4**	**115.0**	**29.6**	**16.7**	**61.3**	**1.5**

from 29.6 to 115.0 ft bgs. Groundwater elevations ranged from 1.5 to 61.3 ft amsl, and averaged 16.7 ft amsl.

Although depth to groundwater maps for the Yuma Valley are prepared monthly, only the December map is presented in this report (Figure C-5). This map shows that the depth to the water table in 2017 was generally over 8 ft bgs in most areas with small isolated pockets of shallower groundwater occurring in agricultural areas. A large mound of shallow groundwater occurs just south and southwest of the City of Yuma near the Gardenhire Drain. However, depth to groundwater increases rapidly in the direction of the Colorado River. The deepest water levels (> 40 ft bgs) occur just north of the City of San Luis.

A comparison of the water level depth contour maps for the year shows the overall shape of the groundwater surface to be relatively invariant with only subtle changes in the shape and magnitude occurring between monitoring events. However, during some months, primarily April through August, pockets of isolated shallow groundwater appear to expand and become more shallow approaching depths of 4 ft bgs or less in some areas.

Groundwater Elevation Maps

Groundwater elevation maps show the groundwater elevation referenced to mean sea level. Positive values indicate that groundwater elevation is above sea level and negative values indicate that the groundwater elevation is below sea level. Large relative values indicate that the groundwater elevation is high (more shallow), and smaller relative values indicate that groundwater is lower in elevation (deeper). The contours provide a smoothed approximation of the shape of the groundwater surface for the upper portion of the groundwater system where unconfined aquifer conditions exist.

Groundwater elevation contour maps for the entire Yuma area (excluding the Wellton-Mohawk Valley) are prepared by YAO on a semiannual basis in June and December. The December 2017 map is provided in Appendix C as Figure C-6. Groundwater elevations range from a high of just over 170 ft amsl, south of the City of Yuma in the area of Yuma Mesa, to a low of about 22 ft amsl near the SIB. The area of high groundwater elevations beneath Yuma Mesa is associated with a groundwater mound that has developed as the result of recharge to the aquifer from the deep percolation of agricultural irrigation water.

Groundwater flows from areas of high hydraulic head to areas of low hydraulic head in a direction generally perpendicular to the groundwater elevation contours. Therefore, groundwater generally flows radially outward from the Yuma Mesa mound in all directions. In particular, groundwater flows west to Yuma Valley and north to the South Gila Valley. Groundwater flow from the Yuma Mesa mound has tended to raise groundwater levels in these two valley areas and is part of the reason drainage pumping is necessary. In other areas of the map, undulating contours (such as in northern and central Yuma Valley) indicate areas where the groundwater surface is nearly flat. Additionally, offsets in the contours southeast of the mound occur along the Algodones Fault suggest that this fault is behaving as a hydraulic barrier to groundwater flow.

A comparison of the contour lines between the June 2017 and December 2017 maps indicates that the overall shape of the groundwater surface elevation in the Yuma area is relatively constant with only subtle changes occurring during the year.

Groundwater Level Change Map

Maps depicting temporal changes in depth to groundwater can provide insights into the influences of groundwater pumping, irrigation (recharge), and surface water/groundwater interactions. A change in groundwater level contour map for the Yuma area was generated by calculating the differences between measured values obtained in December 2016 and December 2017. This map is presented as Figure C-7 in Appendix C. These calculated differences were subsequently used to estimate changes in groundwater storage for the same period. The water level differences were gridded using a geostatistical interpolation algorithm (Krige, 1951) implemented through a 2-dimensional plotting software package (Surfer®, v. 13.0, Golden Software, Golden, CO). The resulting grid was smoothed and trimmed to the Yuma area. Volumetric change determinations were calculated using the trapezoidal rule and an assumed 20% specific yield to provide the estimated net change in groundwater storage in acre-ft.

The estimated aggregate change in groundwater storage across the Yuma area for 2017 was -33,094 acre-ft. Most of the storage change appears to have occurred in the southwestern portion of the Yuma Valley and along the SIB. This decline is attributed to groundwater pumping in the Mexicali Valley, the cities of San Luis, Arizona and San Luis, Rio Colorado, Sonora, and the 242 Wellfield. Further to the east however, ground water pumping by both the US and Mexico along the 5-mile zone straddling the SIB seemed to have little impact on groundwater storage. Within the 5-mile zone, the reported groundwater withdrawals were 58,624 acre-ft and 146,658 acre-ft for the US and Mexico, respectively[6].

[6] Information supplied by U.S. Section of the IBWC

Groundwater Exploration

In September 2016, the YAO funded an airborne electromagnetic geophysical survey program that was flown over portions of the Yuma area. In total, approximately 1200 line-miles of geophysical survey data were acquired in four areas including the 242 Wellfield, Yuma Valley, South Gila Valley, and the Wellton-Mohawk Valley. The purpose of the survey was to develop an improved understanding of the hydrogeology of the Yuma area and to investigate the potential for developing additional groundwater resources in the Yuma Groundwater Basin and the Wellton-Mohawk Valley. Data obtained from the geophysical survey program provide evidence to support the existence of deep zones of enhanced groundwater quality in portions of the areas surveyed. Ongoing data analysis will aid in guiding a targeted drill program to validate the results of the geophysical survey.

SUMMARY

This Annual Groundwater Status Report documents aspects of recent groundwater investigations and the water resources in the Yuma area; water supply, drainage, and groundwater levels. Data presented in this report were compiled from several sources including Reclamation data, USGS reports, and YAO and program-partner field measurements. Over 500 observation wells were monitored and groundwater contour maps were routinely prepared to show current groundwater conditions that are used to assist water managers and agricultural districts in the Yuma area. The groundwater basin subareas included in the monitoring program include the North Gila Valley, Reservation Division (including the Island), South Gila Valley, Yuma Mesa, and Yuma Valley areas. For purposes of the report, the Wellton-Mohawk area is also included in the assessment program.

During 2017, the average depth-to-groundwater in the Reservation Division and Wellton-Mohawk area were relatively shallow at 10.7 and 9.1 ft bgs, respectively. The groundwater surfaces in the North Gila Valley, South Gila Valley, and the Yuma Valley subareas were somewhat deeper at 14.8, 13.3 and 14.1 ft bgs, respectively. However, the Yuma Mesa area generally had a much greater depth-to-groundwater, averaging 112.7 ft bgs, primarily due to deepening of the groundwater surface away from the Yuma Mesa recharge mound towards the Mexico border.

Areas of shallow groundwater monitored by the program are of concern to irrigation districts and other water users. The DTW maps prepared under this program are helpful for locating areas of shallow groundwater that could impact agricultural or construction activities and for the planning of dewatering or drainage operations.

During 2017, DTW contour maps were prepared for the Reservation Division (quarterly), South Gila Valley (monthly), Wellton-Mohawk Valley (quarterly), and the Yuma Valley (quarterly). Although DTW maps are not routinely prepared for the North Gila Valley and Yuma Mesa areas, groundwater elevation contours for these areas are included in the groundwater elevation contour maps for the greater Yuma area. Although subtle changes in water depth do occur over time in response to pumping and irrigation practices, the depth to groundwater and elevation contour maps show that conditions are relatively consistent throughout the year.

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Appendix A: Chronology of Significant Events Impacting Water Resources and Development in the Yuma Area

Date	Significant Events
1857	First attempt to build canals in Yuma Valley.
1890	Small private irrigation developments in Yuma Valley.
1892	Small acreage on Yuma Mesa planted to citrus.
1902	Reclamation Act signed. Reclamation Service began survey of Yuma Project.
1904	Yuma Project authorized.
1905	Construction began on Laguna Dam. Reclamation delivered water to Valley Division (Yuma Valley) by pumping from Colorado River.
1908	Diversion of Colorado River water to Reservation Division began.
1909	Laguna Dam completed. Diversion of Colorado River water to North Gila Valley began.
1911	First groundwater observation wells constructed in Yuma Valley and Reservation Division. First groundwater map of Yuma Valley published.
1912	Colorado River siphon completed and began delivering water to Yuma Valley. First observation wells constructed in North Gila Valley.
1913	Construction of open drains began in Reservation Division.
1915	First irrigation well constructed in South Gila Valley.

Date	Significant Events
January 1916	Colorado/Gila flood flows at Yuma reached 220,000 cfs.
1916	Construction of open drains began in Yuma Valley.
1917	Yuma Auxiliary Project (Unit B) authorized.
1918	North Gila Valley Irrigation District established.
1919	Boundary Pumping Plant started operating. Yuma Irrigation District established in South Gila Valley.
June 7-8, 1920	Avulsive change in the Colorado River created the "Yuma Island." Cut-off was near the present Gila and Colorado River confluence. Peak discharge estimated at 175,000 cfs.
1922	B-Lift Pumping Plant completed and began delivering water to Yuma Auxiliary Project on the Yuma Mesa.
1925	The Colorado River Front Work and Levee System authorized (with several later amendments) for a drainage and construction program to control floods, improve navigation, and regulate flows of the lower Colorado River from Davis Dam to the Mexican border.
1934	Construction began on All-American Canal.
1935	Hoover Dam completed diminishing flood threat in Yuma area and providing a controlled supply of Colorado River water.
1937	Yuma Mesa Division of Gila Project authorized.
1938	Imperial Dam completed. Parker Dam completed.
1940	All-American Canal completed.
1941	Lake Mead filled.
1942	Early field tests and observation wells for the Coachella Canal.
1943	Gila Gravity Main Canal completed. First observation wells constructed in South Gila Valley.
1944	Yuma Mesa Pumping Plant completed and began delivering water for irrigation of the Yuma Mesa.

Date	Significant Events
1944	The United States and Mexico adopted a treaty allotting 1.5 million acre-ft of water per year to Mexico from the Colorado River.
1947	First drainage wells constructed in Yuma Valley. First observation wells constructed on Yuma Mesa. Gila Project Reauthorization Act established the present Gila Project.
1948	Coachella Canal became operational.
1950	Diversions began at Morelos Dam.
1952	Delivery of Colorado River water to Wellton-Mohawk area began.
1955	The Mexican government authorized the drilling of 281 wells in the Mexicali Valley to augment Colorado River water supplies.
1957	The Mexican government authorized the drilling of an additional 100 wells in the Mexicali Valley to augment Colorado River water supplies.
1957	Pilot Knob power plant operational.
1958	Groundwater pumping in Mexicali Valley.
1960	Discharge of Wellton-Mohawk Division drainage water began. Painted Rock Dam completed.
1960	The first nine drainage wells constructed in South Gila Valley.
1964	Twelve additional drainage wells and three supply wells constructed in South Gila Valley. Distribution system completed in South Gila Valley providing delivery of Colorado River water.
1	
1965	Minute 218 to the 1944 Treaty with Mexico for the United States to construct an extension to the MOD as a temporary solution to the salinity problem.
1966	Six Reclamation drainage wells constructed in Yuma Valley. Gila River flood water from Painted Rock Dam reached Colorado River.
1967	Twelve drainage wells constructed on Yuma Mesa for future use.
1972	Yuma Mesa Wellfield became operational. Mexico's San Luis Mesa Well Field became operational. Three additional drainage wells constructed in South Gila Valley.

Date	Significant Events
1973	The United States and Mexico adopt Minute 242 of the 1944 Water Treaty establishing a limit on the salinity of water delivered to Mexico.
1974	Colorado River Basin Salinity Control Act authorizes construction of the Yuma Desalting Plant to reduce salinity levels in the Colorado River.
1977	Construction began on the Protective and Regulatory Pumping Unit ("242 Wellfield"). The Bypass Drain became operational carrying drainage well water from the Wellton-Mohawk Valley to the Gulf of California.
1981	242 Wellfield became operational.
1983	Colorado River high flows. Peak Yuma gage elevation was 130.5 ft on July 4. The peak flow was 32,400 cfs on August 19. Replacement of drainage well YM-2R completed.
1984	Eleven drainage wells completed in northern Yuma Valley (DW-1, DW-2, DW-4, DW-5, DW-7, DW-8, DW-9, YC-1, YC-2, YC-3, YC-4) and one in the South Gila Valley (DW-3).
1988	Groundwater drainage wells DW-17 and DW-18 completed.
1989	Groundwater drainage wells DW-10, 11, 12, 13, 16, and 19 completed.
1990	Groundwater drainage wells DW-14 and 15 completed.
1992	The Yuma Desalting Plant (YDP) began operation with the first desalted water produced in March and desalted water released to the Colorado River on May 6. Operation was terminated after about 9 months.
March 5, 1993	The Gila River flooded resulting in a peak discharge of 24,800 cfs at the Yuma gage and a stage of 124.5 ft msl.
March 1993	Replacement of South Gila drainage well SG-10R completed. October. Replacement of Yuma Valley drainage well YV-13R2 completed.
April 1994	Replacement of Yuma Mesa drainage well YM-3R completed.
November 1994	Replacement of Yuma Valley drainage well YV-23R2 completed. This is the 2nd replacement well at this site.
December 1994	Replacement of Yuma valley drainage well YV-7R completed. This well site is about 0.2 miles north of the original YV-7.

Date	Significant Events
July 1996	New drainage well SG-14 in the South Gila Valley completed using cable-tool.
November 1996	New drainage well in Yuma Valley completed. This well was situated to provide shallow groundwater relief to Padre Rancitos near County 13th St. and the East Main Canal.
December 1996	Replacement well DW-8R completed as a water supply well for the Yuma Desalting Plant and is located in the northwest corner of the facility.
February 1997	Replacement well SG-9R completed in the South Gila Valley. Replacement well YM-7R completed on the Yuma Mesa, but the well failed and was capped.
March 1997	YCWUA completed drainage well YCWUA 14 ½ St. Original well (YCWUA 14 ⅝ St.) was located about ¼ mile west and ⅛ mile south.
March 1997	Replacement well YV-28R completed in the Yuma Valley.
April 1997	YCWUA replaced YCWUA 12 ¼ St. well.
January 1998	YCWUA replaced YCWUA 13th St. well. This is the second replacement well at this site.
February 1998	YCWUA replaced drainage well YCWUA 10 ¾ St. This is the third replacement well at this site.
September 2000	YCWUA installed a new Yuma Valley drainage well (YCWUA 16th St.) at County 16th St. and the East Main Canal.
June 2002	Replacement well YM-2R2 completed; the third well at this site.
September 2003	YCWUA installed a new Yuma Valley drainage well (YCWUA 12th St.) at County 12th St. about 0.1 mile west of the Yuma Main Canal.
February 2004	YCWUA installed a new Yuma Valley drainage well (YCWUA 11 ¾ St.) at Avenue B ½ at the head of an open-ditch drain.
May 2004	YCWUA installed new drainage wells YCWUA 13 ⅞ St. at Ave. B ½ just north of County 14th St. and YCWUA 16 ½ St. at County 16 ½ St. and the Yuma Main Canal.
June 2004	YCWUA installed a new Yuma Valley drainage well (YCWUA 17 1/4 St.) near County 17 St. and the Yuma Main Canal.
2009	Completion of the All-American Canal Lining Project from Pilot Knob to Drop 3.

Date	Significant Events
April 4, 2010	Magnitude 7.2 earthquake shook the Yuma area and destroyed about 1/3 of the irrigation canals in the Mexicali Valley.
May 3, 2010	Pilot run of the YDP began and operated continuously for about 11 months.
October 2012	Pilot holes LCWSP-3 (660 ft) and LCWSP-4 (620 ft) drilled along the AAC in the Imperial Dunes for future production well sites.
November 2012	Groundwater drainage well YM-3R3 completed to replace the existing drainage well.
January 2013	Replacement of well YCWUA-14th St. completed for YCWUA.
April 2013	Replacement of drainage well YM-8R3 completed. Well site moved east and closer to the Yuma Mesa Conduit.
May-June 2013	Eight additional relief wells completed along the base of Senator Wash Dam between the existing relief wells: RW-3 ½, RW-4 ½, RW-5 ½, RW-6 ½, RW-7 ½, RW-8 ½, RW-9 ½, and RW-10 ½.
August 2013	Replacement well 242-2R completed in the 242 Wellfield.
October 2013	Water supply well LCWSP-1R in the Imperial Dunes was completed to a deeper level (550 ft) with extended pump chamber and screened interval to replace existing well.
November 2013	An additional production well (INWR-3) used for native fisheries was drilled for Imperial National Wildlife Refuge.
February 2014	Replacement well 242-3R completed in the 242 Wellfield.
March 23, 2014	Minute 319 pulse flow water delivered to the Colorado River delta in accordance with Minute 319 of the U.S.-Mexico water treaty. The pulse flow flooded riparian areas throughout the delta and reached the Gulf of California during high tide on May 15.
May 2014	Replacement well 242-4R completed in the 242 Wellfield.
July 2014	Replacement of Yuma Mesa drainage well YM-11R completed.
October 2014	Replacement of South Gila drainage well SG-2R completed.
November 2014	Replacement of Yuma Mesa drainage well YM-9R completed. Existing well had collapsed the previous month.

Date	Significant Events
January 2015	Replacement of Yuma Mesa drainage well YM-2R3 completed. This is the fourth drainage well drilled at this site and was drilled deeper (395 ft) than any of the previous wells.
March 2015	Replacement of South Gila drainage well SG-12R3 completed.
April 2015	Replacement of South Gila drainage well SG-10R2 completed.
June 2015	Replacement well 242-22R completed in the 242 Wellfield.
August 2015	Replacement well 242-21R completed in the 242 Wellfield.
October 2015	Replacement well 242-18R completed in the 242 Wellfield.
December 2015	Report of the Reservation Division observation well resurvey and reconciliation project completed.
December 2015	Replacement of South Gila drainage well SG-714R3 completed to a depth of 685 ft. This experimental deep well produces water with half of the total dissolved solids (1,080 ppm) of its shallow predecessor drainage well.
March 2017	Lower Colorado Water Supply Well 4 (LCWSP-4) completed.
August 2017	Groundwater drainage well YV-13R3 completed to replace the existing drainage well in Yuma Valley.
September 2017	The United States and Mexico adopt Minute 323 of the 1944 Water Treaty to provide for a binational water scarcity contingency plan for the Lower Colorado River.
October 2017	Groundwater drainage well PP-1B completed in Wellton-Mohawk Valley.
December 2017	Groundwater drainage well YV-8R completed to replace the existing drainage well in Yuma Valley.

Appendix B: Groundwater Depth Measurements

Depth to groundwater measurements, commonly referred to as ‘tape readings’ are made manually and referenced to a point at the top of each well casing. For readings made in shallow observation wells, a “popper” tape is used and for readings in deeper wells, an electrical ‘sounding’ tape is used (Figure B-1).

The popper tape uses a bell-shaped, brass weight attached to its end. The tape is lowered slowly into a well until the popper just contacts the water surface, thereby emitting a popping sound that can be heard at the ground surface. Once the sound is heard, the tape reading is taken. This measurement method is effective for relatively shallow measurements (i.e., less than about 50 ft.) where the water level is above the top of the screened interval in the well.

With the electrical sounding tape, an audible buzzing sound is emitted when two electrical contacts at the end of the tape touch the water surface, thereby closing the electrical circuit. This measurement method is most effective for water level depths greater than 50 ft. Both methods are used in the monitoring program to measure groundwater levels to the nearest hundredth of a foot (0.01 ft.).

Figure B-1: Popper tape (left) and electrical sounding tape (right).

Benchmark surveys are used in the program to accurately measure the top-of- casing for use as a reference elevation at each observation well for the calculation of groundwater elevations. The groundwater elevation at each measured well is computed by subtracting the tape reading from the top-of-casing reference elevation to provide groundwater elevations in ft amsl using the NGVD-29 vertical datum.

Depth to groundwater measurements taken at wells, in general, represent depth to the water table below land surface and are reported in units of ft below ground surface (bgs). For preparing contour maps of depth to groundwater in agricultural areas, the water table depth or depth to groundwater is computed by subtracting the groundwater surface elevation from the average elevation of the surrounding agricultural fields. Because adjacent agricultural fields are often at slightly different elevations across a field break, off-sets in depth to groundwater contours can develop in the contour maps.

Appendix C: Groundwater Contour Maps

Depth to Groundwater Maps

Reservation Division

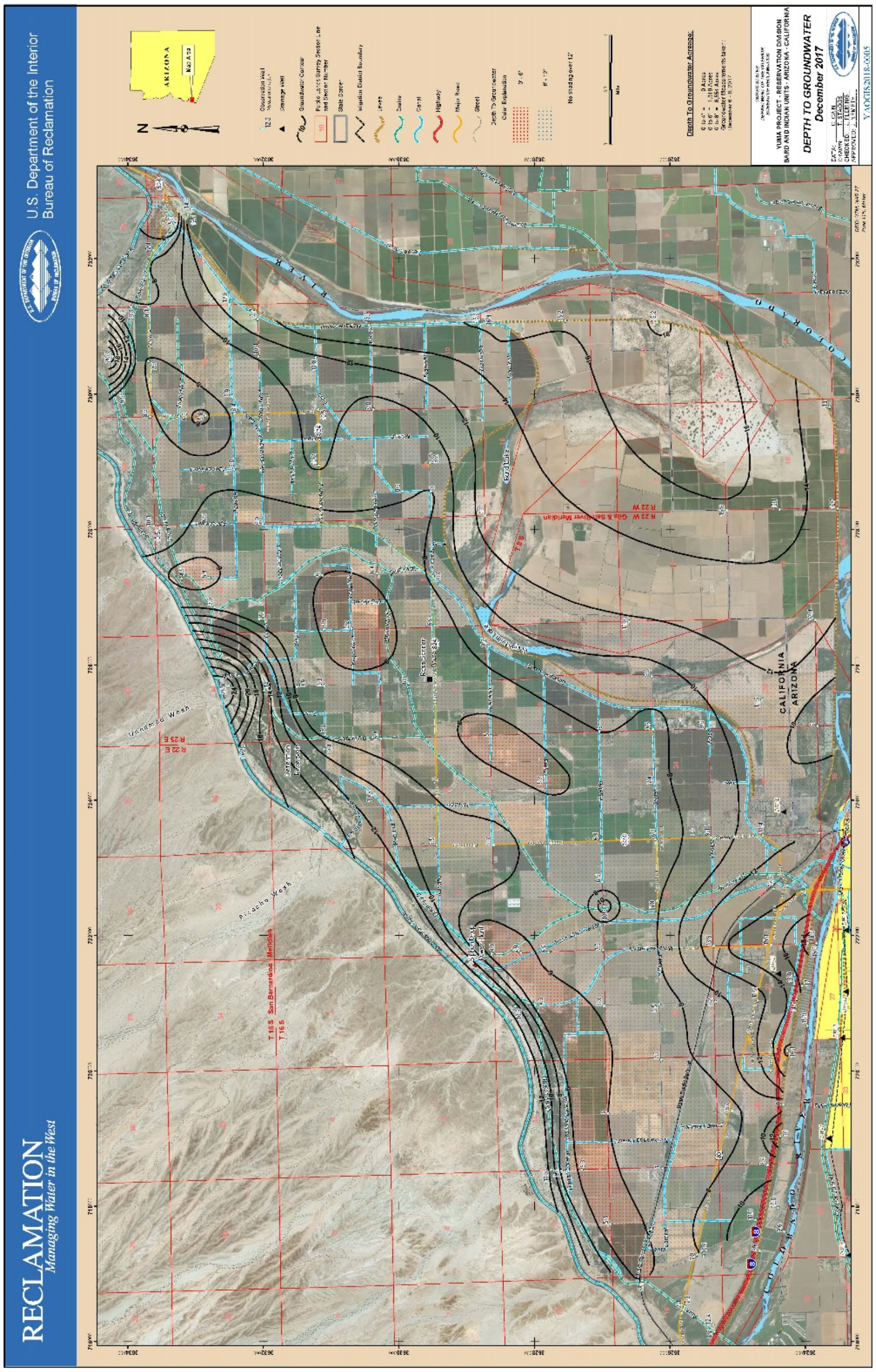

Figure C-1. Reservation Division depth to groundwater map, December 2017.

South Gila Valley

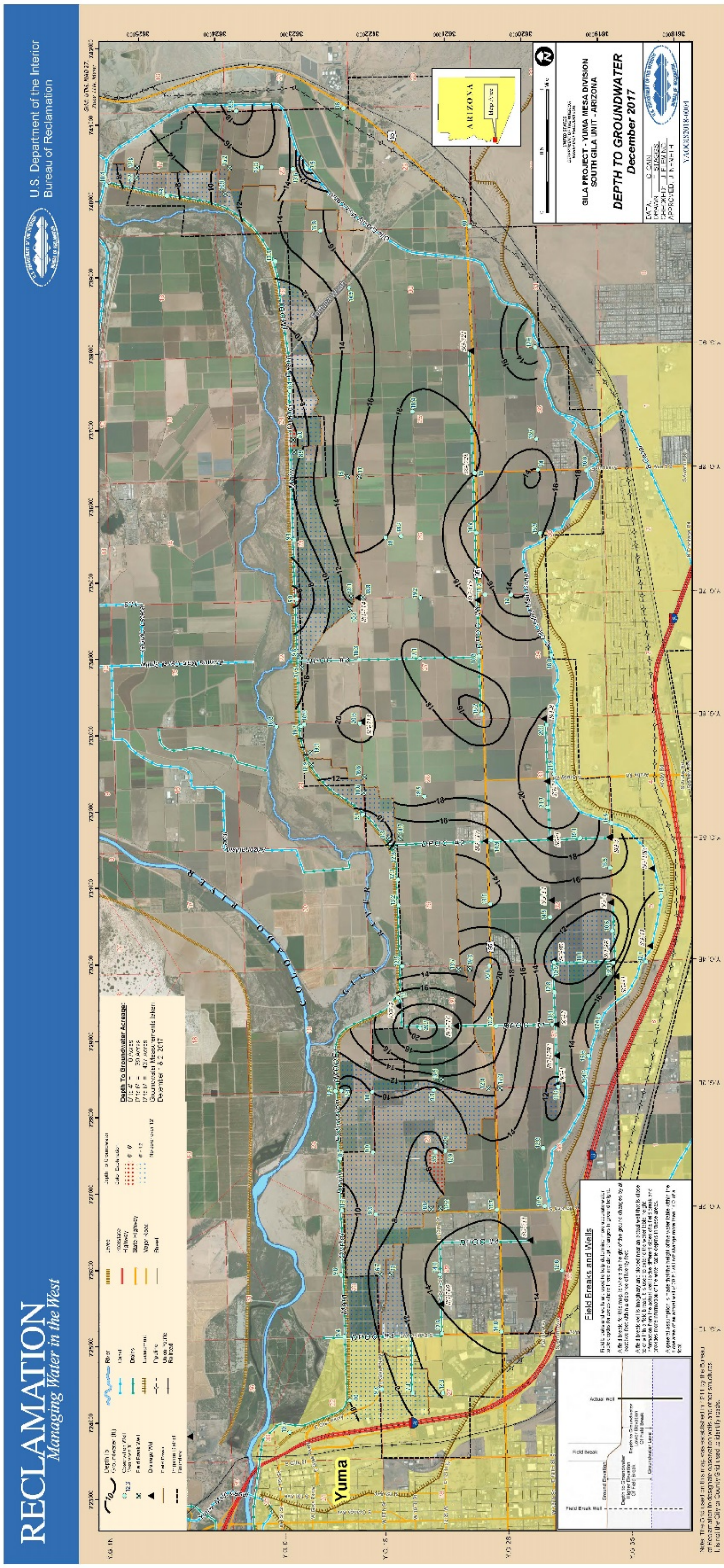

Figure C-2. South Gila Valley depth to groundwater map, December 2017.

Wellton-Mohawk Valley

Figure C-3. Wellton-Mohawk Valley depth to groundwater map, October 2017.

Yuma Valley

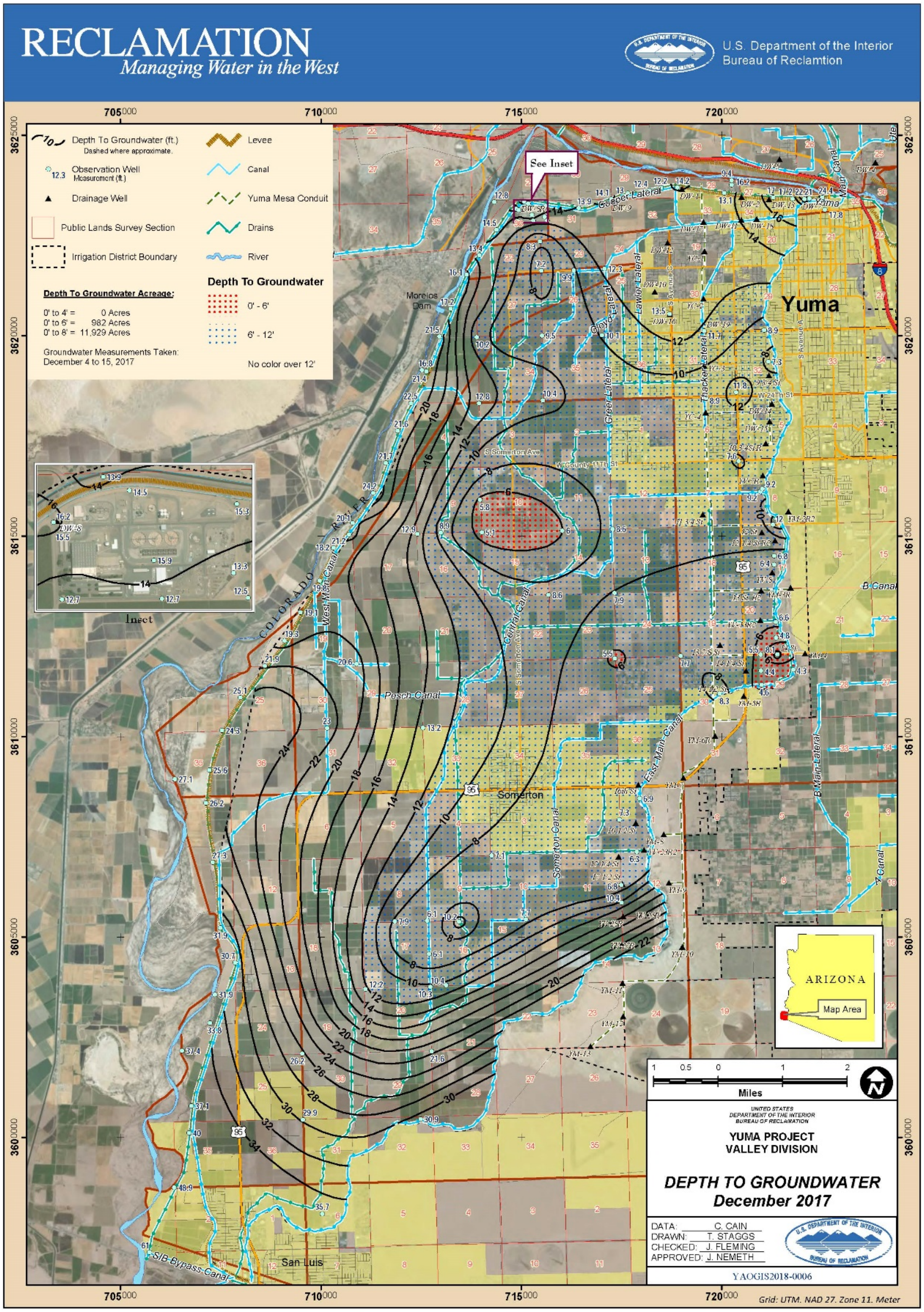

Figure C-4. Yuma Valley depth to groundwater map, December 2017.

Groundwater Elevation Map

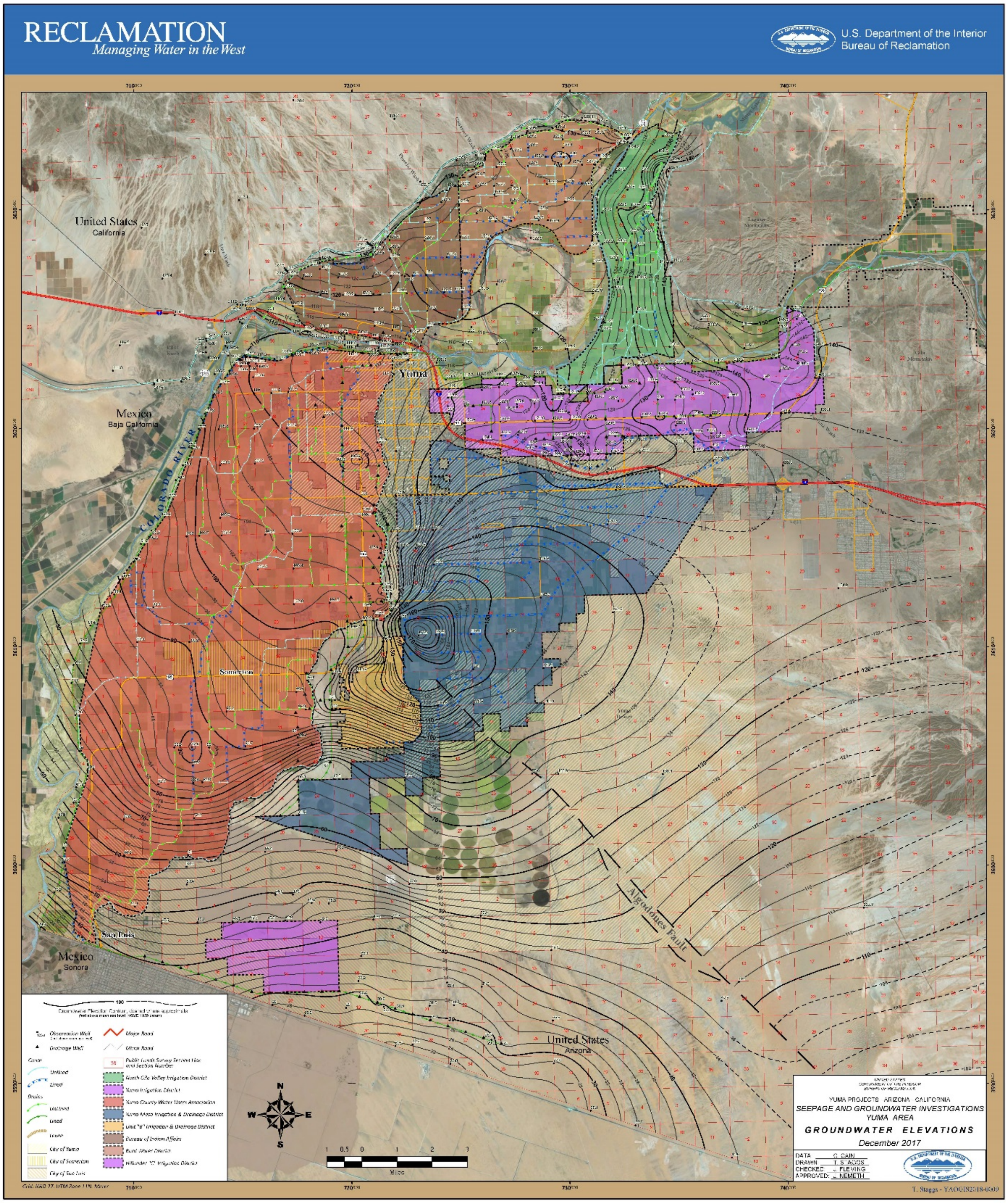

Figure C-5. Yuma Area groundwater elevation map, December 2017.

Yuma Area Change in Groundwater Level Map

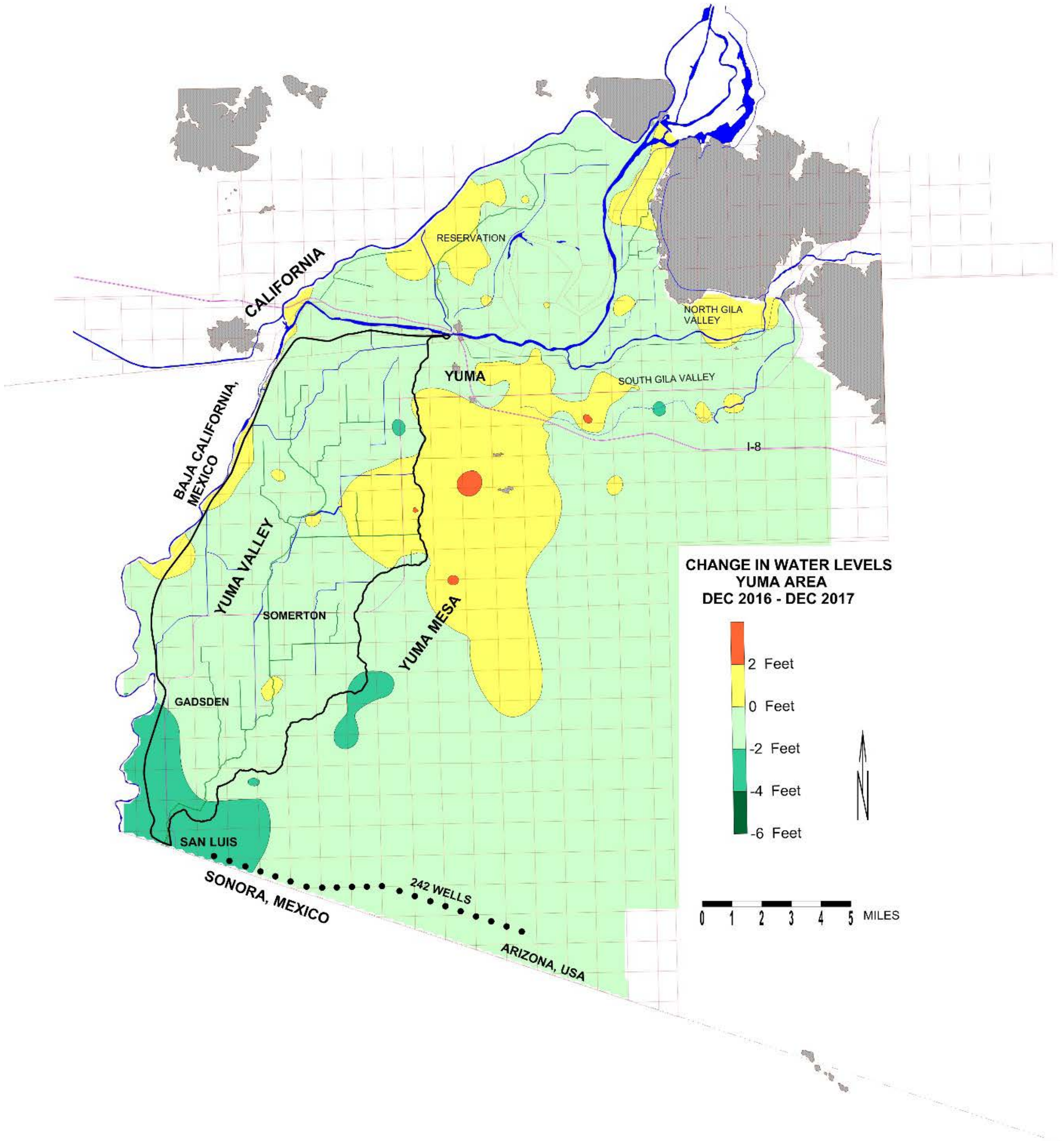

Figure C-6 Yuma Area change in groundwater levels between December 2016 and December 2017. Areas colored in various shades of green indicate a decline in water levels and areas in yellow and orange indicate a rise in water levels.