Prepared in consultation with the Secretaries of Agriculture and Defense and in cooperation with the Upper San Pedro Partnership in response to Public Law 108-136, Section 321

Water Management of the Regional Aquifer in the Sierra Vista Subwatershed, Arizona—2010 Report to Congress

U.S. Department of the Interior
U.S. Geological Survey

FMC000737

U.S. Department of the Interior
Ken Salazar, Secretary

U.S. Geological Survey
Marcia McNutt, Director

U.S. Geological Survey, Reston, Virginia 2011

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Suggested citation:
Upper San Pedro Partnership, 2012, Water management of the regional aquifer in the Sierra Vista Subwatershed, Arizona—2010 report to Congress: Washington, D.C., U.S. Department of Interior, 18 p.

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Executive summary

Section 321 of the Defense Authorization Act of 2004, Public Law 108-136, requires each annual 321 report to address five requests, of which four are quantitative. The responses to the four quantitative requirements of the Act for the calendar-year 2009 reporting period follow. A negative value indicates a decrease in regional storage:

1. The quantity of the overdraft of the regional aquifer reduced during the reporting period, 2009, compared to the previous reporting period, 2008: **-900 acre-ft** (after taking into account all revisions to the base groundwater budget that have occurred since 2002)
2. Whether the reduction in (1) met the goal specified for the reporting period: **No**
3. The water-use management and conservation measures undertaken by each water-use controlling member of the Partnership during the reporting period: See table 4 for the breakdown by jurisdiction
4. The extent of the contribution of such measures to the reduction of the overdraft: **8,100 acre-ft**

The overall situation in the regional aquifer of the Sierra Vista Subwatershed today is not improving; rather, it continues to get worse at a rate slower than in 2002. Although the annual overdraft of the aquifer has been greatly reduced from the 14,400 acre-ft originally anticipated for 2009 (fig. 1) to 6,100 acre-ft today, this is still another 6,100 acre-ft of water that has been removed from storage in addition to the 54,500 acre-ft removed since 2002 (the beginning of 321 monitoring), and the hundreds of thousands of acre-ft that have been removed from storage since groundwater pumping commenced in earnest in the first half of the 20th century. Until the aquifer begins to accrete storage (i.e., the annual water budget bottom line becomes greater than 0) there will be no reduction in the cumulative deficit, and until additional management measures are undertaken, it is unlikely that there will be further progress made toward this goal.

Table 5 of this report presents the 8 indicators of sustainability the Partnership has agreed to track and should provide the reader with a more general sense of the overall progress toward sustainable yield in the Subwatershed than is possible from the water budget deficit alone. There is improvement in a few of the indicators compared to last year and in some of the short-term indicator trends. At this time, however, the indicators show little long-term progress toward the goal of sustainable groundwater use. It should be noted that the response time of management and conservation measures for many of the indicators will be, at a minimum, years and in many cases decades or longer; capture of natural discharge from the system continues for long periods of time even when pumping is entirely discontinued (Bredehoeft and Durbin, 2009; Leake and others, 2008).

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Table ES1. Water recharged to and withdrawn/discharged from the regional aquifer underlying the Sierra Vista Subwatershed in 2009

[Water-budget volumes are in acre-ft/yr; inflows are assigned positive numbers, outflows are assigned negative numbers; all values are estimates based upon the best available data and computational methods. Total is 100 acre-ft larger than sum of components due to rounding error calculating component volumes from subcomponents]

Component	Estimated volume
Natural aspects of system	1,900
Pumping	-16,500
Active management measures	4,100
Passive recharge resulting from human activities	4,500
Total aquifer storage change	**-6,100**

Preface

The Defense Authorization Act of 2004, Public Law 108-136, Section 321, stipulates the way in which Section 7 of the Endangered Species Act applies to the Fort Huachuca, Arizona military reservation. Section 321 of this Act further directs the Secretary of the Interior to prepare reports to Congress on steps to be taken to reduce the overdraft and restore the sustainable yield of groundwater in the Sierra Vista Subwatershed:

> The Secretary of [the] Interior shall prepare, in consultation with the Secretary of Agriculture and the Secretary of Defense and in cooperation with the other members of the Partnership, a report on water use management and conservation measures that have been implemented and are needed to restore and maintain the sustainable yield of the regional aquifer by and after September 30, 2011. The Secretary of the Interior shall submit the report to Congress not later than December 31, 2004. . . . Not later than October 31, 2005, and each October 31 thereafter through 2011, the Secretary of the Interior shall submit, on behalf of the Partnership, to Congress a report on the progress of the Partnership during the preceding fiscal year toward achieving and maintaining the sustainable yield of the regional aquifer by and after September 30, 2011.

Pursuant to this requirement, an initial Section 321 report, submitted to Congress in 2005, established goals to achieve sustainability and indicated the various water management measures planned by Partnership members to meet the targeted reductions in aquifer use (Department of the Interior, 2005).

The report that follows is an annual progress report, the sixth in a series of such reports to be prepared through 2011. The report utilizes the best information available at this time including data from Partnership research studies of the Sierra Vista Subwatershed and data collected by the monitoring program which has been tailored to Section 321 information needs. The authorship of this report is attributed collectively to the Upper San Pedro Partnership, a consortium of Federal and State agencies, local jurisdictions, and non-governmental organizations. Information for this report was supplied by several agencies including the Arizona Department of Water Resources, the U.S. Geological Survey, the Agricultural Research Service, the Bureau of Land Management, the Bureau of Reclamation, and other Upper San Pedro Partnership members.

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	4,047	square meter (m^2)
	Volume	
gallon (gal)	0.003785	cubic meter (m^3)
acre-foot (acre-ft)	325851	gallon (gal)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
	Flow rate	
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year (m^3/yr)
cubic foot per second (cfs)	448.812	gallon per minute (gpm)
gallon per minute (gpm)	1.6141	acre foot per year (acre-ft/yr)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallon per day (gal/d)	0.003785	cubic meter per day (m^3/d)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows: °F=(1.8×°C)+32
Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows: °C=(°F-32)/1.8
Vertical coordinate information is referenced to the insert datum name (and abbreviation) here for instance, "North American Vertical Datum of 1988 (NAVD 88)."
Horizontal coordinate information is referenced to the insert datum name (and abbreviation) here for instance, "North American Datum of 1983 (NAD 83)."
Altitude, as used in this report, refers to distance above the vertical datum.

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Water Management of the Regional Aquifer in the Sierra Vista Subwatershed, Arizona—2010 Report to Congress

Submitted to Congress by the Secretary of the Interior, in consultation with the Secretary of Agriculture and Secretary of Defense and in cooperation with the other members of the Upper San Pedro Partnership.

Section 321 Reporting

Section 321 of the Defense Authorization Act of 2004, Public Law 108-136, requires each annual 321 report to include the following:

1. The quantity of the overdraft of the regional aquifer reduced during the reporting period;
2. Whether the reduction in (1) met the goal specified for the reporting period;
3. The water-use management and conservation measures undertaken by each water-use controlling member of the Partnership during the reporting period;
4. The extent of the contribution of such measures to the reduction of the overdraft;
5. The legislative accomplishments made during the reporting period in removing legal impediments that hinder the mitigation of water use by Partnership members.

The first four quantitative requirements are addressed in order, below. The fifth reporting requirement is addressed after a brief discussion of items one through four.

The fiscal year prior to the due date of this report to Congress (fiscal year 2010)—specified in Section 321 as the reporting period—was still underway during the preparation of this report and therefore was not a useable reporting period. As with previous Section 321 reports, the previous calendar year (2009) was used instead.

1. The quantity of the overdraft of the regional aquifer reduced during 2009

The numerical value of the annual Subwatershed deficit (or overdraft) calculated using the water budget method increased from a reported 4,400 acre-ft in 2008 to 6,100 acre-ft in 2009. In 2009, therefore, the reported quantity of the overdraft increased by 1,700 acre-ft (fig. 1 and table 1). Two revisions have since been made to the base components of the water budget, however: an increase to the base-flow discharge component (Kennedy and Gungle, 2010) increased the deficit reported in 2008 by 1,640 acre-ft, while a correction to the amount of recharging treated effluent for years 2004 to 2008 subsequently decreased that deficit by 800 acre-ft (table 2a). When these revisions are applied to the 2008 water budget the best estimate of the overdraft for 2008 is now about 5,200 acre-ft (fig. 1 and table 2b). From 2008 to 2009, therefore, the corrected quantity of the overdraft of the regional aquifer increased by about 900 acre-ft. The base water budget revisions and the quantity of the overdraft (storage deficit) are discussed in more detail on p. A51 to A52 (Appendix A) of this report.

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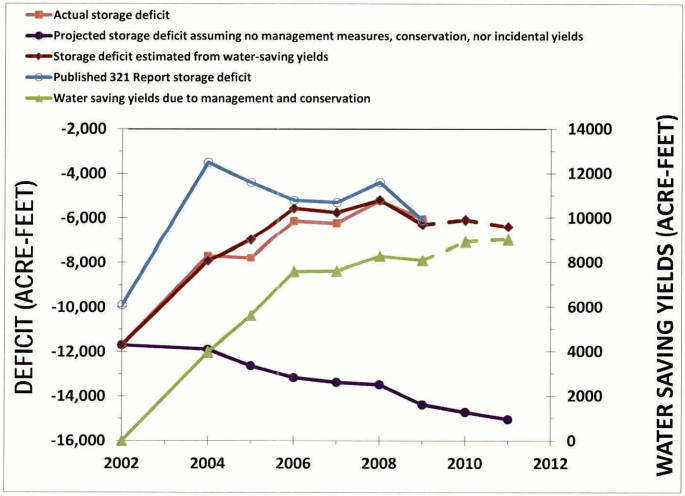

Figure 1. Effect of management-measure yields (planned yields and estimates of actual yields) on annual aquifer storage change (calculated as the difference between projected annual aquifer-storage depletions if no management measures are taken and the water saving yields due to management measures and conservation). In other words, the purple line plus the green line equals the maroon line. The actual storage deficit calculated for each year (column 6 in table 2b) is shown for comparison, as are the deficits originally published (column 2 in table 2b). All other deficit values shown for all years include all updates to the base groundwater budget that have occurred since 321 reporting began in 2004

Table 1. Water recharged to and withdrawn/discharged from the regional aquifer underlying the Sierra Vista Subwatershed in 2009

[Water-budget volumes are in acre-ft/yr; inflows are assigned positive numbers, outflows are assigned negative numbers; all values are estimates based upon the best available data and computational methods]

Component	Estimated volume	Description
Natural aspects of system		
Natural recharge[1]	15,000	Inflow largely from percolating waters on and around mountains and through ephemeral channels
Groundwater inflow[1]	3,000	Subsurface inflow from Mexico
Groundwater outflow[1]	-440	Subsurface outflow at USGS San Pedro River near Tombstone streamflow-gaging station (09471550)
Stream base flow[2]	-4,890	Groundwater discharge to the river that flows out of the Subwatershed
Evaporation and plant transpiration[3]	-10,800	Groundwater consumed in the riparian system exclusive of evapotranspiration supplied by near-riparian recharge from precipitation or flood runoff
Sub-total	1,900	Natural aspects of system
Pumping		
Pumping, water companies and public supply– gross	-10,047	Groundwater extractions by water companies and municipalities (excluding golf courses)
Pumping, rural/exempt well – gross	-4,680	Groundwater extractions by private wells
Pumping, industrial (turf, sand and gravel, stock tanks, golf courses) – gross	-1,428	Groundwater extractions for industrial uses (including golf courses)
Pumping, irrigation – net[4]	-389	Groundwater extractions for agricultural use
Sub-total	-16,500	Pumping
Active management measures		
Reduction of riparian evapotranspiration	615	Management of invasive mesquite
Municipal effluent recharge[5,6]	3,230	
Detention basin recharge[7]	235	
Sub-total	4,100	Active management measures
Passive recharge resulting from human activities		
Incidental recharge[8]	2,239	
Urban-enhanced recharge[9]	2,300	
Sub-total	4,500	Passive recharge due to human activities
Total aquifer storage change[10]	**-6,100**	Additions or reductions in stored aquifer water

[1] Flow volume estimated by the Arizona Department of Water Resources (2005).

[2] Base flow discharge at Tombstone gaging station estimated from entire period of record (Kennedy and Gungle, 2010).

[3] Evapotranspiration value is the average of the high and low estimates of Scott and others (2006).

[4] Pumping for irrigation is consumptive use only. Area considered is the groundwater basin portion of the Sierra Vista Subwatershed only. The area within the boundaries of the Sierra Vista Subwatershed includes more agricultural lands—primarily located in the head waters of the Babocomari River—than the area within the groundwater basin portion of the Subwatershed.

[5] Municipal effluent recharge is water returned to the aquifer through recharge facilities as reported by the City of Sierra Vista (Brenda Foote, written commun., April 8, 2010), Fort Huachuca (Tom Runyon, written commun., May 15, 2010), City

of Tombstone (Carla Molina, Tombstone Public Works, personal commun., May 24, 2010), and City of Bisbee (Russ McConnell, written commun., June 12, 2009).

[6] The City of Sierra Vista has known for some time that several hundred additional acre-ft of incidental recharge have been infiltrating through the bottoms of the EOP wetlands ponds, although the amount of that additional recharge has not been known. A recent consultant's study of the city's recharge facility concluded 350 acre-ft/yr of incidental recharge from the wetlands should be included in the 2009 recharge total. Previously unreported recharge from 2003 – 2007 is estimated to be about 700 acre-ft/yr, and for 2008 about 800 acre-ft (written commun., Mike Hemesath, Director, Department of Public Works, City of Sierra Vista, April 9, 2010).

[7] Recharge of stormwater within basins installed to mitigate flood peaks in urban ephemeral-stream channels.

[8] Incidental recharge is an estimate of water returned to the aquifer from septic tanks and turf watering.

[9] Urbanization in semiarid climates can increase recharge by concentrating rainfall runoff in ephemeral-stream channels (Kennedy, 2007; Lohse and others, 2010). Estimate provided by the Agricultural Research Service. Recharge caused by urbanization only partially mitigates the increased pumping that accompanies increased urbanization.

[10] Subtotals and total are equal to sum of individual terms rounded to nearest 100 acre-ft/yr; sum of subtotals can differ from sum of all individual terms rounded to nearest 100 acre-ft/yr.

Table 2a. Revisions to base groundwater budget, Sierra Vista Subwatershed of the Upper San Pedro basin, 2002 to 2009. Negative values indicate an increase in the aquifer storage overdraft (deficit). Calendar year 2003 water budget data were not analyzed in the 321 Report series.

[Volumes are in acre-ft/yr]

Water budget year	Base groundwater budget element revised in given year	Volume before revision (original)	Volume after revision (improved)	Resulting change in water budget value	Cumulative change in water budget deficit[1]
2002	none			0	0
2003	none	NA	NA	NA	NA
2004	Urban enhanced recharge	0	3,100	3,100	3,100
	[treated effluent incidental recharge][1]	[0]	[700]	[700]	3,800
2005	Urban enhanced recharge	3,100	2,300	-800	3,000
2006	Exempt well pumping	-5,030	-4,390	640	3,640
	Evapotranspiration	-7,700	-10,800	-3,100	540
2007	none			0	540
2008	[treated effluent incidental recharge][1]	[700]	[800]	[100]	640
2009	Base flow discharge	-3,250	-4,890	-1,640	-1000
	[treated effluent incidental recharge][1]	[800]	[0]	[-800]	-1,800

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Table 2b. Annual aquifer storage overdraft (deficit) for the Sierra Vista Subwatershed. For each year of 321 reporting, the overdraft is presented as published in the annual 321 Reports (column 2), as calculated using only water budget elements originally used in the CY 2002 water budget (column 3), and after taking all revisions to base water budget elements (as of the writing of this report) into account (column 6). The differences in the value of the overdraft as originally published compared to the value calculated using CY 2002 base budget elements only (column 4), and as compared to the value calculated taking all revisions to the base water budget elements into account, as found in the CY 2009 water budget (column 5), are also presented. Note that the water budget year is not the same as the year of the 321 Report (see footnote 1, p. A-1), and that calendar year 2003 water budget data were not analyzed in the 321 Report series.

[Deficits are in acre-ft/yr]

Water budget year	Deficits published in 321 Reports	Deficits if no base revisions to 2002 water budget[1]	Published deficits relative to 2002 water budget components	Published deficits relative to 2009 water budget components	Corrected deficits using current base budget revisions[1]
2002	-9,900	-9,900	0	1,800	-11,700
2003	NA	NA	NA	NA	NA
2004	-3,500	-5,900	2,400	4,200	-7,700
2005	-4,400	-6,000	1,600	3,400	-7,800
2006	-5,200	-4,340	-860	940	-6,140
2007	-5,300	-4,440	-860	940	-6,240
2008	-4,400	-3,440	-760	1040	-5,240
2009	-6,100	-4,300	-1,800	0	-6,100

[1]From 2004 to 2008 there was on average 700 acre-ft of leakage per year (800 acre-ft in 2008) from the Sierra Vista Waste Water Facility (written commun. From Mike Hemesath, Director, City of Sierra Vista Department of Public Works, April 9, 2010; Hemesath, 2010). This is considered recharge and before now has not been included in the published annual 321 Report water budgets. This volume is a management measure that went into effect after 2002, and thus is not considered to be one of the base water budget revisions; this is indicated by the brackets. In order to have the most accurate water budget possible, however, this volume is now included in the water budget accounting for years 2004, 2005, 2006, 2007, and 2008. In 2009 it is estimated that 350 acre-ft of leakage (recharge) occurred at the facility, and this is included in the water budget found in the current report (table 1). The deficit if no base revisions are made to the 2002 water budget (table 2b, column 3) must include this additional 700 acre-ft per year (800 acre-ft for 2008) to be correct as it is a previously missing management measure from 2004-2008, not a permanent base revision to a water budget element. The corrected deficit using base water budget element revisions (table 2b, column 6) must also include this additional volume to be correct. The deficits published in the annual 321 reports (table 2b, column 2), however, are just that, what was actually published, and so do not include this correction.

2. Whether the reduction in the deficit met the goal specified for the reporting period

The water budget goal for 2009 presented in table 4 of the 2004 321 Report (Department of the Interior, 2005) was for the Partnership to have erased the annual water budget deficit and to have accreted 700 acre-ft of storage by the end of 2009. Taking into account the revisions to the water budget presented in (1), above, this goal is revised to a deficit of -1,100 acre-ft in 2009. The projected change in aquifer storage from 2008 to 2009 was an increase of 800 acre-ft (table 3). As indicated in (1), above, the quantity of the overdraft of the regional aquifer was not reduced during 2009; rather, aquifer storage decreased (the overdraft increased) by about 900 acre-ft. Therefore, the "reduction in the deficit" from 2008 to 2009 did not meet the goal specified for the reporting period.

The change in aquifer storage calculated using the water budget method is discussed in Appendix A, p. A52 to A54.

Table 3. Original and revised 2009 water budget deficit/surplus goals and actual water budget deficit or surplus. Values include all revisions to base groundwater budget as of 2009. Positive numbers indicate an increase or surplus; negative numbers a decrease or deficit

[in acre-ft; all values rounded to nearest 100 acre-ft]

Change in annual deficit/surplus Original 2008 to 2009 goal from 2004 321 Report	Change in annual deficit/surplus Actual 2008 to 2009 change in annual deficit/surplus	Original 2009 annual deficit/surplus goal from 2004 321 Report	Revised 2009 deficit/surplus goal	Actual 2009 annual deficit/surplus
800	-900	700	-1,100	-6,100

3. Water use management and conservation measures undertaken by each water-use controlling member of the Partnership

The water use management and conservation measures undertaken by each water-use controlling Partnership member in 2009 are detailed in table 4. The actual yields from the measures undertaken in 2009 (10,400 acre-ft) are about 300 acre-ft less than the 2009 planned yields as projected in last year's report (10,700 acre-ft). The Partnership has chosen to include urban enhanced recharge as a separately categorized conservation yield in table 4. Because it was included in the base water budget, however (tables 1 and 2a), as a component of passive recharge from human activities, it must be subtracted from the total yield in table 4 to avoid double counting. Therefore, the actual water savings from conservation yields in 2009 is 8,100 acre-ft rather than 10,400 acre-ft (see fig 1).

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Table 4. Planned and estimated actual yields for 2009 of Partnership member measures to reduce aquifer overdraft and of increased recharge from urbanization

[Yields are in acre-ft/yr; numbers compiled March—June 2009 based on data provided by respective jurisdictions or in conjunction with USGS; conservation yields in each year are relative to a zero yield in the baseline year of 2002; recharge yields are total values and are relative to a baseline of zero acre-ft]

Description	Measure type	2009 Yield Planned	2009 Yield Actual
Fort Huachuca			
Conservation measures[1,2]	Conservation	[1,000]	[750]
Effluent recharge[3]	Recharge	200	100
Stormwater detention basins[4]	Recharge	50	15
Cochise County			
Conservation measures[5]	Conservation	120	120
Stormwater detention basins	Recharge	30	30
Sierra Vista			
Conservation measures[1,2]	Conservation	1,600	1,700
Improved golf course efficiency	Conservation	15	15
Effluent recharge[6]	Recharge	2,800	2,600
Stormwater detention basins[7]	Recharge	240	190
Bisbee			
Conservation measures	Conservation	40	40
Reduced groundwater pumping through effluent reuse	Conservation	0	0
Effluent recharge[8]	Recharge	470	440
Huachuca City			
Conservation measures[2]	Conservation	20	55
Tombstone			
Conservation measures[2]	Conservation	10	10
Effluent recharge[9]	Recharge	100	90
Bureau of Land Management			
Mesquite reduction[10]	Conservation	615	615
Urban enhanced ephemeral-stream channel stormwater recharge			
Increase in stormwater recharge in ephemeral channels by urbanization[11]	Recharge	2,300	2,300
Incidental yields			
Retirement of agricultural pumping[12]	Conservation	2,070	2,070
Total yields			
Total yield[13]		10,700	10,400

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[1]Fort Huachuca is wholly contained within the boundaries of the City of Sierra Vista, and Fort Huachuca's conservation yields are included in the Sierra Vista yields included in table 3. The Planned and Actual Total Yields found at the bottom of this table do not include the values from the Fort Huachuca Conservation Measures line. Fort Huachuca's yields were double counted in previous 321 reports and this accounts for the 100 acre-ft discrepancy in 2008 Planned Total Yield data from the 2008 and 2009 321 Reports.

[2] Yield relative to 2002 baseline of zero. Conservation efforts started earlier than 2002 that continue to provide yields do not contribute to a reported yield because they are already incorporated in the baseline actual water-use figures. Yield calculated as the difference between pumping reported by the agency for 2009 and the pumping that would have occurred using the 2002 gallons per capita per day for the associated population estimated for 2009 using Arizona Department of Commerce (2010) data.

[3] Because Ft. Huachuca was already recharging 239 acre-ft of effluent in 2002, only the increase in recharge since 2002 is credited here. Tom Runyon, Fort Huachuca Hydrologist, written commun., June 5, 2009.

[4] Recharge from stormwater detention basins on Fort Huachuca. Estimate derived from Fort Huachuca biological opinion annual report (Fort Huachuca, 2010). Report estimates based partially on monitoring data and therefore yield is subject to 2009 rainfall.

[5] Conservation yield attributable to Cochise County could not be calculated owing to the large number of small unmetered wells. The reported yield of 120 acre-ft is attributable to toilet-replacement rebates and assumed savings from code changes. Cochise County undertook various code changes that should have yielded water savings, but that cannot be quantified owing to lack of available metered water-use data, for example, hot water on demand, gray water plumbing, high-efficiency commercial laundry facilities, ban on artificial water features, humidity sensors on outdoor irrigation, new turf restrictions, limits on evaporative coolers.

[6] Brenda Foote, City of Sierra Vista, written commun., April 8, 2010. Recharge values are based on metered inflows to infiltration basins minus estimated evaporative loss. A recent consultant's study of the city's recharge facility concluded 350 acre-ft/yr of incidental recharge from the wetlands should be included in the 2009 recharge total. Previously unreported recharge from 2003 – 2007 is estimated to be about 700 acre-ft/yr, and for 2008 about 800 acre-ft (Mike Hemesath, Director, Department of Public Works, City of Sierra Vista, written commun., April 9, 2010).

[7] Recharge of stormwater in 2009 in the City of Sierra Vista's stormwater detention basins. Values based on a Sierra Vista calculation derived from a Partnership sponsored study of runoff and recharge (Stantec Consulting and GeoSystems Analysis Inc., 2006). This technique was developed to provide a consistent method to calculate yields from Fort Huachuca, Sierra Vista, and Cochise County basins.

[8] Russ McConnell, Bisbee Public Works, personal commun., May 22, 2010. Recharge from effluent released into Greenbush Draw; 95% of total effluent discharged is assumed to recharge the groundwater system.

[9] Carla Molina, Tombstone Public Works, personal commun., May 24, 2010. Recharge from effluent produced by residents of Tombstone that is released into Walnut Gulch; 95% of total effluent discharged is assumed to recharge the groundwater system.

[10] Water-use savings through management of invasive mesquite using various treatments. Mesquite reduction reduces water use by replacing mesquite with more shallowly rooted plants. Yield estimated using an Agricultural Research Service model of riparian evapotranspiration in the San Pedro Riparian National Conservation Area. Water conservation is greatest initially following treatment and decreases over time.

[11] Urbanization in semiarid climates can increase recharge by concentrating rainfall runoff in ephemeral-stream channels. Estimates provided by the Agricultural Research Service; credit not claimed by any particular Partnership member. These preliminary estimates will be refined through ongoing research and monitoring programs. Increased water use due to urbanization likely exceeds increased recharge. All urban-enhanced recharge estimates represent quantities expected in an average year—no current monitoring can provide year-specific values.

[12] Yield did not result from any specific Partnership member actions.

[13] Total yields rounded to nearest 100 acre-ft. Yields based on the best current data and assumptions. Yield values differ in places from prior Section 321 reports owing both to changes in implemented and planned projects and to reanalysis of yields using improved methods.

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Note that the water budget shown in table 1 is calculated using combined estimated total pumping with management-measure yields, but excluding explicit conservation measures: the estimated reduction in gross pumping volume due to conservation measures is implicit in any reductions in groundwater pumping included in table 1. Because these conservation measures are often rough estimates, the totals in table 4 have a large margin of error. Management and conservation measures are discussed in Appendix A, p. A48–A51.

4. Extent of contribution of management and conservation measures to the reduction of the overdraft

Had neither management nor conservation measures been employed, the deficit projected for 2009 (taking into account all revisions to the water budget as well as an adjustment for the difference between the projected and actual population) would have been about 14,400 acre-ft; the storage deficit calculated for 2009 based on planned management projects and conservation is about 6,300 acre-ft. The contribution of management and conservation measures to the reduction of the overdraft in 2009, therefore, equaled about 8,100 acre-ft (fig. 1). The deficit calculated for 2009 using the water budget method and including all revisions to the base groundwater budget is about 6,100 acre-ft (table 1). The deficit calculated via planned projects and conservation is larger than the standard accounting deficit found in table 1 owing to unaccounted for conservation yields and to small errors in the original 2004 projections of incidental recharge and of industrial and agricultural pumping. Management and conservation measures are discussed in Appendix A, p. A48—A51 and the quantity of the overdraft is discussed on p. A52—A54.

Summary and conclusions from 2010 321 reporting

Section 321 of the Defense Authorization Act of 2004, Public Law 108-136, requires each annual 321 report to address five requests, four of which are quantitative and have been discussed above. Item 5, Legislative accomplishments and impediments, is discussed further below. To summarize the responses to the four quantitative-based requirements of the Act:

1. The quantity of the overdraft of the regional aquifer reduced during the reporting period:
   The quantity of the overdraft increased by **900 acre-ft** in 2009 (after taking into account all revisions to the base groundwater budget)
2. Whether the reduction in (1) met the goal specified for the reporting period:
   No
3. The water-use management and conservation measures undertaken by each water-use controlling member of the Partnership during the reporting period:
   See **table 4** for a complete breakdown by water-use controlling member of the Partnership
4. The extent of the contribution of such measures to the reduction of the overdraft:
   8,100 acre-ft

The overall situation in the regional aquifer of the Sierra Vista Subwatershed today is not improving; rather, it continues to get worse but at a rate slower than in 2002. Although the annual overdraft of the aquifer has been greatly reduced from the 14,400 acre-ft anticipated for 2009 (fig. 1) to 6,100 acre-ft today, this is still another 6,100 acre-ft of water that has been removed from storage in addition to the 54,500 acre-ft removed since 2002 (the beginning of 321 monitoring), and the hundreds of thousands of acre-ft that have been removed from storage since groundwater pumping commenced in earnest in the first half of the 20th century. Until the aquifer begins to accrete storage (the annual water

budget bottom line becomes greater than zero) there will be no reduction in the cumulative deficit, and until additional management measures are undertaken, it is unlikely that there will be further progress made toward this goal.

Table 5 presents the 8 indicators of sustainability the Partnership has agreed to track and shows whether each indicator: (1) has improved or degraded since last year (2008), (2) shows a statistically significant improving or degrading short-term trend for the period of 321 reporting, 2002–09, (3) shows a statistically significant improving or degrading long-term trend beginning with the earliest useful data available. Collectively, these indicators provide a more general sense of the overall progress toward sustainable yield in the Subwatershed than that provided bythe water-budget deficit alone. There is improvement in a few of the indicators compared to last year and in some of the short-term indicator trends. At this time, however, the indicators show little long-term progress toward the goal of sustainable groundwater use in the Subwatershed. It should be noted, however, that the response time to management and conservation measures for many of the indicators will be, at a minimum, years and in many cases decades or longer; capture of natural discharge from the system continues for long periods of time even when pumping is entirely discontinued (Bredehoeft and Durbin, 2009; Leake and others, 2008).

Table 5. 2009 evaluation matrix for indicators of progress toward sustainable yield of groundwater use in the regional aquifer of the Sierra Vista Subwatershed, Upper San Pedro Basin, Arizona

[Values observed in 2008 and 2009 are reported in their respective columns; "2008–2009 DIFFERENCE" column evaluates 2008–2009 change for each indicator; box color and arrows highlight whether indicator has improved (green,), remained unchanged (orange,), or degraded (red,) since 2008; "2002–2009" column evaluates short-term trend in each indicator over period of 321 reporting; "EARLIEST DATA–2009" column evaluates long-term trend in each indicator, from earliest useful data to 2009 (see plots in Appendix A); dates in parentheses indicate first year of record evaluated; NA, not available (data record does not include enough points to make trend evaluation meaningful); cfs, cubic feet per second]

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INDICATOR EVALUATION MATRIX

INDICATORS	2008	2009	2008–2009 DIFFERENCE	TREND 2002–2009	TREND EARLIEST DATA–2009
Regional Aquifer Water Levels	Feet below land surface--change since 2002		Difference (feet)		
Ft. Huachuca	-3.10	-3.60	-0.50 ↓	↓	↓ (1995)
Environmental Operations Park (EOP)	0.52	0.38	0.14 ↑	↑	↑ (2000)
Southwest	-7.45	-0.55	6.9 ↑	≈	≈ (1973)
East	-0.09	-0.08	0.01 ↑	≈	≈ (2000)
Alluvial Aquifer Water Levels	Feet below land surface--change since 2002		Difference (feet)		
Palominas	3.15	NA	NA	NA	NA
Hereford	0.53	NA			
Hunter	2.16	NA			
Central	1.86	NA			≈ (1995)
North	-0.11	-0.88	-0.77 ↓	≈	NA
Near Stream Vertical Water Level Gradients	Feet/foot--gradient change since 2002		Difference (feet/foot)		
Palominas	0.14	0.075	-0.06 ↓	≈	NA
Hereford	0.0020	0.0016	-0.0004 ↓	↓	
Hunter	NA	NA	NA	NA	
Central	0.035	0.031	-0.004 ↓	≈	
North	0.031	0.059	0.03 ↑	≈	
Springs	Annual median (gallons per minute)		Change (percent)		
WEST Horsethief	10.89	9.87	-9.4 ↓	↑ (2005)	NA
Murray	200.44	213.44	6.5 ↑	↑ (2003)	
Moson	20.65	17.95	-13 ↓	≈ (2007)	
EAST (Lewis Springs)	33.21	28.28	-14 ↓	≈ (2005)	
SOUTH (McDowell-Craig Farm)	41.52	23.19	-44 ↓	≈ (2005)	
Streamflow permanence	Percent of year		Difference (percent of year)		
Tombstone	84	47	-37 ↓	≈	↓
Fairbank	88 (86-90)	58 (54-63)	-30 ↓	≈	NA
Boquillas	100	100	0.0		
Charleston Mesquite	82 (71-93)	75 (60-90)	-8 ↓	≈	
Charleston	100	100	0.0		
Moson	100	100	0.0		NA
Lewis Springs	100	100	0.0		NA
Hunter	92	91	-1 ↓	≈	
Hereford	100	100	0.0	≈	
Palominas	100	76	-24 ↓	≈	↓
Streamflow discharge	Cubic feet per second *or* Days		Difference (cfs *or* days)		
7-DAY WINTER LOW FLOW Charleston	12.43	11.69	-0.74 ↓	≈	↓ (1936)
7-DAY SUMMER LOW FLOW Charleston	0.65	1.64	0.99 ↑	≈	↓ (1936)
ANNUAL ZERO-FLOW DAYS Tombstone	57	193	-136 ↓	≈	↓ (1968)
ANNUAL ZERO-FLOW DAYS Palominas	1	87	-86 ↓	≈	↓ (1931)
Aquifer storage change (gravity)	Improved	Unchanged	Degraded 2008–2009		
	4	24	16	↓	↓ (2005)	NA
Annual storage deficit* (water budget balance ≥ 0 = sustainable)	Acre-feet				
	-5,200	-6,100	-900 ↓	↓	↓

EXPLANATION:

IMPROVING (↑)	
UNCHANGED (≈)	
DEGRADING (↓)	

*After taking all revisions to the base water budget into account, the annual storage deficit increased 800 acre-ft from 2008 to 2009. The cummulative storage deficit also increased, but by the amount of the annual deficit, or 6,100 acre-ft. The amount added to the cummulative storage deficit since 321 reporting began in 2002 is about 60,600 acre-ft. When the annual water budget balance (storage deficit) in the Subwatershed reaches 0 or greater, the annual storage deficit indicator will be evaluated as "improving."

5. Legislative accomplishments

Consistent with the requirements of Section 321, the initial report included a list of potential legal barriers to the implementation of certain management measures. Section 321(d)(2)(C) further requires that annual reports include a discussion of what progress has been made in addressing these legal impediments. To meet this reporting requirement, the following list restates the legal impediments discussed in the initial Section 321 report and includes the current status of proposals to address these barriers. Recognizing that changes in applicable legal standards have broad-based policy effects that are beyond the scope of this report, this discussion of legal impediments carries no explicit or implicit recommendation or endorsement for any legislative action by any Partnership member or Federal, State, local, or other entity.

This past year the Partnership reviewed the legal impediments that have remained partially or totally unresolved since the first 321 Report in 2004. The result of this review is reflected in two changes: 1) additional or revised impediments, and 2) the deletion from Appendix C of the previously resolved impediments reported [in the appendix] noting, however, that such information can be obtained from past reports.

Water-Management Measures and Legal Impediments had been identified in three major categories: ***Conservation Measures, Recharge/Reuse Measures,*** and ***Augmentation/ Importation Measures.*** Within each major category specific issues have been determined to be important to meeting the stated goal of sustainability. Individual member entities have worked on those issues under their jurisdiction during the past six years. Additionally, the Partnership has tracked legislation as it has been introduced in the Arizona Legislature along with any final action or inaction taken. The Partnership has added an additional major category: ***Statutory/Adjudication Issues.*** This new category lists items of concern that if resolved could result in a dramatic change in the Partnership's ability to reach sustainability, at the same time recognizing their political challenges.

General Report on Major Actions:

Augmentation/Recharge:

In 2009 Congress passed Public Law 111-11 that authorized the Bureau of Reclamation to conduct a feasibility study of water augmentation alternatives in the Sierra Vista Subwatershed. The goal of the study is to develop an augmentation alternative that is politically, legally and financially feasible. The first year of the study will be initiated on several key activities including a water budget analysis, economic analysis, recharge evaluation and evaluation of the preferred alternative. Congress appropriated $289,000 for FY10 covering 45% of the first year's costs. A Memorandum of Understanding between Reclamation, BLM, Fort Huachuca, State of Arizona, City of Sierra Vista and The Nature Conservancy for the matching 55% has been executed. No Congressional funding has been identified for FY11. Due to poor economic conditions local cost sharing is questionable for future years; therefore, budget constraints will affect the work and the schedule.

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Non-Federal Funding Opportunities:

Member agencies of the USPP began development of a series of conceptual proposals for possible funding by a major private foundation, during 2009. Partnership members continue to operate under an adaptive management framework toward sustainability, and they recognize the need to address the management of existing and future water demands, as well as the augmentation of water supplies, to meet both human and river water needs. Their conceptual funding proposals addressed water conservation, groundwater modeling to assess the effectiveness of recharge locations, stormwater management, and land acquisition for water protection, as well as improvements in water delivery and wastewater infrastructure for Naco, Sonora. Most if not all of these proposed projects would also likely require federal, state and/or local matching funds.

Upper San Pedro Water District Election:

Since the establishment of the Upper San Pedro Water District by the Arizona Legislature in 2007, the nine appointed members of the Organizing Board have been working on the required plans in order to bring them before the voters of the District. The goal of the District is to maintain the conditions needed to sustain the Upper San Pedro River and to help meet the water supply needs and water conservation requirements for Fort Huachuca and the communities within the District. In 2010, the Organizing Board requested the Cochise County Board of Supervisors call for the election to be held on November 2, 2010. The County adopted the necessary resolution as requested. On the ballot for the General Election, two questions are proposed: Shall the Upper San Pedro Water District be established; and the election of a seven member permanent board. Although the Organizing Board had the option to include a third question on applying a tax on water users who are connected to an ACC regulated or municipally owned water provider, the Board did not include this question for the ballot. Should the voters approve the formation of the District but elect fewer than seven people to the board, the Board of Supervisors will fill the remaining positions by appointment. The formation of the District and its ultimate ability to own, construct and operate water facilities would have beneficially addressed some of the yet unresolved legal impediments to sustainable water management. This ballot measure was narrowly rejected by Subwatershed voters, however. It can be included on the ballot again in 2011, but at this time it is not clear whether this will occur.

Legislative Actions:

The passage and signing of HB2661 establishes a Water Resources Development Commission to project water needs in each county for the next 25, 50 and 100 years. The purposes of the commission are: to identify currently available sources of water; identify potential sources to meet future needs; identify legal or technical issues associated with developing future supplies; identify methods to finance the acquisition of future supplies; and make recommendations regarding the need for further studies and evaluations. The Director of ADWR will appoint the Commission consisting of no more than 15 members. A report must be submitted to the Legislature and Governor by October 1, 2011.

HB2617, passed and signed into law, makes various changes to the statutes pertaining to groundwater, water quality and remedial cleanup and mitigation actions as they relate to metal mining operations in the state. Among myriad other authorizations, the bill allows groundwater to be transported between the Upper San Pedro and Douglas groundwater basins, if the groundwater is transported by a metal mining

facility located in both groundwater basins and if the transportation is necessary to comply with an order from ADEQ regarding a remedial action. Notice of transportation must be given to the ADWR Director before transportation begins and the notice must include a copy of the mitigation or remedial action order.

Budget cuts and their impact on the mission of the Arizona Department of Water Resources:

During the last legislative session ADWR's budget was cut on several occasions. The end result is a decrease in manpower from 200 to 95 and a funding cut from $16 million to $7.2 million. These cuts will have a negative impact on the efforts of the USPP including loss of funding for projects. Three personnel who previously supported all of the efforts in Rural Arizona are gone. One person previously assigned to that effort has been transferred to Hydrology and given the responsibility to support 11 watershed partnerships in the northern half of the state. Another individual with other responsibilities was also transferred to Hydrology and given the additional responsibility to support the USPP, the Gila Watershed Partnership, and several other watershed groups in the southern part of the state.

SB 1359's passage protected revenue derived from various fees charged by ADWR that are deposited in the newly established Water Resources Fund to carry out any statutory purpose and may not be appropriated or transferred by the Legislature to fund the general obligations of the state. These fees are anticipated to provide approximately $2 million in funding to ADWR. In January 2011 the agency will evaluate the fees generated. If the actual does not meet the anticipated funding, additional layoffs could occur.

Report on Actions Taken on Specific Impediments:

Conservation Measures:

Code Changes:

- Limited authority exists for local (city, county) action with respect to modifying human behavior subsequent to final building inspection or for actions not related to development (i.e., water wasting ordinances).
    - Although there have been no additional authorities requested or granted to local governments, many of the municipalities and Cochise County continue to work with developers in the voluntary mitigation of water use in new residential and commercial subdivisions.
- Current state law does not provide any effective mechanisms for local/regional water management authority, or local ability to create funding mechanisms outside of Active management Areas (AMAs).

During the 2007 legislative session a bill was passed and signed by the Governor authorizing the establishment of the Upper San Pedro Water District subject to the approval of the voters of the Sierra Vista Subwatershed. Development of the required plans subsequent to an election have been ongoing for the past two years by the nine member appointment organizing board. At the November 2, 2010

general election voters were asked to approve the formation of the District and elect seven members from within the subwatershed boundaries. If formation of the District had been approved, the issue of funding would have still remain to be resolved. The ballot measure was narrowly rejected by Subwatershed voters, however. It can still be included on the ballot again in 2011, but at this time it is not clear whether this will occur.

- Under current state law regarding ADWR determination of "water inadequacy" (ADWR's "water adequacy certificate"), only availability for human use, not ecological uses are considered.
    - No legislative change addressing this issue was requested or passed during the 2010 session.

- No Arizona agency has the authority to restrict new wells or require the metering of existing or new wells outside of designated active management areas and irrigation non-expansion areas, regardless of the groundwater availability in the area.
    - No legislative change addressing this issue was requested or passed during the 2010 session.

Zoning:

- Current law limits counties from applying subdivision standards (with respect to water resource management) to lot splits of five or fewer (ARS 11-806/11-809)
    - No legislative change addressing this issue was requested or passed during the 2010 session.

Easements:

- Current state law regarding the establishment of 'irrigation non-expansion areas (INA)' applies to entire basins or sub basins, and cannot be applied to a subwatershed such as the Sierra Vista Subwatershed (ARS 45-432).
    - No legislative change addressing this issue was requested or passed during the 2010 session.

- Current tax policy provides incentives for water consuming uses but not for water conservation uses on undeveloped lands (ARS 42-15004).
    - No legislative change addressing this issue was requested or passed during the 2010 session.

Technology Incentives:

- Currently, there are no matching funds from state sources for conservation projects outside of the riparian zone to help address water management issues.
    - Although no State funds became available during FY10 due to huge budget deficits, USPP has been working with a private foundation on a series of potential projects and studies that would help address this impediment.

Recharge/Reuse Measures:

Effluent Recharge/Reuse:

- Currently, there are no matching funds from state sources for conservation projects outside of the riparian zone to help address water management issues. Additionally, sufficient funding is not available for communities to meet EPA/ADEQ's high water-quality standards for effluent to be recharged through shallow basins.
    - Although no State funds became available during FY10 due to huge budget deficits, USPP Technical Committee has been working with its member agency USGS to identify suitable recharge locations.

Stormwater Recharge:

- Currently Arizona limits the disposition and (or) use options for State trust lands. Such options could permit construction of optimally located recharge facilities.
    - Although no State funds became available during FY10 due to huge budget deficits, USPP Technical Committee has been working with its member agency USGS to identify suitable recharge locations. The Arizona State Land Department will cooperate with the effort under its statutory guidelines.

Augmentation/Importation Measures:

- Currently Arizona limits the disposition and (or) use options for State trust lands. Such options could permit construction of optimally located recharge facilities.
    - Although no State funds became available during FY10 due to huge budget deficits, USPP Technical Committee has been working with its member agency USGS to identify suitable recharge locations. The Arizona State Land Department will cooperate with the effort under its statutory guidelines.
- Current State law generally prohibits interbasin transfer of ground water, and intrabasin transfer of ground water between subbasins may be subject to the payment of 'damages.'

- Each year the legislature passes a one-year session law that allows for interbasin transfers under emergency drought conditions.
- HB2617 allows for groundwater transportation between the Upper San Pedro and the Douglas Basins if required to comply with an ADEQ order for remedial action by a metal mining operation.

Statutory/Adjudication Issues:

- The Arizona Corporation Commission (ACC), Arizona's public utilities commission, is limited in its ability to consider area-wide conservation pricing for the private and individually owned water providers who serve a major portion of the area's population.

- Under Arizona law appropriable surface water, including the subflow of a river or stream, and groundwater are regulated separately when, hydrologically, there is no line that separates the two water sources.

- The outcome of the Gila River Adjudication, which has been ongoing for over 30 years, may render some projects unfeasible. Arizona's definitions regarding surface water, ground water, and the potential connections between them are subject to the judicial proceedings in the Gila River Adjudication.

- At the present time Native American CAP entitlements cannot be leased for exportation and used outside of the Central Arizona Water Conservation District service area except by exchange. Any change to this would require modification of existing Indian water contracts as well as state law and the CAP Master Repayment Contract. However, it does not require a change in the settlement legislation. In addition, Tucson CAP subcontractors have a first right of refusal to any Tucson area Indian water being leased for more than 25 years.

See Appendix D for details of legal impediments and legislative accomplishments from the 2008 and earlier 321 Reports.

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