Sierra Vista Subwatershed Domestic Well Study

Prepared for Western Resource Advocates by
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WESTERN RESOURCE ADVOCATES

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Significance

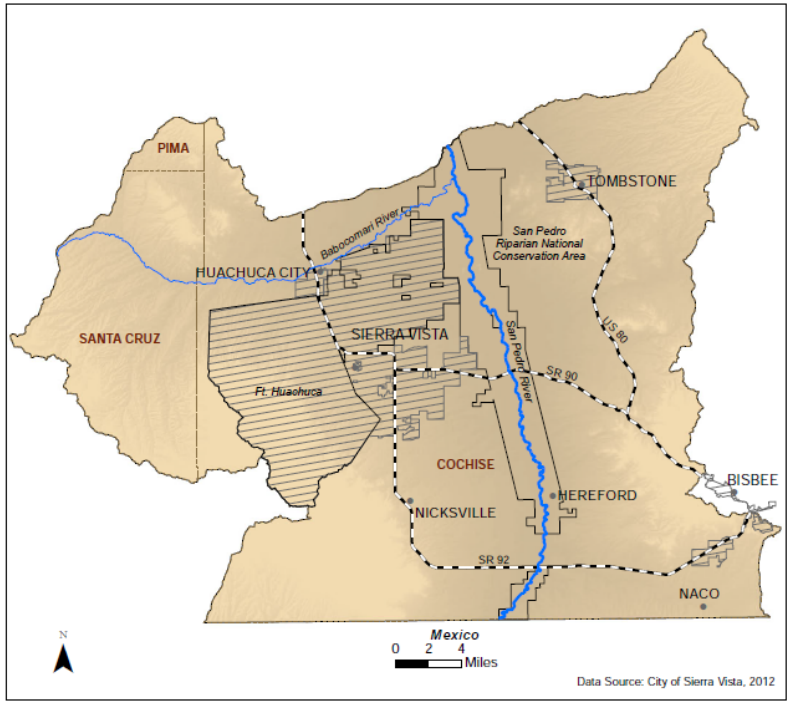
- Uncertainty of demand, impact, potential to conserve
- Domestic wells serve almost 20% of population
- Wells unmetered, estimates vary; up to 4,400 afy
- Proximity to San Pedro River and SPRNCA
- Contribute to overdraft and have a stake in aquifer sustainability

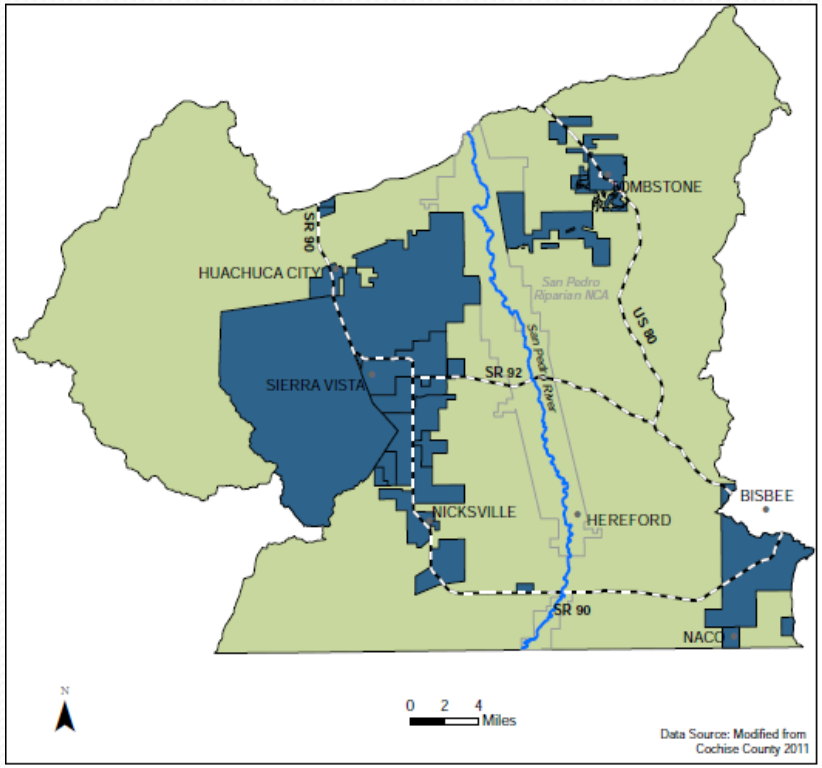
Purpose of study

- Provide information for planning and conservation program purposes
  - No comparable study
- Is it possible to identify water conservation potential using proxies for metered demand?
  - Housing age indicator of plumbing fixture use
  - Remote sensing to identify irrigated areas
  - Identify and target conservation programs and savings
  - Compile domestic well estimates
  - Develop a methodology transferable to other areas

Study area

- Unincorporated area outside water provider service area
- 12,000 residents, 5,000 parcels





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Water Provider Service Areas

Area Outside of Water Provider Serivce Area

TABLE 1 – POPULATION AND PARCEL DATA

Area	2010 Population
Sierra Vista Subwatershed (SVS)	77,300[1]
Portion of SVS Served by Water Providers	62,100[2]
Portion of SVS Not Served by Water Providers	15,200[3] (12,050)[7]
Type of Parcel Improvement	Approximate Number of Private Parcels in Study Area Not Served by Water Providers[4]
Single Family Residence	2,150[5] (2,490)[6]
Mobile Home (includes affixed and park models)	2,180 (2,530)[6]
Multi-Family Residence	2
Commercial	20
Public	10
Yard	3
Other	170
None	3,970 (3,290)[6]
Total	8,515

Indoor Demand

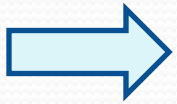
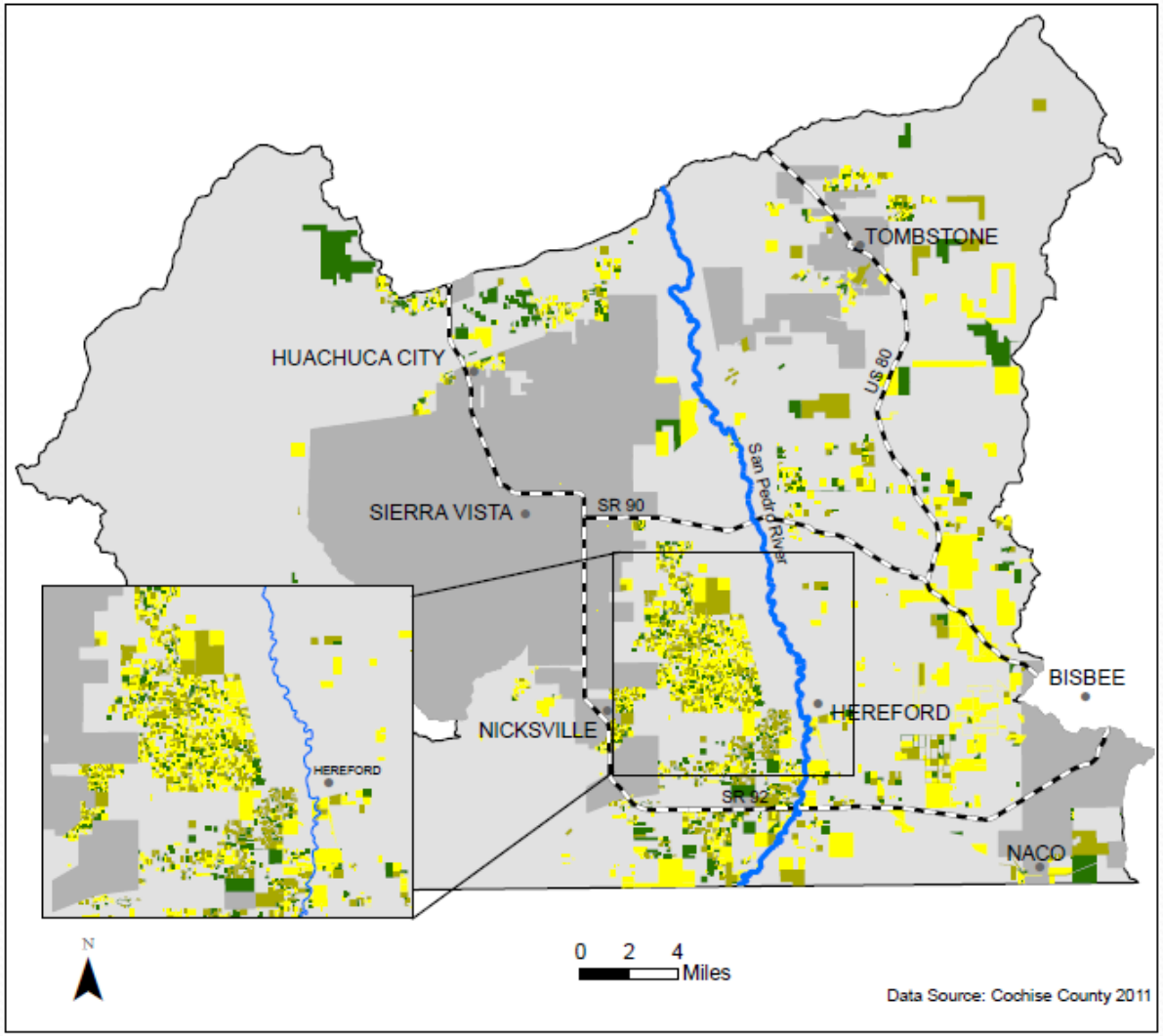
- Cochise County Assessor Records to identify construction dates
  - Prior to 1997 (2,190 houses)
  - 1997-2005
  - 2005 to present  (2,140 houses)
  - No dates for 690+ houses
- Estimated demand based on large-scale studies
  - Prior to 1997 – 69 gpcd (AWWA 1999)
  - 1997 to present – 48 gpcd (Aquacraft, 2011)

TABLE 3 – ESTIMATED INDOOR WATER USE BASED ON HOME AGES IN THE STUDY AREA

Home Age[1]	Number (Percentage) of Households in SVS Not Served by Water Provider[2]	Estimated Average Daily Indoor Water Use Per Household (gallons)[3]									Estimated Total Annual Indoor Water Use by Homes in Study Area (acre-feet)
		Toilets	Clothes Washer	Showers	Faucets	Leaks	Other	Bathtubs	Dishwasher	Total[4]	
Before 1997	2,190 (51%)[5]	44.4	36.0	27.8	26.2	22.8	3.8	2.9	2.4	166.3 (0.19 AFA)	408
1997 to Present	2,140 (49%)	22.6	23.8	24.6	20.7	16.2	2.5	2.9	1.6	114.9 (0.13 AFA)	275
Retrofit Existing Homes with High Efficiency Fixtures[6]	---	18.4	21.1	21.6	18.2	10.1	1.4	6.3	1.8	98.9 (0.11 AFA)	---

Notes:

[1] Home age from construction dates listed in the Cochise County (2011) Assessor cost file.
[2] Includes single family residences and mobile homes with construction data (see Table 1).
[3] Assumes 2.4 people per household based on U.S. Census (2011) data for the study area. Fixture rates taken from AWWA (1999) for pre-1997 homes and from Aquacraft (2011a,b) for newer homes. Aquacraft (2011a,b) also provided fixture rates for retrofitted existing homes.
[4] AFA = Acre-feet per year
[5] Includes approximately 50 households with no reported date of construction.
[6] High efficiency fixtures include 1.28 gallons per flush toilets, 12 to 15 gallons per load clothes washers, 1.5 gallon per minute (gpm) shower heads and 0.5 gpm sink aerators.



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- City or Town
- Water Provider Service Areas

Year Built

- Before 1997 (~2,230 parcels)
- 1997 to 2004 (~1,330 parcels)
- 2005 to Present (~810 parcels)

Limitations/Observations

- Assessor data inaccuracies; houses on "vacant" land (17% - 690 houses) no construction date so incomplete evaluation of demand and savings potential
- Some homes have already installed efficient fixtures (e.g. Cochise County toilet rebate program @ 600+) – where?
- Conservation studies conducted in metropolitan areas
- All indoor use discharged to septic systems does not recharge the aquifer due to loss and evapotranspiration
  - Depends on depth of leach field-likely < 1/3 of indoor use
  - EEC (2002) and ADEQ

Outdoor Demand

- Remote sensing-National Agricultural Imagery Program (NAIP)
  - 1-meter, 4-band imagery, June 2010, with visual analysis and ground-truthing
  - Based on spectral signature grouped areas into categories- pasture, orchard, landscape plants, turf, pools
  - Quantified use by multiplying acres mapped in each category by its annual watering requirement and application efficiency

TABLE 5 – LOCAL OUTDOOR WATERING REQUIREMENTS

Type	Watering Requirement	
	(inches/year)	(gallons/ft^2/year)
Open water (ponds, pools and fountains)[1]	50.1	31.3
Cool season grasses[2]	49.2	30.8
Overseeded grasses (warm and annual cool)[2]	46.4	29.0
Pasture (low to high)[1]	27.4 – 39.7	17.1 – 24.8
Deciduous orchard (low to high)[1]	16.0 – 33.7	10.0 – 21.0
Ground covers and vines (low to high)[3]	14.8 – 32.3	9.2 – 20.2
Warm season grasses[2]	31.2	19.5
Shrubs (low to high)[3]	8.5 – 27.8	5.3 – 17.4
Evergreens and other landscape trees (low to high)[3]	3.5 – 25.8	2.2 – 16.1
Vegetable gardens (low to high)[1]	19.6 – 24.0	12.2 – 15.0
Mesquite (low to high)[4]	1.6 – 19.9	1.0 – 12.5
Xeriscape[2]	3.2	2.0

Notes:

[1] Calculated using crop coefficients (K_c) from Allen and others (1998) and reference evapotranspiration (ETo) rates reported by Brown (2011) based on AZMET station data and Yitayew (1990). Crop consumptive use values were reduced by effective precipitation using USDA (1970) methodology for semi-arid environments and average rainfall data reported by WRCC (2011) for Sierra Vista Station #027880 from 1981 to 2010. Low to high values account for potential variations in growing season length from year to year and physical variations in plant species that affect water consumption. For pools and fountains, total precipitation was subtracted from annual evaporation rates since nearly all rainfall that falls into open water is assumed effective.

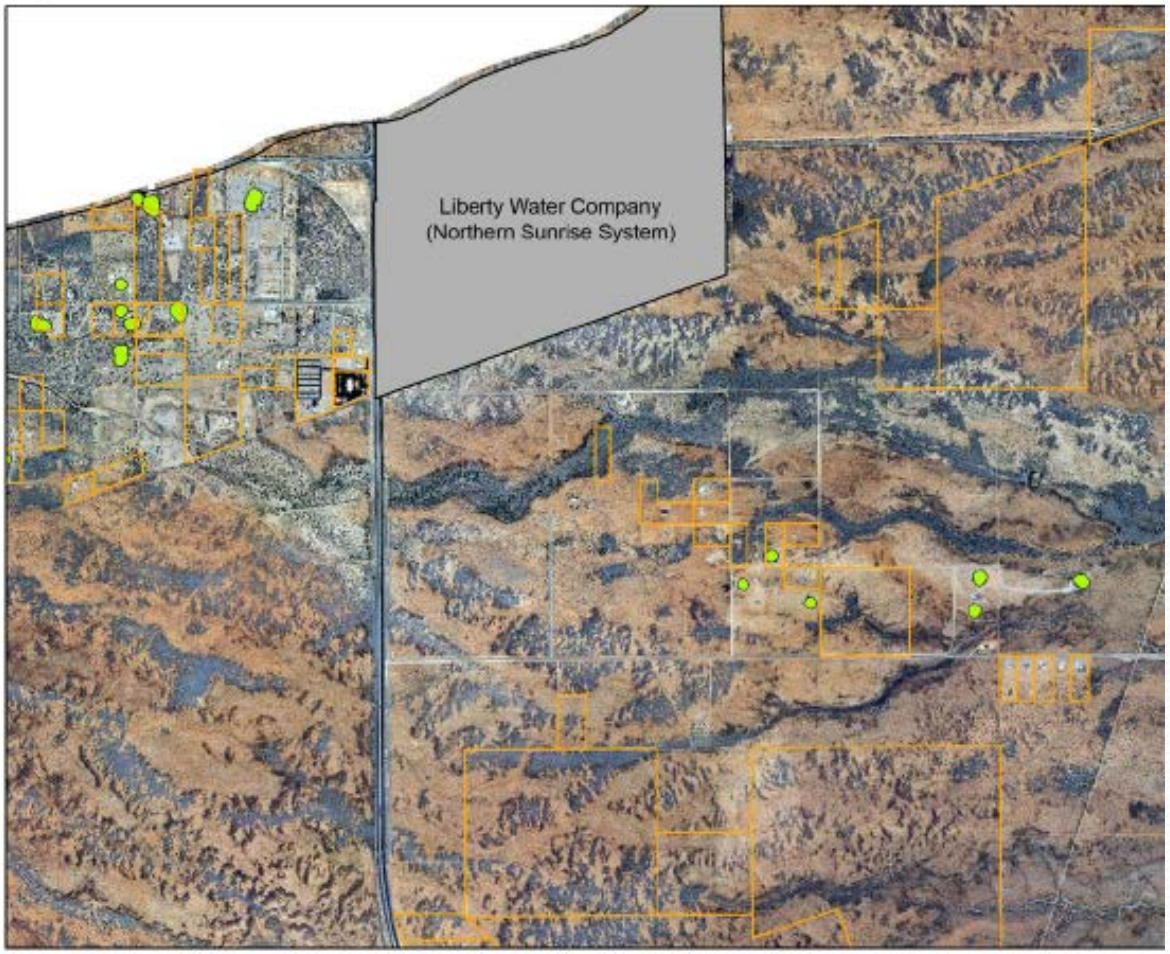
[2] Data from Daily (2011b) and Water Wise, University of Arizona, Cooperative Extension, Cochise County (http://cals.arizona.edu/cochise/waterwise/wateringturf.html). Calculations were reportedly performed separately by Brown using AZMET methodology.

[3] Low to high water requirements were derived using Water Wise information and AZMET methodology, respectively. The Water Wise estimates represent average water needs for common plants in a given category based on a percentage of cover area, the volume of water required to reach a specific depth in sandy loam soil (the dominant soil in the region) and the recommended watering frequency according to the Sunset Western Garden Book (2008) correlated with regional ET data. Differences reflect assumed cover area and plant types.

[4] The low watering requirement is based on Water Wise information, as described in Footnote 3, and assumes it is used for xeriscaping. The high water requirement value is from Leenhouts and others (2006) and represents trees along the San Pedro River that have access to perennial surface water.

Type	Number of Areas Mapped[1]	Total Area (acres)	Annual Watering Requirement (feet)[2]	Assumed Application Efficiency	Estimated Annual Outdoor Water Use (acre-feet)[3]
Pasture[4]	10	31.6	2.3 to 3.3	70 to 85%[7]	86 to 149
Orchards	18	20.1	1.3 to 2.8	70 to 90%[7]	29 to 80
Turf	165	12.4	0.0 to 2.6[5]	40 to 75%[8]	0 to 81
Landscape Plants	115	8.5	0.3 to 2.7[6]	40 to 95%[8]	3 to 57
Pools	64	0.5	4.2	Near 100%	2
Total	372	73.1	---	---	120 to 369

[1] Areas of outdoor water use were originally mapped using June 2010 aerial photography and later revised after ground-truthing in December 2011.
[2] See Table 5 for data sources and additional information.
[3] Calculated by multiplying total area by average annual watering requirement and dividing by assumed application efficiency.
[4] Includes areas of turf that exceed 0.5 acres.
[5] Lower watering requirement reflects the local practice of letting natural grasses grow in yards with little or no supplemental irrigation. Higher watering requirement represents warm season grasses which were observed in some yards.
[6] Represents a variety of vegetation including evergreens and other landscaping trees, shrubs, and ground covers and vines.
[7] Assumed by Tadayon (2011) to estimate water use in the project area; includes efficiencies for flood irrigation (70 to 75%), sprinkler systems (80 to 85%), and drips (90%).
[8] Reported by Daily (2011c) based on the Irrigation Association's *Drip Irrigation in the Landscape*; includes efficiencies for spray (40 to 65%), rotor (50 to 75%) and drip (80 to 95%) landscape irrigation systems.



A - Huachua City Area

Legend

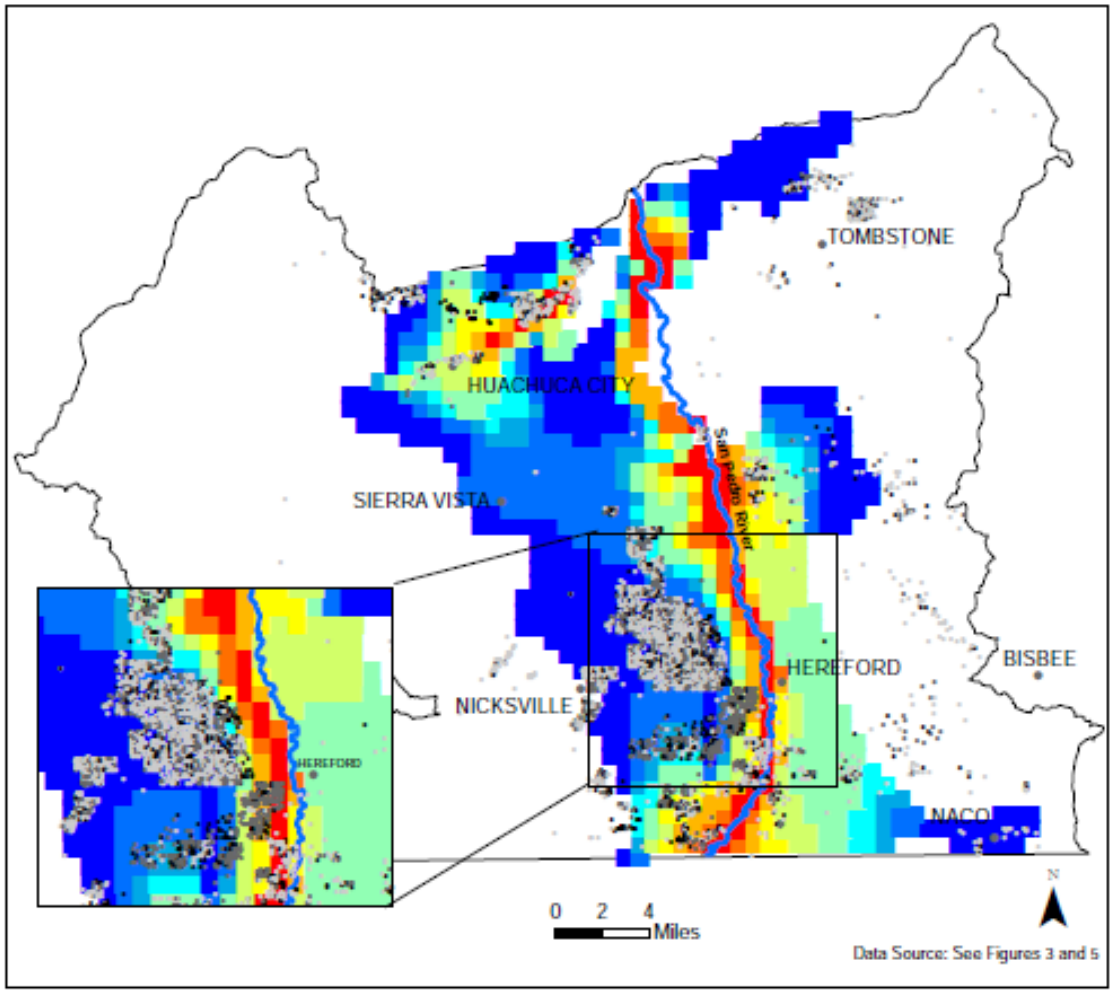
- Water Provider Service Areas
- Parcels
- Outdoor Water Use

Limitations/Observations

- Higher resolution imagery could identify additional irrigation
  - smaller, deficit irrigated or rainfall-dependent areas
- Other outdoor uses e.g. evaporative coolers, livestock, dust control, etc.

Potential pumping impact

- Groundwater capture by well pumpage that impacts ecosystem by reducing stream flow, spring discharge and riparian ET
- Domestic wells assumed to be shallow and in uppermost water-bearing zone
- Simulated groundwater capture zones-constant rate, 25 years



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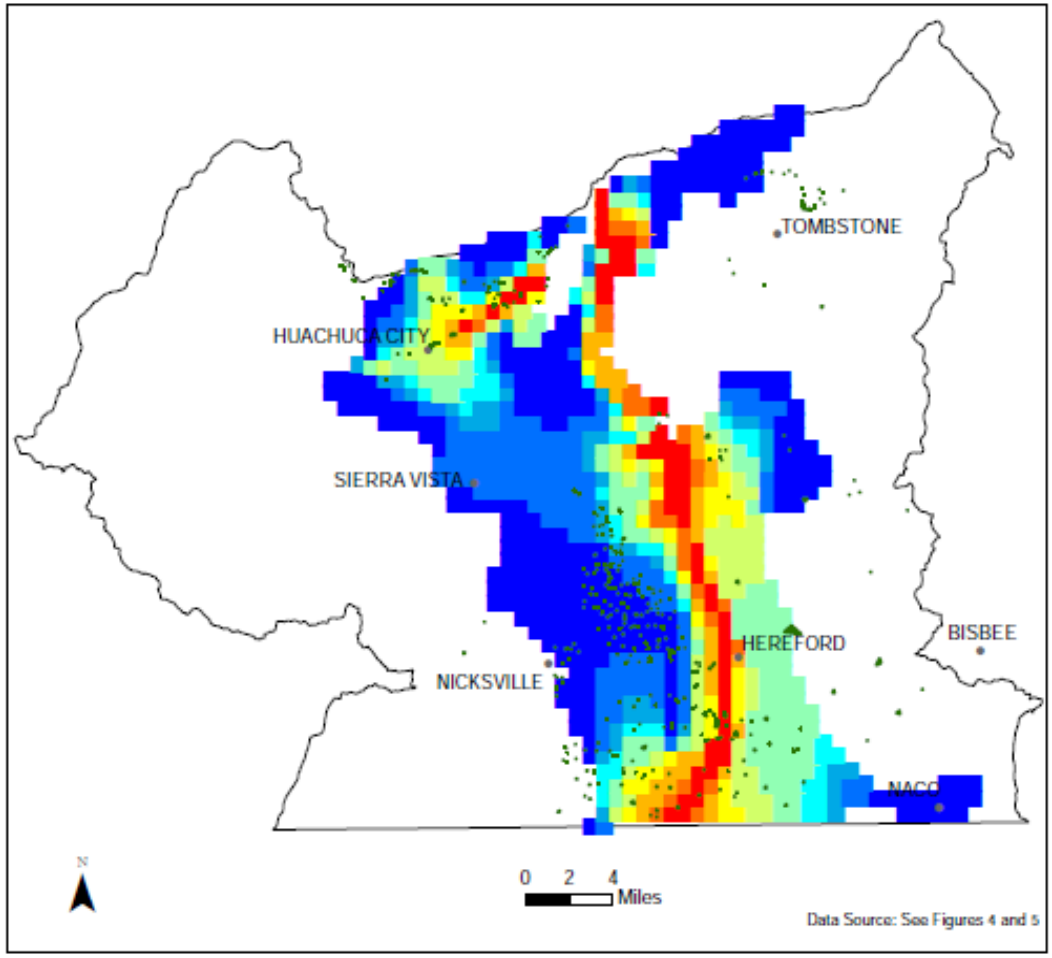
0.9
1.0

Computed capture of streamflow, riparian evapotranspiration, and springflow along the San Pedro River as a fraction of pumping after 25 years of constant rate withdrawals from shallow wells.

Age of Single-Family Homes Served by Domestic Wells

- Before 1997 (~2,190 parcels)
- 1997 to 2004 (~1,330 parcels)
- 2005 to Present (~810 parcels)



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Outdoor Use
(area exaggerated for mapping purposes)

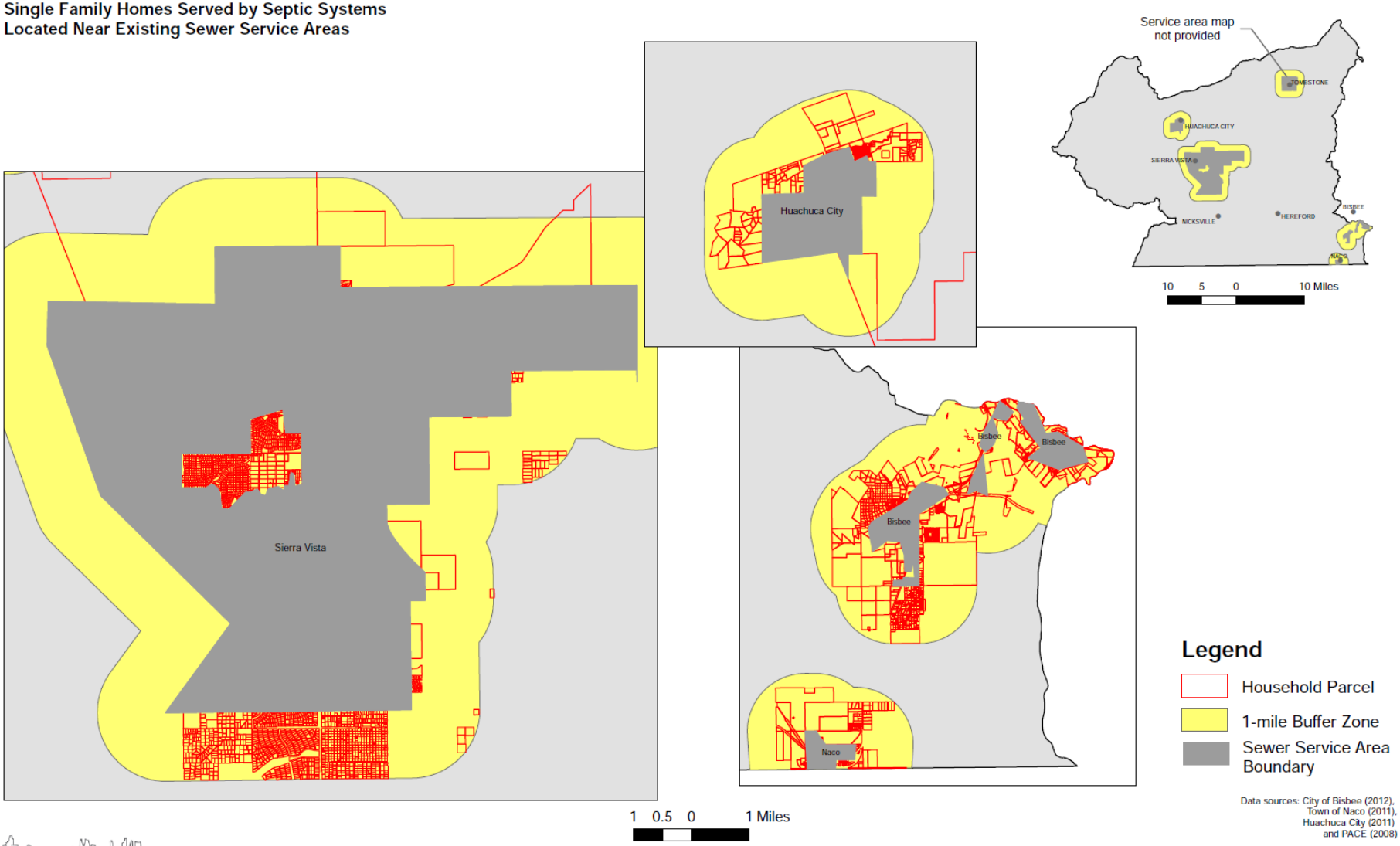
Water Conservation

- Local Programs
  - Rebates, codes, education, etc.
- Indoor conservation potential
  - HE fixture retrofit – 41 gpcd achievable
  - Potential savings = 7 (newer) 28 gpcd (older)
    - 40 afy (newer) 164 afy (older) @ 100%
  - Toilet (and other fixture) replacement focused on older homes, leak reduction, audits
  - On-demand hot water recirculation systems
    - 30 afy @ 100%

Water Conservation

- Outdoor conservation potential
  - Savings difficult to quantify
  - Improve orchard and pasture irrigation efficiency
    - 46 afy @ 20% improvement
  - Rainwater harvesting for landscaping
    - 57 afy @ 100%
  - Turf to xeriscape conversion
  - Pre-1997 houses slightly more outdoor use
- Identified highest users capturing greatest fraction of groundwater that would otherwise flow to the river

Figure 8
Single Family Homes Served by Septic Systems
Located Near Existing Sewer Service Areas



Data sources: City of Bisbee (2012), Town of Naco (2011), Huachuca City (2011) and PACE (2008)

SVS Domestic Well Study

Plateau Resources, LLC

Service area extension

- Pros
  - Effluent for regional management
  - Water reliability to users
  - Maintenance cost avoidance
  - Conservation messaging
- Cons
  - Expensive to utility and user
  - Low housing density
  - Monthly service fees to users
  - Prior homeowner investment
  - Acceptability

Location	Year	Number of Homes	Average Annual Use (acre-feet)		Data Source
			Per capita	Per household	
Metered					
Sierra Vista Subwatershed[1]	Between 2005 and 2007	8	0.12 (107 gallons per day)	0.24	Daily (2011a)
Sierra Vista, AZ[2]	2010	799	0.09 (76 gallons per day)	0.21	Liberty Water Company (2011)
Near Santa Fe, NM[3]	2009	250	---	0.30	Chavez (2010)
Estimated or Assumed Values					
Sierra Vista Subwatershed	Current	---	0.13 (118 gallons per day)[4]	0.31[5]	USFWS (2007)
			0.35 (312 gallons per day)[6]	0.84[5]	USGS (2010)
Statewide *('standard' domestic use when filing an application to appropriate water)*			0.20 (180 gallons per day)	0.48[5]	ADWR (2011b,c)
Adjudication Areas *(suggested domestic use when filing adjudication claims)*			0.17 (150 gallons per day)[7]	0.41[5]	

Conclusions

- Water use by domestic wells can be reduced through targeted conservation programs
- Potential indoor savings <230 afy
  - Septic tank recharge does not equal indoor demand – indoor conservation important
- Potential outdoor savings <100 afy
- Studies support well demand .30 afy
- Focus on greatest conservation potential in proximity to river
- Surveys, metering, detailed site visits, higher resolution imagery for outdoor demand

Conclusions

- Transferable methodology – first estimation
  - Water provider service area maps
  - Population data
  - Parcel maps and files with construction dates
  - Aerial imagery (recent, 1-meter resolution or better, multi-spectral bands, during irrigation season)
  - Climate records (local watering requirements and evaporation rates)

Questions?