Civano and Tucson Residential Water Use, Revised*

Prepared for the Community of Civano, LLC

by

Al Nichols Engineering, Inc.

August 15, 2002

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1. Executive Summary: The Impact of Reclaimed Water Use

The Civano *IMPACT System Memorandum of Understanding on Implementation and Monitoring Process* (June 26, 1998) specifies maximum daily potable water use to be no more than 53 gallons per person at Civano. Reclaimed water use is not to exceed 28 gallons per capita per day (Section 5.1.3, 5.1.5). This report, required by the MOU, analyzes potable and reclaimed water use for Civano residences built between 1998-99, and evaluates the impacts and costs of reclaimed water use at Civano.

Assuming 2.25 people per residence at Civano results in a daily per capita potable water use of 52 gallons and a daily per capita reclaimed water use of 25 gallons. Data from the first 18 months of residential water use at Civano confirm that, to date, the Civano first neighborhood has successfully fulfilled the water use goals set forth by the Civano partners.

The results of Civano water data reported here are compared to two water-use baselines in Tucson: 1) water use for Tucson residences "at-large", and 2) water use for new homes built during 1998-99—i.e., built during the same year as Civano homes reported here. The Tucson "at-large" baseline provides a benchmark of water use across all—old and new homes—in Tucson. The latter baseline provides a database by which to evaluate Civano's water reductions as compared specifically to similar homes built during the same time period and under the standard—rather than sustainable—Codes.

The average annual potable water use per Civano residence is 57 CCFs (42,390 gallons) per year, as compared to potable water use in Tucson (at-large) residences of 147 CCFS (109,589 gallons). Civano residential potable water use per home is 39% that of Tucson residential use. This reflects an avoided potable water use of 61% by Civano homes as compared to Tucson homes.

Comparing Civano residential use of 57 CCFs per home to that of Tucson 1998-99 homes, which use108 CCFS (80,534 gallons) per residence per year, Civano uses 53% the potable water of comparable new homes; avoided potable water use is 47% per Civano residence.

Total water use at Civano, including reclaimed and potable water, is 84 CCFs per year as compared to 147 CCFs for Tucson at-large residences, and 108 CCFs for Tucson 1998-99 homes.

In this report, total water use reduction at Civano is correlated with reduction in energy consumption and CO2 emissions; water delivery takes energy. *Civano's reduced water use* results in an annual reduction of 125 lbs. per house CO2 emissions as compared to Tucson 1998-99 homes for water delivery alone, and an annual reduction of 328 lbs. of CO2 emissions as compared to Tucson residences at-large.

This report examines development-wide water use to provide a comprehensive analysis of water use reductions at Civano. Approximately 22% of total water use at Civano is reclaimed water supplied to common-areas, for example, common-area landscaping. The findings here suggest that use of reclaimed water across 150 Civano homes and their surrounding landscape would save over 13 million gallons of potable water per year as compared to 150 Tucson homes located in another development. One independent business at the mixed-use development of Civano, The Civano Nursery, uses more than 98% reclaimed water for its total water use. This nursery may well be the only nursery in the State of Arizona to conserve potable water to this extent.

The limitation of this initial evaluation of water use at Civano was its reliance on voluntary data. Future evaluations should capture the relevant analyses based on blind data provided by the City of Tucson Water Department.

The Economics of Reclaimed Water Use

While potable and reclaimed water use at Civano is saving water for the residents and City of Tucson, both the initial and ongoing costs to users/developers for delivery of reclaimed water are as expensive as that for potable water. The initial cost of $1,600 for the reclaimed-water meter for each home—in addition to the potable water meter—arguably benefits the City as such investment supplies revenues to fund reclaimed water infrastructure and delivery. But the meter cost deters reclaimed water use at the user/developer end. (Approximately $3,000 per home additional up-front cost is required per home for the additional stub outs, water lines, and meter associated with reclaimed water use). This up-front cost cannot be recovered and virtually doubles the start-up cost of water delivery for Civano and other reclaimed water users.

Because reclaimed water meters are read separately—and monthly—at individual homes, the long term cost of using reclaimed water is the same as—and additive to—that of using potable water. Water users pay long term fees for two water meters. Monthly monitoring of individual meters creates a host of unsustainable costs: the labor and traffic costs to read meters monthly; associated resource costs, such as the separate piece of paper to print the bill, etc.

The current system creates a severe barrier to the use of City-supplied reclaimed water for landscaping in that it—counter-intuitively—increases the overall cost of water to the developer and/or the homeowner when reclaimed water is used. For these reasons, use of reclaimed water does not correlate with the financial incentive that it should. Using reclaimed water benefits desert communities and the City as such reduces overall and potable water use, energy consumption and emissions, and provides economic support for reclaimed water infrastructure by providing the market for it.

Several alternative approaches to potable and total water use reductions, that also lower costs, could eliminate this substantial *barrier to sustainability* (see Appendix D).

Metering

One alternative to the current economic disincentive associated with City-provided reclaimed water would be to meter reclaimed water in larger blocks, for example, at the development property line. Such would require that charges for reclaimed water be passed on to residents through an averaged fee-for-use (e.g., as part of the HOA fees). This solution would avoid the initial $1,600 fee charged to homeowners and/or the development for the meter. Ongoing problems—including fees—due to monthly meter reading would also be addressed. Additionally, development of more sustainable distribution and monitoring methods would likely lower the cost of reclaimed water to other stakeholders as reclamation becomes common in the desert community water management.

A possible problem with this solution is that everyone would pay the same fee—even if they use less reclaimed water than their neighbor, or none at all. Such might also encourage over-use of reclaimed water.

Cisterns

A second alternative would eliminate use of City-provided reclaimed water in individual lots (while possibly maintaining its use in common and commercial areas, below) in favor of rainwater harvesting cisterns for use in private areas (see Appendix F, *Passive and Active Rainwater Harvesting*). Cisterns collect rainwater and store it for use on xeriscape landscaping (xeriscape is already required at Civano). Use of cisterns would require an initial investment by owners but would benefit them over the long term through elimination of water use fees. Initial (costs of) infrastructure—stub outs and water lines—might also be eliminated.

Total and potable water use at Civano would likely continue to be lower than city-wide use through application of this type of landscape watering system. Given the average Civano lot size (generally less than 5000 square feet), rainwater collection devices could serve as a (primary or secondary) landscaping water source. Use of cisterns is complementary to required xeriscape at Civano: native plants are adapted to low total water use and to seasonal rainfall patterns. Thus the cistern system could fully or largely meet the water needs of these plants after they are established.

The cost of cisterns varies, depending upon material type and size, but ranges between approximately $150-600 for a 211 to 1700 gallon capacity (culvert) storage unit.

Cistern systems, like other systems, have limitations. For example, harvesting devices have a limited capacity of some hundreds of gallons of water. In dry years, landscape watering might need supplementation by potable water. Harvesting is seasonal (and dependent on the quantity of rainfall) in Tucson; thus some seasons/years would potentially require potable water for landscape needs. Cisterns would likely not provide the quantity of water required to establish landscaped areas; however, it would contribute more proportionally as landscaping became established and water needs decreased.

Clear responsibility for maintenance and installation of the cistern system would need to be established. Care would also need to be taken with placement and design so that water not disperse to building foundations due to faulty seals or overflow and so that coherent community design results.

Reclaimed Water Reductions

A third alternative would restrict City-supplied reclaimed water use at Civano to appropriate common and commercial areas, eliminating its use on and costs to private lots. As a sole method, implementing this alternative would likely result in less potable water reductions at Civano than those reported here for the first neighborhood (i.e., because potable water would be used on private landscaping).

Reducing the Cost of City-Supplied Reclaimed Water Use

A fourth solution would come from City-instituted reductions of the costs associated with reclaimed water use through appropriate rate-adjustments and/or start-up incentives. The City provided 118,000 acre feet of potable water and 10,700 acre feet reclaimed water in 2001 (1 Acre Foot = ~ 325,000 gallons of water or ~436 CCFs). City initiation of creative and cost-effective ways to distribute reclaimed water could increase its use in Tucson. The delivery of ground and CAP water is likely to get more expensive in Pima County, and will likely continue to require energy powered by fossil fuel, and hence release of CO2 and emissions. Ground water is likely to become more limited, while reclaimed water is likely to become more available. For these reasons, Civano and

the City of Tucson have the opportunity to greatly benefit water use management in Tucson by implementing changes that reduce barriers to sustainability now. To the extent that Civano and the City of Tucson can help create a model for use in other communities, this move is key to development of proactive and smart water management systems.

Background: Potable and Reclaimed Water

The City of Tucson Water Department provides potable water to Civano and to Tucson. *Potable* water is purified to a degree optimal for drinking and bathing/washing as per the State of Arizona's standard of "full-body" contact.[1] Cost-to-supply potable water in Tucson includes drilling of groundwater, cost for CAP water, pumping and distribution, and metering and monitoring costs. Supply of potable water uses energy at a cost of approximately $0.17 per CCF in Tucson, with approximately 5.21 pounds of CO2 per CCF released into the atmosphere.[2]

Reclaimed water is supplied to Civano and to the City of Tucson by Pima County Wastewater Management. Reclaimed water is the final product of a multiple-stage treatment that cleans wastewater. This process produces water suitable for irrigation but not for full-body contact. Using reclaimed water matches water quality with water use to conserve groundwater resources. High quality water is reserved for drinking and bathing, while reclaimed water is ideal for irrigation.

At Civano, reclaimed water is used at the individual home site and in common-areas (for landscaping, such as walkway foliage, trees, etc.). Because it is not drilled and extracted from depths determined by the level of the groundwater table, nor is it pressurized (to the same degree as potable water), the energy needed to supply reclaimed water is somewhat less than that for potable water; therefore, CO2 production/release is also somewhat less for reclaimed water than potable water.

Homeowners at Civano use reclaimed water for landscaping. They are served reclaimed water at their homes; this water is metered through a separate meter at each home. Or the homeowner may install water harvesting devices (collection devices which claim rain or runoff water) rather than using City-supplied reclaimed water for home landscaping needs. The impact of reclaimed water use at Civano is reported here, while water harvesting at Civano is not.

2. Introduction: Purpose of the Study and Methods Used

Purpose of This Study

The *Civano IMPACT System Memorandum of Understanding on Implementation and Monitoring Process* (signed June 26, 1998) specifies reclaimed and potable water use at Civano to be as follows (Section 5.0, *Specific Procedures for Implementation*):

> 5.1.3. Impact (MOU) Establish exterior water budgets, monitor water consumption, and develop a contingency program to achieve compliance with the budgets if water conservation targets are not met, which utilize City-provided reclaimed water in landscaping **for individual residential properties not to exceed 28 gallons per capita per day**.
>
> 5.1.5 Establish interior water budgets, monitor water consumption and develop a contingency program to advance compliance with the budgets if water consumption targets are not met, for each building and design the plumbing systems accordingly that **will reduce the interior use of water in residential structures to 53 gallons per person per day and to 15 gallons per person per day in non-residential structures.** The guidelines shall specify the manner in which water use has been calculated and the principal measures to be taken to meet these budgets.

The current study reports on potable and reclaimed water use during 2000-01 at Civano, for houses built between 1998-99. The results of Civano water data are compared to two water-use *baselines*[3] in Tucson: 1) average water use for Tucson residences at-large, and 2) average water use for new homes built during 1998-99 —the same year as Civano homes reported here. The former baseline provides a benchmark of water use across all--old and new homes--in the Tucson area. The latter baseline provides a comparison to new Tucson homes—i.e., a comparison sample more closely approximating Civano homes. The Tucson new-home baseline is likely to approximate city-wide current building practices; relevant here, these new-homes are likely to utilize newer, water-savings appliances—as Civano does. The Landscape Ordinance of Pima County was passed in 1990, restricting landscaping to more desert-normalized flora than had previously been required; water use in Tucson new homes is likely to reflect the impact of this Ordinance, while the Tucson at-large average does not. Comparison between residential water use in these three fields—Tucson at-large, Tucson new homes built 1998-99, and Civano homes—teases apart reductions in water use resulting from current City/County water-use Codes (such as plumbing devices and landscaping use), as compared to the impact of reclaimed water use.

This study provides two important keys to accurate utility analysis. First, it points out a method for data normalization which reflects actual residential water use (versus water used during construction and other pre-residential phases). This method is given as Appendix C.

Second, this report looks at Development-wide water use to provide a more comprehensive view of total water use than one examining only individual home use. Tucson homes are increasingly located in larger organizational units, such as the Development. Accurate accounting of total water used (and saved) is reflected in the Development as a whole—including water used in common, or shared-areas. Because reclaimed water and potable water are metered separately at Civano, a unique opportunity exists to evaluate the impact of landscape water use on the Development as a whole (Section 3.2). This study associates water use with energy use and CO2 emissions by evaluating the impact of a set of 150 Civano houses using reclaimed water sources for landscaping (Section 4).

Finally, this report suggests alternatives which can reduce *barriers to sustainability*[4] that exist under current methods of monitoring (for both reclaimed and potable water; Section 5).

The goal of the Memorandum of Understanding is to confirm the strategies for sustainable development and to implement and monitor the Civano IMPACT System…Subsequent monitoring of performance…will provide the basis for determining the success in meeting the IMPACT System Standards as well as the basis for improving future conservation and sustainability strategies and standards (Civano IMPACT MOU, Sections 1-3)

Methods

Potable and reclaimed water are metered (separately) at individual Civano homes while reclaimed water is metered at several common-use areas in the Development. Data from individual Civano residences were collected from homeowners' bills (on a volunteer basis), as supplied by City of Tucson Water Department and Pima County Wastewater Management. Significantly, because participating Civano homes contributed *all* utility data (electric, water, and natural gas where applicable), a criterion for analyzing residential water use—as distinct from water used during the pre-use stages of construction—evolved and was used to normalize data. Essentially, for Civano homes all utility data were examined for each participating home; therefore, the move-in date for residency was determined when utility bills for each of potable water and electric (and reclaimed water and gas, if applicable) began to accrue. See Appendix C for details.

Table 1 shows Civano sample size and average CCFs used per residence per month (1 CCF = 745 gallons).

	POTABLE				**RECLAIMED**				**ALL WATER**
	SS	**SS**	**SS**	**AVG. CCFS**	**SS**	**SS**	**SS**	**AVG. CCFS**	**AVG. CCFs**
	2001	**2000**	**TOTAL**		**2001**	**2000**	**TOTAL**		
MONTH									
DEC	32	22	54	4.1	28	19	47	1.8	6
NOV	32	19	51	4.8	28	16	44	2.8	7.6
OCT	32	16	48	4.8	28	14	42	2.8	7.6
SEP	32	13	45	5.3	28	12	40	3.2	8.5
AUG	32	13	45	4.5	28	12	40	2.5	7.1
JUL	31	13	44	5.3	27	12	39	3.5	8.8
JUN	30	7	37	5.1	27	6	33	2.3	7.4
MAY	29		29	4.6	26		26	2.6	7.2
APR	28		28	4.3	24		24	1.7	6
MAR	28		28	4.7	24		24	1.6	6.3
FEB	26		26	4.6	23		23	1.2	5.8
JAN	24		24	4.8	22		22	1.3	6.1

Table 1: Sample size (SS) and average CCFs for months/years for Civano potable and reclaimed Water. 1 CCF = 745 gallons. Civano annual average potable water use/month: 4.7 CCFs (3,502 gallons/mo.). Civano annual average reclaimed water use/month: 2.3 CCFs (1,714 gallons/mo.).

Average annual water use for years 2000-2001 by Tucson single family residences at-large (i.e., by homes built in any year) was supplied by the Tucson Water Department. Table 2 shows averaged data (sample size was not provided).

POTABLE			
	2001	2000	AVG. CCFS
MONTH			
DEC	11.0	9.5	10.3
NOV	12.1	9.2	10.7
OCT	13.0	12.3	12.7
SEP	14.7	13.8	14.3
AUG	13.0	14.8	13.9
JUL	14.8	14.8	14.8
JUN	15.7	16.6	16.2
MAY	12.5	14.4	13.5
APR	10.4	11.8	11.1
MAR	9.1	10.5	9.8
FEB	8.4	10.4	9.4
JAN	9.9	10.8	10.4

Table 2. Tucson single family residences at-large, average potable/total water use per residence.

Data for comparison to Tucson new homes built in 1998-99 were provided by *The Baseline Study for Residential Energy Use*, 1998/1999 (Appendix B). Pending actual demographic data, the per capita average for residences was assumed to be 2.25.

3. Water Use at Civano

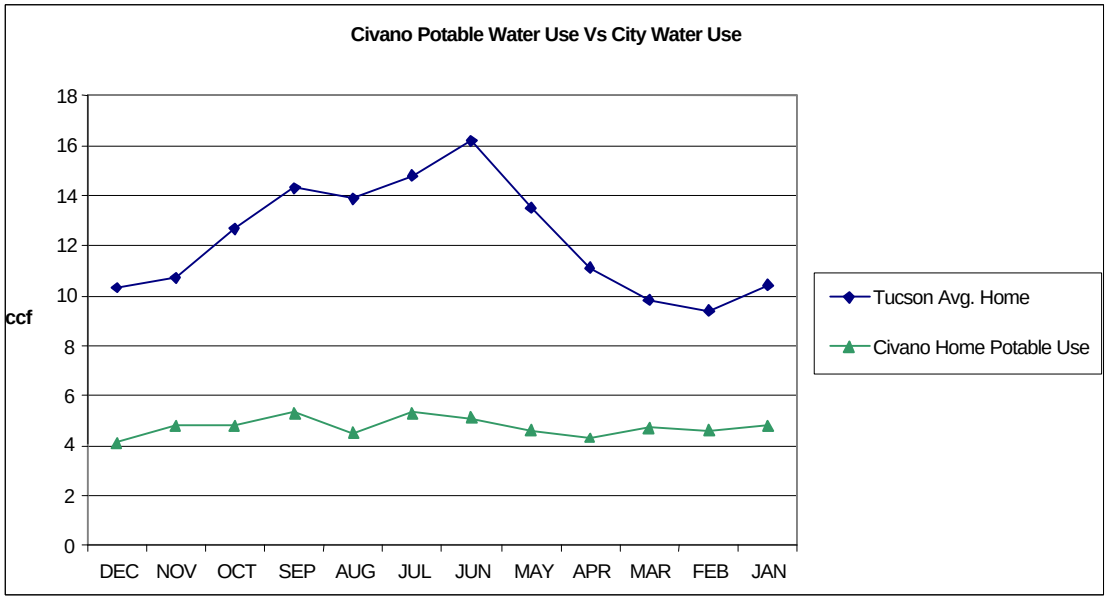
The analysis of reclaimed and potable water use at Civano for the first neighborhood can be measured in three ways: 1) by comparison to prescribed water use in Sections 5.13, 5.15 of the Civano IMPACT Systems MOU; 2) by comparing residential use at Civano to water use by all Tucson residences and to use by just newer homes; and 3) by measuring water use at Civano development-wide, that is, including water use in common-areas.

3.1 Comparison of 2000-01 Civano Water Use to Civano IMPACT System MOU, Section 5

As shown by data in Table 1, Civano annual average per month potable water use is 3,502 gallons and annual average per month reclaimed water use is 1,714 gallons. Assuming a per capita residence of 2.25 people/residence provides for a per capita daily potable water use of 52 gallons. Assuming the same 2.25 residents per residence produces a per capita per day reclaimed water use of 25 gallons. Because the Civano MOU specifies 53 gallons/day/person potable water and 28 gallons/day/person as the target maximum reclaimed water use, data from 2000-01 confirm that the Civano first neighborhood has successfully fulfilled the water-reduction goals set forth by the founding partners of Civano.[5]

3.2 Civano Water Use Compared To Average Tucson Residential Use

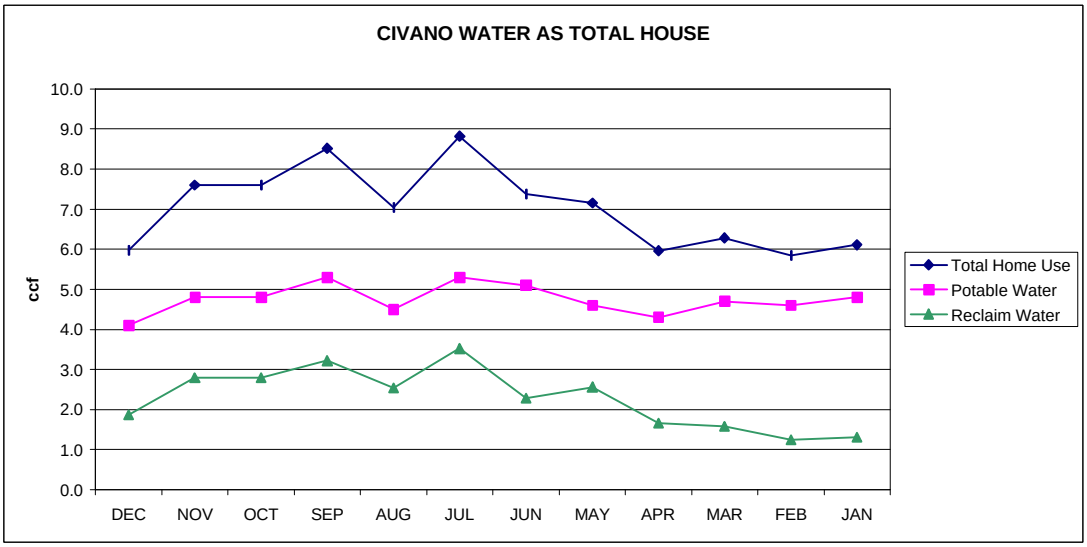
The average annual potable water use per Civano residence is 56.9 CCFs (42,390 gallons). The average annual use of potable water for Tucson residences is 147.1 CCFS (109,589.5 gallons). Civano residential use per home is 38.7% that of Tucson (at-large) use per residence; this reflects an avoided potable water use of 61.3% by Civano homes as compared to average Tucson homes.



Graph 1: Tucson at-large average residential potable water use vs. Civano average residential potable water use. Y-axis indicates water use in CCFs (1 CCF = 745 gallons).

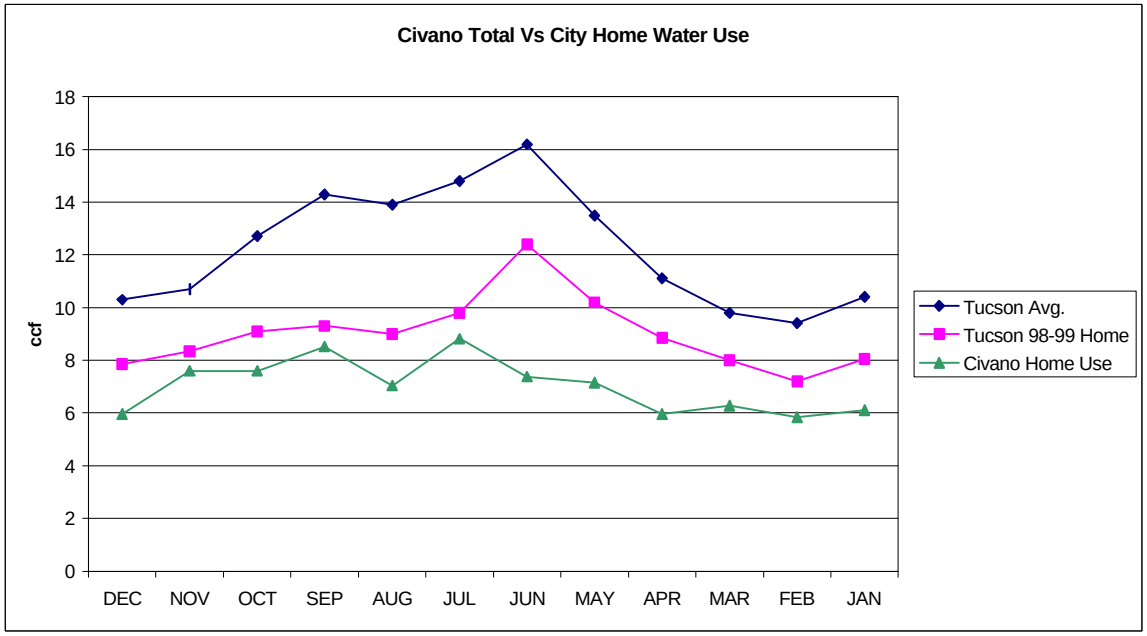
Averaging total water use of the first 150 Civano homes as compared to the average from 150 Tucson homes, annual potable water use for 150 Civano homes collectively totals 8,535 CCFS, while that for 150 comparable houses from Tucson totals 22,065 CCFs.[6] The first 150 Civano residences together, then, avoid an annual use of over 10 million gallons of potable water as compared to an equivalent set of Tucson houses.

The average annual reclaimed water use per Civano residence is 27.38 CCFS (20,398.1 gallons).



Graph 2: Civano reclaimed, potable and total water use. Y-axis indicates water use in CCFs (1 CCF = 745 gallons).

Taken together, the average annual total water use per Civano residence is 84.28 CCFS (62,788.6 gallons), or 57.3% that of water used per average Tucson residence.[7] This presents a 42.7% annual savings over total average Tucson residential water use.



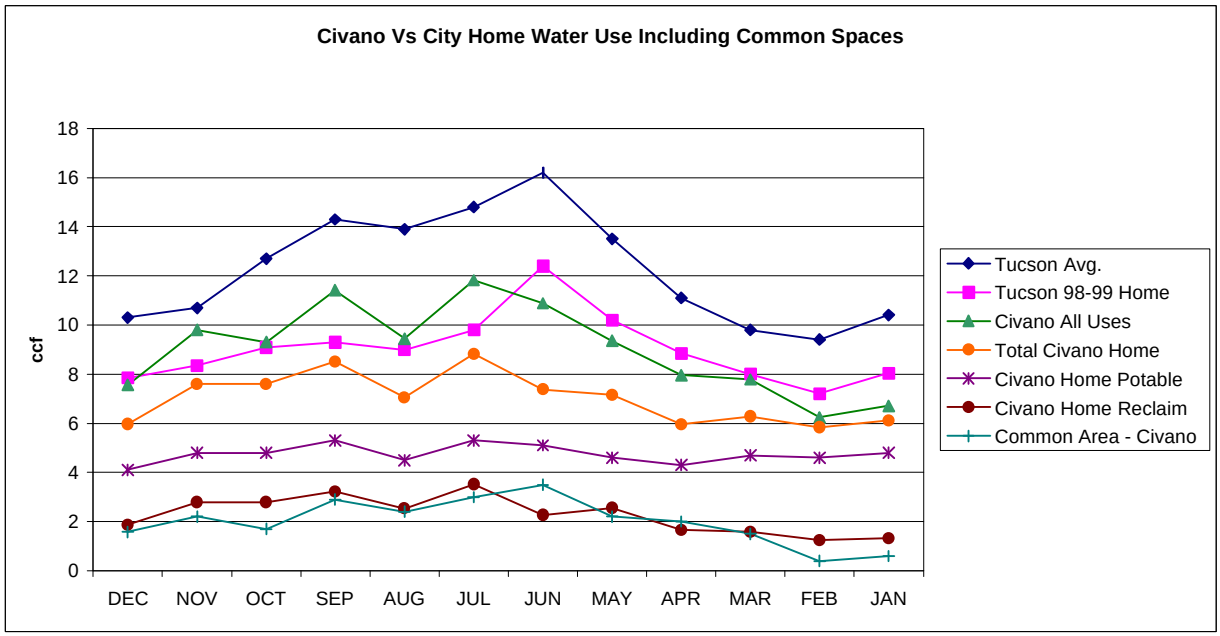
Graph 3: Civano total individual residence vs. Tucson total use per residence (Newer Tucson 1998-99 homes are discussed below and shown here for comparison). Y-axis indicates water use in CCFs (1 CCF = 745 gallons).

3.3 Comparison of Civano Water Use to 1998-99 Tucson Homes

Water data from new homes built in 1998-1999 were taken from *The Baseline Study for Residential Energy Use, 1998/1999* (Appendices B, C). Because new homes are built under newer codes prescribing low water-use appliances and following the Landscape Ordinance (1990), comparison of water use in Civano homes to that of Tucson 98-99 homes demonstrates the impacts of reclaimed water use over and above impacts due to current Codes. Review of total water use also points to Civano's water savings over and above that achieved by mandatory use of desert landscaping and use of reclaimed water together.

With an annual potable water use by new homes built in 1998-99 of 108.1 CCFS (80,534.5 gallons) as compared to Civano's 56.9 CCFs, Graph 3 (and Appendix B/C), Civano individual residences use 52.7% the potable water of other new homes (avoided potable water use is 47.3% per residence). Comparing Civano total water use (84.26 CCF) per residence to the total water use of comparable 1998-99 homes (108.1 CCFS) shows that Civano uses 78% the total water of comparable 1998-99 homes (an avoided water use of 22%, or 17,760.8 gallons per house, per year). Collectively, Civano's first 150 houses avoid over 2.5 million gallons of water per year (potable and reclaimed) over that of 150 similar new houses built in Tucson during 1998-99.

Graph 4 summarizes the results of these water data.



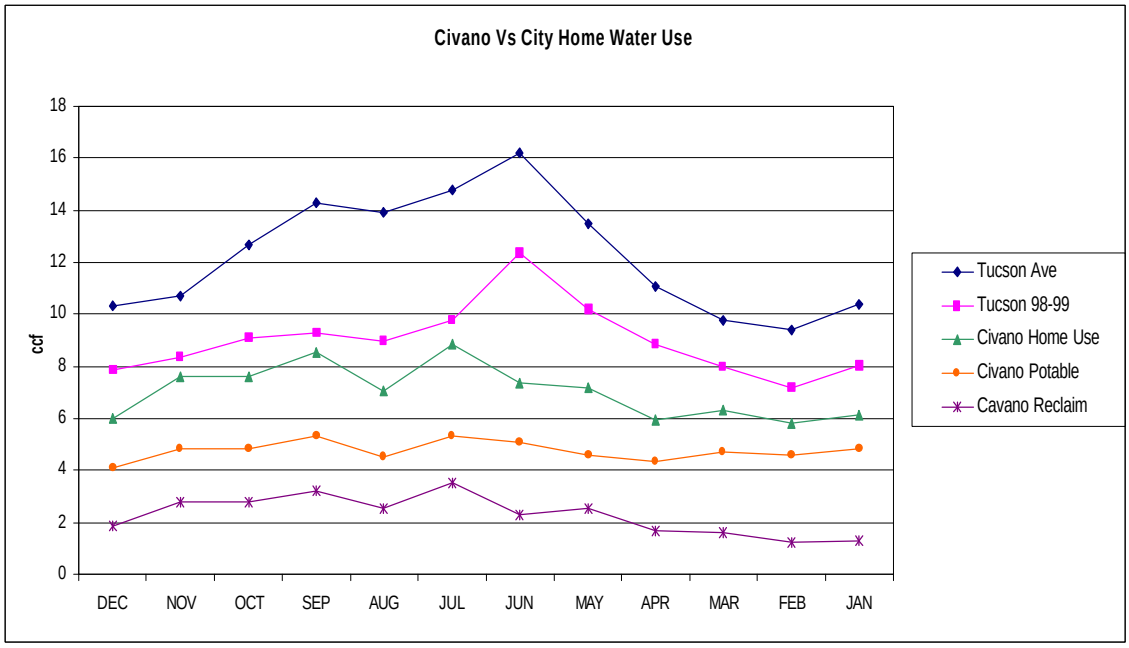
Graph 4: Comparison of Civano, Tucson at-large, and Newer Tucson 98-99 homes. Y-axis indicates water use in CCFs (1 CCF = 745 gallons).

3.4 Development-Wide Water Use, Including Common-Areas

Individual Civano homes, 1998-99 home water use is a large fraction of total water use at Civano. Other water use includes that used to water common-area landscape.[8] Likewise, Tucson residences are frequently located within some larger organizational unit, such as a Development. Data reported above are for water metered at individual homes and do not include water used for common-areas (i.e. for landscaping, pools, gardens...etc.), which typically have separate metering systems. Data for Civano common-areas were made available by the Tucson Water Department. While the following results are suggestive only—requiring validation by use of accurate total-water metering data—the following results are suggestive of a more complete water-use scenario.

If common-area water use (water used to sustain common areas) is distributed across 150 homes of the first Civano neighborhood, each home uses 23.98 CCFs of reclaimed water per house per year for

common-areas (see note 6). Taken together with the individual home use, total water use per house for the Civano Development as a whole is approximately 108.26 CCFs (84.28 CCFs metered at the individual home for reclaimed and potable water, and 23.98 CCFs per home as averaged from common area meters). Graph 5 shows total water use of Civano as a sum of reclaimed water use at individual and common-areas, and potable water use at individual homes. Assuming this distribution of common-area reclaimed water suggests that approximately 22.5% of total water use at the Civano Development is for common areas.



Graph 5: Total water use by Civano compared to Tucson averages. Y-axis indicates water use in CCFs (1 CCF = 745 gallons).

Although data are not available for comparison to either the Tucson 1998-99 homes, nor for the Tucson homes at-large, a reasonable starting point in identifying actual total water use in Tucson developments is to increase each individual home's water use by 22%. Because the Tucson at-large and the 1998-99 new home data use potable water for landscaping, this increase indicates an increase in potable water use for each data sample except those at Civano.

Using this approximation, Tucson at-large total annual potable water use per residence would be 179.5 CCFs, and for homes built in 1998-99 would be 131.9 CCFS, as compared to Civano's 56.9 CCFs annual potable water use.

Assuming these numbers, Civano would avoid 56.9% water use as compared to new Tucson 1998-99 homes, and 68.3% as compared to Tucson residences at large. For the first 150 Civano homes, this would cumulate as a savings of almost 8.5 million gallons annually as compared to 150 average Tucson 1998-99 homes, and over 13.7 million gallons per year as compared to 150 Tucson homes. Actual total data for water use are needed to verify these predicted water impacts.

4. Costs, Energy Savings and CO2 Reduction

Less water used means less energy used and fewer CO2 emissions. Cost for supply of water in Tucson (potable and reclaimed) is approximately $.17 per CCF. Approximately 5.21 pounds of CO2

emissions results per CCF (see note 2). Average annual Civano total water use per residence is approx. 84 CCFs, Tucson at-large homes is approx. 147 CCFs, and Tucson 98-99 homes is approx. 108 CCFs. The average reduction in CO2 per Civano house due to decrease in total water use is 125 lbs. CO2 emissions per house as compared to Tucson 98-99 homes. Civano reductions due to avoided water use is 328 lbs. CO2 emissions per house as compared to Tucson residences at-large. This translates as more than 9 tons reduced emissions annually for the first 150 Civano homes as compared to a set of 150 98-99 homes, and as nearly 25 tons annual avoided emissions relative to Tucson homes at-large. This reduction is for water use alone, and does not include reductions directly accrued to reduced utility energy use (*See Civano and Tucson Energy Report*, ANE, Inc.).

5. Barriers to Sustainability and Alternatives

Analysis for Future Monitoring

One limitation of the initial evaluation of water use in Tucson was its reliance on voluntary data. It is difficult to receive permission to use utility data after homeowners are in the house (a detailed report of the problem is given in *The Baseline Report* in Appendix B). Future evaluations should therefore capture the relevant analyses based on blind data from the City of Tucson Water Department.

Comparing Civano residential use of 57 CCFs per home to that of Tucson 1998-99 homes, which use108 CCFS (80,534 gallons) per residence per year, Civano uses 53% the potable water of comparable new homes; avoided potable water use is 47% per Civano residence.

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The Economics of Reclaimed Water Use

While potable and reclaimed water use at Civano is saving water for the residents and City of Tucson, both the initial and ongoing costs to users/developers for delivery of reclaimed water are as expensive as that for potable water. The initial cost of $1,600 for the reclaimed-water meter for each home—in addition to the potable water meter—arguably benefits the City as such investment supplies revenues to fund reclaimed water infrastructure and delivery. But the meter cost deters reclaimed water use at the user/developer end. (Approximately $3,000 per home additional up-front cost is required per home for the additional stub outs, water lines, and meter associated with reclaimed water use). This up-front cost cannot be recovered and virtually doubles the start-up cost of water delivery for Civano and other reclaimed water users.

Because reclaimed water meters are read separately—and monthly—at individual homes, the long term cost of using reclaimed water is the same as—and additive to—that of using potable water. Water users pay long term fees for two water meters. Monthly monitoring of individual meters creates a host of unsustainable costs: the labor and traffic costs to read meters monthly; associated resource costs, such as the separate piece of paper to print the bill, etc.

The current system creates a severe barrier to the use of City-supplied reclaimed water for landscaping in that it—counter-intuitively—increases the overall cost of water to the developer and/or the homeowner when reclaimed water is used. For these reasons, use of reclaimed water does not correlate with the financial incentive that it should. Using reclaimed water benefits desert communities and the City as such reduces overall and potable water use, energy consumption and emissions, and provides economic support for reclaimed water infrastructure by providing the market for it.

Several alternative approaches to potable and total water use reductions, that also lower costs, could eliminate this substantial *barrier to sustainability* (see Appendix D).

Metering

One alternative to the current economic disincentive associated with City-provided reclaimed water would be to meter reclaimed water in larger blocks, for example, at the development property line. Such would require that charges for reclaimed water be passed on to residents through an averaged fee-for-use (e.g., as part of the HOA fees). This solution would avoid the initial $1,600 fee charged to homeowners and/or the development for the meter. Ongoing problems—including fees—due to monthly meter reading would also be addressed. Additionally, development of more sustainable distribution and monitoring methods would likely lower the cost of reclaimed water to other stakeholders as reclamation becomes common in the desert community water management.

A possible problem with this solution is that everyone would pay the same fee—even if they use less reclaimed water than their neighbor, or none at all. Such might also encourage over-use of reclaimed water.

Cisterns

A second alternative would eliminate use of City-provided reclaimed water in individual lots (while possibly maintaining its use in common and commercial areas, below) in favor of rainwater harvesting cisterns for use in private areas (see Appendix F, *Passive and Active Rainwater Harvesting*). Cisterns collect rainwater and store it for use on xeriscape landscaping (xeriscape is already required at Civano). Use of cisterns would require an initial investment by owners but would benefit them over the long term through elimination of water use fees. Initial (costs of) infrastructure—stub outs and water lines—might also be eliminated.

Total and potable water use at Civano would likely continue to be lower than city-wide use through application of this type of landscape watering system. Given the average Civano lot size (generally less than 5000 square feet), rainwater collection devices could serve as a (primary or secondary) landscaping water source. Use of cisterns is complementary to required xeriscape at Civano: native plants are adapted to low total water use and to seasonal rainfall patterns. Thus the cistern system could fully or largely meet the water needs of these plants after they are established.

The cost of cisterns varies, depending upon material type and size, but ranges between approximately $150-600 for a 211 to 1700 gallon capacity (culvert) storage unit.

Cistern systems, like other systems, have limitations. For example, harvesting devices have a limited capacity of some hundreds of gallons of water. In dry years, landscape watering might need supplementation by potable water. Harvesting is seasonal (and dependent on the quantity of rainfall) in Tucson; thus some seasons/years would potentially require potable water for landscape needs. Cisterns would likely not provide the quantity of water required to establish landscaped areas; however, it would contribute more proportionally as landscaping became established and water needs decreased.

Clear responsibility for maintenance and installation of the cistern system would need to be established. Care would also need to be taken with placement and design so that water not disperse to building foundations due to faulty seals or overflow and so that coherent community design results.

Reclaimed Water Reductions

A third alternative would restrict City-supplied reclaimed water use at Civano to appropriate common and commercial areas, eliminating its use on and costs to private lots. As a sole method,

implementing this alternative would likely result in less potable water reductions at Civano than those reported here for the first neighborhood (i.e., because potable water would be used on private landscaping).

Reducing the Cost of City-Supplied Reclaimed Water Use

A fourth solution would come from a City-instituted reductions of the costs associated with reclaimed water use through appropriate rate-adjustments and/or start-up incentives. The City provided 118,000 acre feet of potable water and 10,700 acre feet reclaimed water in 2001 (1 Acre Foot = ~ 325,000 gallons of water or ~436 CCFs). City initiation of creative and cost-effective ways to distribute reclaimed water could increase its use in Tucson. The delivery of ground and CAP water is likely to get more expensive in Pima County, and will likely continue to require energy powered by fossil fuel, and hence release of CO2 and emissions. Ground water is likely to become more scarce, while reclaimed water is likely to become more available. For these reasons, Civano and the City of Tucson have the opportunity to greatly benefit water use management in Tucson by implementing changes that reduce barriers to sustainability now. To the extent that Civano and the City of Tucson can help create a model for use in other communities, this move is key to development of proactive and smart water management systems.

Appendices

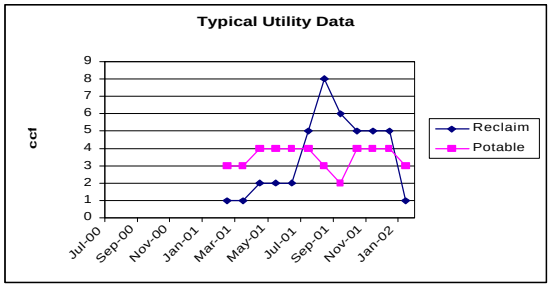
A. Civano IMPACT System Memorandum of Understanding on Implementation and Monitoring Process, signed June 26, 1998—Available on Request
B. Baseline Study for Residential Energy Use, 1998/1999—Available on Request
C. Normalization of Data— Below
D. Development Center for Appropriate Technology, Annual Report 2001— Available at www.dcat.org
E. Gray water Systems for Single Family Dwellings, Refer to Appendix G of the UPC.
F. Passive and Active Rainwater Harvesting, attached

Appendix C

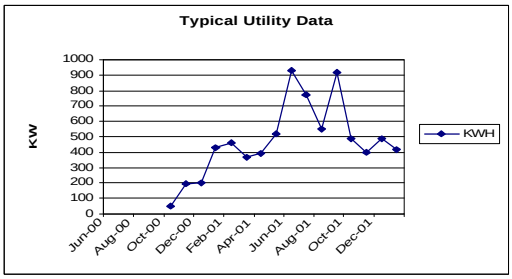
Two stages of water use were reflected in the Civano water data supplied to Civano: pre-use and use stages. *Lifecycle stages* of a house include a *use phase*—period that the house is in residential use--and a *pre-use phase*—the period that the house is under construction (pre-residential). The significance of the pre-use phase to the current report is that during this time, water was used at the house site and therefore metered and reported. Inclusion of such data would not reflect true residential water use. Significantly, in every case examined for this report, inclusion of pre-use data would artificially lower the reported average water use. Hence, they were eliminated from the Civano data. In a large enough sample, the numbers would eliminate the impact of this problem. To the best of our knowledge, neither the comparative Baseline (Appendix B), nor the Tucson at-large water use averages reflect this normalization. Figure 1 demonstrates the data normalization process assumed here.

Figure 1 data normalization. Since all three utilities are screened for the same residence, the probable move-in data aligns with the month at which all utilities were on—March, 2000. Note that while energy was used previous to these dates, the water was not on. The likely date for residential occupancy was assumed to be March, 2000.

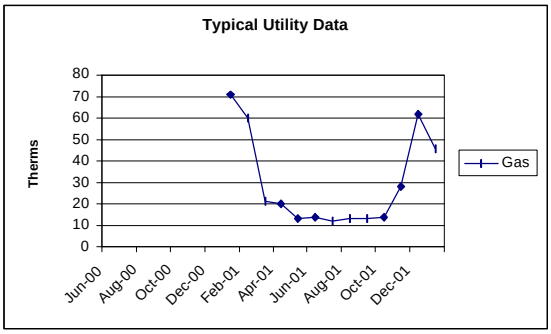
WATER



ELECTRICITY



GAS



Appendix F

Passive and Active Rainwater Harvesting

By Scott Calhoun, ACNP

Residential water use is too often looked at from a supply-side perspective. When you consider reducing demand, especially in regard to exterior landscaping, many more options are available to meet conservation goals. Given the small size of Civano lots (in most cases less than 5000 square feet) there is no reason that rainwater could not be the primary or secondary landscape water source for many residents.

Designing gardens with xeric plants is an integral part of designing a water harvesting system. Native plants, particularly those that are adapted to our seasonal rainfall patterns, are ideal candidates for such a garden. Using native plants provides the added benefit of creating gardens with regional sense of place.

Rainwater harvesting systems, using both simple and complex methods, are already in use in the gardens of several Civano residents. Simple methods of rainwater harvesting include sloping a patio, sidewalk, or driveway toward a planting area or tree. The goal of these simple methods is to slow water down allowing it to percolate into the soil. Swales (berms), and gabions (low rock dams) are other simple devices used to slow water and direct it to planting areas. Swales can be created at the time of the final grade at very little additional cost.

Complex rainwater harvesting methods involve capturing rainwater in above or below ground cisterns. Although these systems are called "complex," the cisterns currently installed in Civano do not employ pumps or other moving parts relying instead on gravity to transfer water to planting beds. All of the current cisterns in the community are above ground cisterns that hold between 422 and 580 gallons of water. Each cistern costs between $250-600 installed.

The most successful rainwater harvesting systems use a combination of simple and complex methods based on the realities of the lot.

The table below is an actual case study of a home in Civano using harvested rainwater as its primary landscape water source. As noted in the table, this 1500 sq. ft. home can capture 8825 gallons per year using two 422 gallon cisterns. The home's garden, which is comprised of desert adapted plants, requires less water than is harvested from rainfall.

Month	Average Monthly Rainfall in Tucson in Inches	Amount (in gallons) Collected off 1500 sq. ft roof	Amount (In gallons) needed for Irrigation	Surplus or (Deficit)
January	1.2	1072.5	300	772.5
February	1.0	825	450	375
March	.9	742.5	450	292.5
April	.3	247.5	540	(292.5)
May	.3	247.5	540	(292.5)
June	0	0	1040	(1040)
July	1.3	1072.5	1040	32.5
August	1.8	1485	1040	445
September	1.0	825	890	(65)
October	.7	577.5	740	(162.5)
November	.7	577.5	450	127.5
December	1.4	1155	300	855
Total	**12**	**8825**	**6740**	**997**

Some points to consider when comparing rainwater harvesting to reclaimed water include:

- Water harvesting is dependant on rainfall. During exceptionally dry years, supplemental potable water may be required to keep some plants alive.
- A formalized design process would have to be established to ensure that residents who are planning to harvest rainwater design gardens that are compatible with the available water supply. This will also ensure that conservation standards are met.
- Civano already has a comprehensive recommended list of low-water use plants ranked by water use in its Residential Landscape Design Guidelines.
- Even landscapes using xeric plants will need supplemental potable water during their first year in the landscape. After this first year of establishment, rainwater will be usually be sufficient to keep the plants alive.
- Rainwater is very low in dissolved salts. Reclaimed water has considerable dissolved salts. There are no studies on the long-term effects on plants of irrigating with reclaimed water but there is visible salt build up in the planting basins of many residential trees in neighborhood one.

*ANE, Inc. would like to thank the City of Tucson Water Department, especially, Tom Arnold, for graciously providing water data for Civano and averaged water data for residences in Tucson. ANE, Inc. would also like to thank participating residents of Civano for permission to use utility data in this study, and Gary Jurkin, PE, and Ms. Ardi Whalen for help compiling this report. Thanks to Scott Calhoun for materials provided in Appendix F. For research, writing and analysis, ANE, Inc. is grateful to Cari Spring, Ph.D.

[1] From *Things You Should Know About Using Reclaimed Water*. Pima County Wastewater Management Department Brochure.

[2] Water must be drilled, stored, transported and otherwise located to point-of-use, therefore incurring an energy cost in terms of both dollars and CO2. Metering and monitoring of water distribution is also costly in terms of labor and associated resource consumption, such as transportation costs. Potable water distribution costs slightly more than reclaimed water distribution. See Spring, 2001 *Connecting the Dots: water, energy and growth in South Pinal County*. The Oracle, April 2001.

[3] A *baseline* is an analysis of data used as the general case by which to compare different sectors or demographics; here, Civano water use is the specific case being compared to the water use in the more general local of Tucson residences outside of Civano.

[4] On *Barriers to Sustainability* see the (Tucson-based) Development Center for Appropriate Technology Annual Report and reports referenced therein (Appendix D).

[5] Future analyses of Civano utility data should be based on Development-wide residential utility data (rather than solely on data provided by volunteers) to avoid any artificial lowering of the numbers due to the volunteer basis of the data.

[6] As of this writing, approx. 135 Civano homes are in occupancy with over 200 sold. The comparison to 150 homes is a (round) figure, useful for comparing total impact scenarios only, and should not be taken as the exact number of homes currently effecting the water data reported here.

[7] In Graph 3, Tucson potable water per residence is assumed as the home's total water use; this assumption does not account for whatever reclaim or reuse water systems might be operating in individual residences in Tucson.

[8] For ease of exposition, data from common areas include pool water--which is potable, not reclaimed.