Water Reuse to Offset Growth-Driven Water Scarcity in the Southwest: From Supply Augmentation to Substitution

A proposal submitted on May 1, 2007, to the WaterReuse Foundation (WRF-06-016) by:

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Understanding of the Problem

The Southwest, including the U.S.-Mexico border, is experiencing extremely rapid population and economic growth. Expanding urban water demand in the context of water scarcity raises the need for, and attractiveness of, reclaiming wastewater and using the resulting effluent to meet a range of growth-driven demands for water. Effluent is used in southern Arizona primarily for turf (grass, for instance on golf courses), public landscaping (parks and campuses), environmental use (instream flows), power generation (cooling), aquifer replenishment (recharge and recovery), and irrigation (non-food crops); in northern Sonora, Mexico, agriculture is an important reuse option. Yet, as conventionally practiced, reuse is essentially a strategy to augment water supply from surface and groundwater resources. In situations of water scarcity such as the Southwest, expanding total water use may continue to deplete groundwater even with water reuse. In order to more effectively address the emerging growth-with-scarcity situation, water reuse will likely need to move toward supply substitution, i.e., replace existing uses of potable water, and increasingly be used to sustain ecosystems. This is not simply a matter of designing and financing enhanced technology—although technology remains at the core of safe, feasible, and environmentally sustainable reuse schemes. It is about the role of institutions—the management and legal frameworks—and fundamentally, about altering public perceptions and influencing public choice.

Consumer preference is critical for such supply-substituting practices as water reuse for household landscaping (supplanting drinking water for residential outdoor use that consumes up to half of total residential water supply), and indirect potable reuse (through recharge and recovery). Additionally, using reclaimed water for riparian area conservation is increasingly recognized as important in maintaining the environmental amenities that enhance a community’s quality of life.
Goal

Determine the challenges to sustainable water reuse and where appropriate, facilitate its adoption in three rapidly growing municipalities: Tucson and Sierra Vista, Arizona, and the twin cities of Ambos Nogales on the Arizona-Sonora (Mexico) border, through improved understanding of the interactions among technology, cost, institutions, and public choice.

Background

The Southwest’s rapid economic growth and expanding population, including internal migration within the U.S., are driving steep increases in the demand for water. Because a relatively constant percentage of indoor water usage is recovered, wastewater volumes grow roughly in proportion to population. However, rapid population growth may result in demand for water that exceeds conventional supplies in a water-scarce region, particularly when effluent is not put to full beneficial use.

Arizona is the fastest growing state in the country, with population growth taking place mostly in towns and cities. Southern Arizona, including the border with Mexico (Figure 1), is experiencing particularly accelerated growth. From 2000 to 2020, population along the border is projected to increase by 64 percent (USEPA, 2003), with population in Santa Cruz County, Arizona, by 67 percent. Since 1990 the unincorporated areas of Cochise County (where Sierra Vista is located) have grown at a rate of 35.8 percent, while the incorporated areas of the county have grown at a rate of 12.1 percent (City of Sierra Vista, 2007). Pima County (where Tucson is located) recently crossed the one million population mark and is projected to grow 33 percent from 2000 to 2020 (Educational Needs Index, 2005).

Lack of a reliable water supply greatly diminishes the value of a home and the attractiveness of a community. Therefore, it is in homeowners’ and communities’ best interest to ensure a long-term reliable water supply. Although most Arizona communities do not worry about imminent water outages, the combination of explosive population growth and persistent drought has water managers very concerned about the possibility of shortages in the near future. Importation of water is already being practiced, and the nearest untapped supplies are many hundreds of miles away. Desalination of ocean water is extremely expensive, especially in land-locked areas where there are limited options to dispose of concentrate. Moreover, it is extremely energy intensive. Water reclamation and reuse would appear to be attractive solutions to the problem, as effluent increases with population. Water reuse is growing worldwide, particularly in Australia (Russell and Lux, 2006) and in developing countries (Scott, 2005), where it is driven by economic and environmental values, although often with inadequate safeguards (Scott, 2004).

In the Southwest U.S., non-potable reuse of effluent is practiced in specific cases without significant public opposition. However, as the projected urban water demand outstrips secure, renewable supplies, indirect potable reuse has emerged as a cost-effective alternative. There is also increasing recognition of the importance of effluent to support instream flows and riparian ecosystems. In many instances this has resulted from effluent released to streambeds, instead of intentional allocations of reclaimed water for the environment. Combined, these water reuse practices still represent only two percent of Arizona’s water demand (Eden and Megdal, 2006).

Water managers recognize that public support of water reuse, for both non-potable and indirect potable use, requires extensive education about the safety of reclaimed water (Bruvold, 1988; WRF, 2006). However, lingering doubts about the quality of reclaimed water often combine with other misgivings about the effects of growth on a community, such as increased traffic, loss of open space and natural amenities, and strains on municipal services.
Fig 1. Southern Arizona Growth Region
These factors can result in the characterization of water reclamation as being forced upon a community along with other undesired consequences of growth, leading to attempts to address growth-related problems through opposition to the use of reclaimed water. The most successful indirect potable reuse projects in the U.S. have taken place in Orange County, California (WRF, 2004), and Scottsdale, Arizona, extremely affluent communities with high per capita water usage. They also feature strict zoning controls and building design standards that preserve a high quality of life, as well as high home values. Hypothetically, the incentive to protect homeowners’ assets, the ability to pay for state-of-the-art treatment, and a feeling of empowerment with regard to the local water utility contributed to the embrace of indirect potable reuse in these communities.

On the other hand, in Los Angeles, poor communication and a lack of public involvement led to the abandonment of the East Valley Water Recycling project. The areas to be served by this project were much less affluent than Orange County and Scottsdale, and likely did not place a high value on water for lush landscaping, swimming pools and golf courses. Residents did not trust the utility to incorporate its input and perceived it as arrogant. Lack of supply reliability was not felt to be an important issue, perhaps because home values were low to begin with and recipients of reclaimed water were not likely receive the benefits of growth. These examples show that water reuse can be viewed as a safe method of ensuring reliable water supplies, or an unnecessary risk imposed on a community, depending on the context in which it is presented. Thus, understanding the relationship between communities, their views about growth, and types of water reuse, is a much-needed topic of research.

Proposed Case Studies

**Tucson, Arizona** has an active water reuse program with 8% of total water demand (existing and future) met through reclaimed water (Clark and Dotson, 2003; City of Tucson, 2004); see Figure 2. Adoption of water reuse, including for uses other than turf and landscaping (although these remain the most important), has been promoted through flat-rate ($1.31/Ccf) reclaimed water supply (Dotson, 2003a). Figure 3 shows the reclaimed water distribution system in 2000 (City of Tucson, 2004).

Fig. 2. Tucson Projected Reclaimed Water Use

Fig. 3. Reclaimed Water Distribution System
Additionally, effluent represents an important—though still relatively small—component of the aquifer recharge and recovery strategy as part of the Tucson Active Management Area’s (AMA) statutory goal of achieving safe-yield by 2025 and maintaining it thereafter. Safe-yield is defined as the “long-term balance between the annual amount of groundwater withdrawn in the AMA and the annual amount of natural and artificial recharge” (ADWR, 2007). Currently, groundwater in the Tucson AMA is pumped approximately twice as fast as it is recharged. (Five AMAs—delineated by groundwater basins—were established in Arizona pursuant to the 1980 Groundwater Management Act and are administered by the Arizona Department of Water Resources.) The Santa Cruz AMA, where Nogales, Arizona is located, was separated from the Tucson AMA in 1994 (ADWR, 2007). There is no AMA in the area of Sierra Vista, Arizona.

**Sierra Vista, Arizona** – is home to both Fort Huachuca, the U.S. Army’s intelligence and testing center and a major local employer, and the San Pedro Riparian National Conservation Area (SPRNCNA), a globally important desert river reach that serves as a stopover for millions of migrating birds and habitat for several endangered species. To preserve both of these resources, the Upper San Pedro Partnership (Partnership) collaborates in the management of the Sierra Vista subwatershed of Upper San Pedro Basin and is responsible to the U.S. Congress under the National Defense Authorization Act of 2004 (PL-108-136) to “restore and meet sustainable yield of the regional aquifer by and after September 30, 2011.” Water service in Cochise County is provided by multiple private water companies, represented in the Partnership by Bella Vista Ranches/Water. Although Partnership member agencies have implemented multiple conservation and reuse measures, there is an estimated 3,500 acre-feet/year deficit even with these “management measures” (USPP, 2005).

Sierra Vista’s wastewater is recharged into the regional aquifer by the City’s Water Reclamation Facility in an effort to mound groundwater between the cone of depression under the city and the San Pedro River, whose baseflow depends on the aquifer. The Bureau of Reclamation is currently monitoring the effectiveness of the City’s effluent recharge project. New real estate developments such as “Tribute” have been required to establish a budgeted reuse for the new treated effluent from this project, and this prerequisite could be required of other developers. Fort Huachuca, a Partnership member agency, has a recurring program of re-using effluent on its parade field, golf course, and outdoor sports complex where an estimated 400-450 acre-feet are no longer pumped from groundwater. Cochise County government, another Partnership member agency, is considering a model ordinance regarding use of gray water plumbing. Future strategies include planned and proposed effluent recharge activities in four areas. In addition, the Cochise County Local Drought Impact Group has recognized the need for increased water conservation and storage and has developed a county drought preparedness plan that could incorporate treated wastewater reuse.

In 2003, the Partnership authorized an intercept survey and a series of “Community Connector” meetings to solicit residents’ preferences toward approaches to managing water issues. At that time “retaining, cleaning and putting water back” received the second place ranking for water management strategies, with “saving and conserving water use” receiving the first ranking. Respondents also indicated they would be willing to support an increased level sewer rate between 1-5 percent to pay for this recharge.

**Nogales, Arizona, and Nogales, Sonora (Ambos Nogales), or “Both” Nogaleses** represent a crucial case of binational water sharing that in large measure is effluent. Because the water reuse challenges and solutions are applicable to additional border “twins” (cities and towns on the U.S.-Mexican border from California to Texas; GNEB, 2005), it is important to include
them in this proposal. As mentioned above, the Arizona side is managed as part of the Santa Cruz AMA under a conservation plan whose “primary goal … [is] to gradually reduce water consumption by encouraging the use of the best available water conservation practices and maximizing the efficient use of all water supplies including the direct use of effluent (SCAMA website). The Nogales International Wastewater Treatment Plant, run by the binational International Boundary and Water Commission (IBWC), collects wastewater from both sides and releases reclaimed water in the north-flowing Santa Cruz River for riparian area conservation on the Arizona side.

Water in Nogales, Sonora, is supplied by the Organismo Operador Municipal de Agua Potable, Alcantarillado y Saneamiento (OOMAPAS). Approximately half of Nogales, Sonora’s water supply is pumped in to the Santa Cruz river basin from the Alisos/ Magdalena basin (entirely within Mexico) to the south. Mexican effluent cannot be used toward an assured water supply designation in Arizona because Mexico maintains the right to recapture the effluent and reuse it within its own country (IBWC, 1967). However, with the newest construction effort at the International Wastewater Treatment Plant, existing wastewater flows from Mexico are expected to continue, while flows above 9.9 MGD would be pumped to the Los Alisos Basin in Sonora. There is also the possibility that a newly formed Santa Cruz Water Management and Importation authority might purchase water rights, store and recharge water, and provide short-term option agreements during times of shortage (Sprouse, 2005: 7-9). In addition, the Santa Cruz Local Drought Impact Group has recognized the need for water storage and is in the process of constructing a county drought preparedness plan, which could incorporate treated wastewater reuse. It is important to note that while most of the effluent is generated on the Sonoran side, the activities this project will carry out in Mexico will be limited to interaction with OOMAPAS and not directly with water users or the public.

Although wastewater is collected and effluent generated at the municipal scale, reuse is practiced on broader spatial scales and under more complex institutional arrangements. For example, in the Tucson metropolitan area, effluent generated by customers of several water providers, including Tucson Water (the City of Tucson’s water utility) is treated in facilities operated by Pima County. Rights to effluent are apportioned between Pima County, the water service providers, and other parties. Some effluent is treated further and distributed through Tucson Water’s reclaimed water system, which extends outside of city boundaries. The remainder of the effluent is discharged into the Santa Cruz River, where it supports riparian habitat along while recharging the aquifer in the northern, downstream portion of the Tucson Basin. Although the riparian vegetation along the Santa Cruz River is a significant natural amenity, the river itself has no in-stream flow rights, and entities that control effluent are permitted to divert it for other purposes. Meanwhile, municipalities downstream on the Santa Cruz River are already practicing indirect potable reuse, even if not by technical or institutional design. A particular innovation of this project is to address the complex institutional and technical interactions in support of sustainable water reuse.
Technical Approach

Objectives
This proposed applied research project aims to:
A. Partner with public utilities and water managers to inventory existing water reuse programs and document planning for reuse in the municipalities shown in Table 1.
B. Assess the variety of prevailing public attitudes on water reuse, especially as they relate to growth.
C. Identify both institutional restrictions and enabling conditions for the adoption of supply-substituting water reuse practices.
D. Improve understanding of the expected impact of different levels of water reuse adoption on future water demand and supply in the region.
E. Provide guidance on incorporating public input into water reuse planning.

Table 1. Growth-with-Scarcity Case Studies for Sustainable Water Reuse

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<th>Municipality</th>
<th>Growth drivers</th>
<th>Water management institutional context</th>
<th>Water reuse range of options</th>
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<td>Tucson, Arizona</td>
<td>U.S. internal migration, retirement lifestyle, new ‘tech’ job growth, representative of the ‘New West’</td>
<td>Separate city water company and county wastewater department, both holding rights to effluent, along with other parties; part of an Active Management Area (safe yield goal), historically enlightened public with influx of non-water savvy residents.</td>
<td>Turf, landscape, residential and non-residential outdoor use, industrial use, ecosystems, and indirect potable reuse</td>
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<td>Sierra Vista, Arizona</td>
<td>Ft. Huachuca the major employer, coupled with retirement lifestyle, relatively high degree of exurbanization, neighboring agricultural and ranching areas</td>
<td>Active watershed partnership, federally designated SPRNCA and mandated compliance to sustainable yield goals. Effluent for nature.</td>
<td>Ecosystems and turf</td>
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<td>Ambos Nogales, Sonora and Arizona</td>
<td>Border trade, maquiladora (assembly plants in Mexico), ‘security establishment’</td>
<td>Loosely coupled U.S. and Mexican water management (IBWC international wastewater treatment plant, NADBank projects), Santa Cruz AMA relying on Mexican effluent discharge (half of which derives from inter-basin transfer on the Mexican side). To treat and reuse within Mexico or not?</td>
<td>Landscaping, ecosystems, and indirect potable reuse</td>
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Activities

This study will undertake a set of activities with the purpose of characterizing and capitalizing on the opportunities for water reuse to offset growth-driven water scarcity, and identifying how growth-with-scarcity influences public attitudes towards different water reuse options. Following the sequence of the project’s five objectives, specific activities are as follows:

A.1. Complete a review of relevant literature—published and on the Internet—on water reuse in the Southwest, with a particular focus on Southern Arizona and the U.S.-Mexico border region, including global examples (e.g., Australia) that are relevant to this region.

A.2. Inventory existing reuse practices through interaction with water and wastewater utility managers, review documentation, and visit key facilities in Tucson, Sierra Vista, and Ambos Nogales; organize this information by completing Table 2.

A.3. Document the stage of water reuse planning in the three municipalities, with particular emphasis on the range of reuse options under considerations, motives for (financial, institutional, public perceptions) identifying these particular options, and perceived obstacles against other options.

Table 2. Format for Inventory of Existing Water Reuse Practices

<table>
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<tr>
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<th>Present volume of wastewater generated (MGD, AF/year), by treatment facility</th>
<th>Existing non-potable reuse (specify reuse type, year initiated, agency responsible)</th>
<th>Existing reclaimed water for ecosystem conservation (specify year initiated)</th>
<th>Existing indirect potable reuse (specify year initiated)</th>
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B.1. Characterize growth, water management, and water reuse in the communities as follows:
- Population levels and growth rates, educational levels
- Employment (specify major sectors), job growth rates, and income levels
- Average home prices, trends over time, percentage of homes owned vs. rented
- “Quality of life” uses of water – landscaping, pools and spas, lawns, sports fields, golf courses
- “Ecosystem” uses of water and perceptions on environmental quality
- Incorporation of drought and climate change in water management planning
B.2. Assess public perceptions on the range of water reuse options identified in A.2 and A.3 above through a combination of focus group meeting and semi-structured surveys in the three communities (limited to the Arizona side of Ambos Nogales), particularly through stakeholder forums including the Tucson and Santa Cruz Active Management Areas’ Groundwater Users Advisory Councils’ (GUACs), Tucson area “Community Conversation” meetings and the Upper San Pedro Partnership committees. While it will not be possible to sample a statistically representative population of water service customers given the level of funding available, the project proposes to sample a minimum of 200 respondents in each case study area through a questionnaire developed in coordination with water companies and distributed with water bills, or through other means. At each locale, the respondents will also be invited to participate in focus groups to further assess perceptions on the following issues that are central to growth and reuse:
   • Does the public perceive that water reuse (specifically indirect potable reuse) represents a decline in the safety of their environment or some kind of loss that needs to be compensated by the benefits reuse can provide?
   • Does the public perceive growth as positive or negative, and do they feel they have influence over it through exercising a vocal opinion on water reuse?
   • What institutions (organizations, agencies, the media, etc.) most strongly influence opinions on water reuse? How are attitudes towards reuse affected by other water management options (specifically stormwater recharge, rainwater harvesting, landscaping restrictions, agricultural use of reclaimed water, desalination, water importation)?
   • Does the public feel empowered to have an input into water management decisions? Is local government perceived as being responsive to citizens’ concerns over growth and water management and conservation?

B.3. Collaboratively identify opportunities for supply-substituting reuse practices with representatives of the water companies, the AMAs, the Upper San Pedro Partnership, the Bureau of Reclamation, and other water managers through an interactive review of the results of the questionnaires and focus group meetings, including any inequities among income or social groups.

B.4. As a measure of factors that shape broader public perceptions on water reuse options, conduct discourse analysis of newspaper coverage of water reuse in the three urban centers. This will entail collecting relevant news articles archived on the papers’ websites and/or from public libraries, characterizing the coverage as promoting or opposing growth, and identifying opinions on reuse as stemming from psychological, public health, or environmental concerns.

C.1. Identify and characterize the interactions among the principal institutions for the management of water, with particular emphasis on water reuse (on the Sonora side, this will be limited to the first four bullets below):
   • Laws and regulations
   • Active Management Area or other institutions that establish water management goals
   • Operational responsibility for water supply and reclaimed water
• State, county, and local agencies
• Non-governmental organizations
• Citizens’ groups

C.2. Assess the social and economic dimensions of growth and water reuse, with the aim of identifying restrictions and/or enabling conditions for the adoption of water reuse practices:

• Is the need to attract new development/jobs and its requirement for a reliable water supply important to residents? Does this correspond with the local unemployment rate or other economic indicators?
• Does the community have strong growth management ordinances that preserve residents’ quality of life despite population growth (building design standards, landscaping requirements, open space preservation policies, etc.)? Are these enforced?
• Are impact fees charged to developers that reimburse the community for the increased costs of providing transportation, education, and recreational facilities for additional residents?
• Are new residents required to implement rigorous conservation measures? Do these requirements extend to current residents?
• What is the community’s water supply outlook and the residents’ knowledge of this situation?

D.1. Link the results of water reuse planning (A.3.) and growth and water reuse (B.1.) to better understand the degree to which the planning process is adequately addressing growth-driven water scarcity and the full suite of options for reuse. Is reuse over-planned or under-planned with respect to expected growth? What are the opportunities to bring reuse more in line with growth?

D.2. Based on the results of D.1., assess public and agency priorities for water reuse (B.3.) combined with the social and economic dimensions of reuse (C.2.) in order to assess the expected impact that different water reuse options and levels of adoption are expected to have on future water demand and supply in the region. How essential is ambitious reuse planning to meet expected water demands? What are the principal obstacles or opportunities that need to be addressed? What are appropriate channels (utilities, elected leadership, organizations, the media, and/or public education) to enhance sustainable water reuse in the region?

E.1. Hold a workshop with key stakeholders (utility and municipal representatives, civil society, state and federal agency staff, researchers, and other stakeholders) to review results of the project, discuss lessons learned, and assess future options for water reuse in the region. The workshop will include a day-long field visit to reclaimed water facilities and reuse sites in and around Tucson, including Sweetwater Wetlands (based on effluent).

E.2. Finalize reports and publications: a) develop a guidance document on water reuse and growth for water managers in the three municipalities, and b) prepare and submit a research report to the WateReuse Foundation on the study’s findings and outcomes.
Management, Communication, and Quality Assurance Plans

The University of Arizona (UA) holds primary responsibility for project management including communicating plans, disseminating results, and ensuring overall project quality. The project PIs work in and across two UA units (Udall Center for Studies in Public Policy and the Department of Geography and Regional Development) that have a history of successful collaboration, including with all the major stakeholders in the three municipalities and Nogales, Sonora as listed in the proposal. Specific responsibilities by team member (and activity #) are as follows:

Christopher Scott – will provide overall project leadership as well as coordination among UA team members, participating utilities and water managers, the WateReuse Foundation, and other stakeholders. He will be responsible for the inventory of existing practices (A.2.), documentation of water reuse planning (A.3.), synthesis of planning and growth (D.1.), and assessment of future impacts (D.2.). Finally, he will lead the team’s efforts at the workshop (E.1.) and be responsible for the submission of progress reports and research outputs (E.2.).

Anne Browning-Aiken – will develop and lead activities to assess public perceptions on water reuse including preparing materials for meetings, conducting focus groups, and developing, administering, and analyzing the survey results (B.2.). Additionally, she will hold primary responsibility for the interactive review of the results of the questionnaires and focus group meetings with water managers (B.3.).

Robert Varady – will be responsible for the institutional analysis (C.1.) including the identification of restrictions and/or enabling conditions for water reuse adoption (C.2.), which will entail an important role for him in the assessment of future impacts (D.2.).

Graduate student research assistant – involvement in the project will contribute to Masters’ or Doctoral research. The research assistant will be responsible for the literature review (A.1.), characterization of growth and reuse (B.1.) including the questionnaire analyses using SPSS or other statistical regression tools (component of B.2.), and the newspaper discourse analysis (B.4.).
Schedule and Deliverables

The project implementation schedule by activity is shown in Table 3 (based on an August 1, 2007 start date). Project deliverables to be submitted to the WateReuse Foundation are indicated (QR# are the quarterly reports, and E.2. includes the guidance document and research report).

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Note: The proposed period of performance is August 1, 2007 – July 31, 2008.
Budget
See attached budget sheets in WRF format.

Qualifications, Resumes, Organizational Charts, Technical Resources, and other Supplemental Information
See attached, short (2-page) curriculum vitae for the three investigators. Several current and incoming (Fall 2007) graduate students in the Department of Geography & Regional Development would be highly suitable to work on this project; the research assistant would be identified from among these students, or from other relevant UA departments.

References
City of Sierra Vista, Arizona (2007).
http://www.ci.sierravista.az.us/Community%20Profile/facts.htm
http://cals.arizona.edu/AZWATER/publications/townhall/finalATHchapter4.pdf


