THE METROPOLITAN WATER DISTRICT *of* SOUTHERN CALIFORNIA

FINAL REPORT ON
STUDY OF LEGAL GREYWATER IRRIGATION

By ReWater Systems
ICP Agreement No. 124218

This is the Final report on the study of 12 greywater irrigation systems, other than any extended reports that are not pursuant to this ICP agreement. This report includes an analysis of the outcome of this study, in particular the water savings, wastewater treatment savings, net energy savings, lessons learned, cost effectiveness of greywater irrigation systems, and the feasibility of a MWD-wide greywater irrigation incentive program.

Analysis of the Outcome

This study determined that privately-owned and operated single-family and commercial greywater irrigation systems save water, reduce wastewater treatment costs, and conserve energy, all to varying degrees, year-round, mainly depending on the number of people in the building producing greywater and the size of the landscape being irrigated. This study also determined that filter performance is a factor in the degree of success of any particular system.

Water savings

As previously reported in more detail, the water savings from greywater irrigation results from two main factors: 1) reuse of the water, and 2) efficiencies from the mandatory underground drip irrigation. For the purposes of this study, we use the metered greywater that went out into the landscape, as that is an empirical number, and apply only the lowest known proven efficiency factor to it, which is 25%, as explained in more detail in an earlier report.

1. Reuse

Meters give us an undeniably quantified volume of water that is actually reused. An additional benefit of the meters is they turned out to help the lay person understand when maintenance on the system was required. As we see from the attached spreadsheet, the number of people in the building producing greywater, and the size of the landscape under greywater irrigation, remain the main factors in how much greywater was reused.

Those two main factors are not absolutely determinative however. The largest number of people living in a home (the Roberts' home in Alpine), which has a large greywater irrigated landscape, has only the second highest meter reading (6050 CF) of the single-family systems in this study. The Mayor's home in Topanga Canyon, with only 4 people living there, does not have a particularly large landscape, but has the highest meter reading. In talking with both owners, the only discernible difference in these two systems appears to be that the Mayor's filter system may be better maintained and able to pass more water through the filter. Mr.

Mayor is retired and reports that he regularly cleans out his filter. Mr. Roberts is a busy business executive who reports that he tries to remember to maintain his filter.

Interestingly, the smallest number of people living in a home (two, at the Small's home in Culver City), which has a small greywater-irrigated landscape, has the lowest meter reading of the single-family systems in this study, even lower than the clothes washer-only system of the Bilson family. This small amount of greywater use can be attributed somewhat to the small landscape at the Small's home but mainly to the tall trees providing shade over most of that property.

A landscape architect and I both talked with Mr. Small independently and we both came to understand that this shady home site simply does not require much irrigation water. In fact, Mr. Small feels it is slightly over-watered even with this small amount of irrigation. We checked the fresh-water connection to the system and the supplement valve is still unwired from the controller, so the greywater irrigation system can't receive any supplemental fresh water from the controller. There is no other irrigation system on site, the homeowner is not hand-watering with a hose, and the landscape if completely fenced in from the neighbors, so there are no other possibilities for water being applied to this landscape. Shade matters a lot.

At the three commercial systems, the size of the landscape still appears to be the deciding factor in how much greywater is being reused. All three of the commercial systems have large sources of greywater: System #12 is a 110-room barracks' shower, tub, and bathroom sink water irrigating 3,500 sq ft; System #15 is a 60-machine public Laundromat irrigating 12,700 sq ft; and System #17 is a 32-room multiple occupancy apartment building's laundry irrigating 9,450 sq ft. Each system has the potential to produce far more greywater than we're seeing recorded on the meters. The only logical explanation for these systems not using all the greywater that is available still seems to be that the landscape's irrigation demands are being met with less greywater than the buildings and their systems are capable of producing.

The accompanying spread sheet shows the water savings and its monetary values for each system. These savings have been determined by multiplying the volume of water used by the water rate.

2. Irrigation efficiencies

As explained in my earlier report, to quantify irrigation efficiency, we rely on the 1996 study by Dr. David Zoldoske at the Center for Irrigation Technology at the California State University, Fresno, which found that drip irrigation to be at least 25% more efficient than sprinklers. This translates into an efficiency multiplier of 1.25. We did not incorporate the efficiency savings into the financial calculations.

Sewer treatment cost savings

As explained in more detail in my earlier report, the meters on these systems measure only the greywater that is actually going out to irrigation. Each gallon of greywater going to irrigation is

thereby kept out of the sewer system, saving the sewer treatment plant operator the cost of treating that gallon. Therefore, the metered amount of greywater also directly indicates the volume of sewer treatment costs that have been saved.

As shown on the attached spread sheet and explained in my earlier report, sewer savings are a significant factor in the value of a greywater irrigation system. One viable incentive to support greywater irrigation would be to have the local sewer district reimburse the owners of the systems based on the metered greywater savings. Where a residential sewer rate is predicated on fresh water usage, as in most of California, when the greywater is reused and thus kept out of the sewer system, the owner of the system should not be charged for the treatment of that greywater. This is not a "subsidy", as the savings from these privately-owned and operated systems are presently being accrued by the sewer districts as windfall profits in violation of Government Code Section 66016 that prohibits a special district from charging more for a service than it cost the district to provide.

Energy cost/savings

As discussed in great detail in my mid-term report, the greywater irrigation process uses energy but that process allows a significant reduction in the energy consumption of any residence that would have otherwise relied on traditional irrigation. This savings is best indicated by the California Energy Commission's finding that 19% of all energy used in California goes to pumping water around this tall state. When we reduce that pumping by reusing water locally, savings from embedded energy reductions accrue. Those savings are quantified for each of these systems in the attached spread sheet.

Cost Effectiveness of Greywater Irrigation

To understand the costs and savings factors of any particular system, we compiled all the empirically known costs and calculated the savings benefits for that system. Those savings are shown for each of these systems in the attached spread sheet.

No matter what the system cost the owner, all the water, wastewater, and energy savings accrue. However, not all of those savings currently accrue to the owner. Some of the retail water savings accrue to the owner, as they don't have to buy so much water for irrigation. However, other savings accrue to the retail water seller. The wholesale water savings accrue to the MWD and San Diego County Water Authority (if the system resides in both jurisdictions), from reduced pre-treatment and infrastructure O&M costs. The wastewater savings accrue to the sewer treatment plant operators, from having to treat less sewage. Similarly, the water's embedded energy savings accrue to the water retailer and wholesaler, and sewer treatment district. The run-off prevention savings accrue to the state, or to the builders who are able to capitalize on this advantage in their planning applications.

The $700 clothes-washer-only system at the Bilson residence (System 16) provides the same type of water, wastewater, energy, and pollution prevention benefits as the $4,000 single-family system at the Mayor home (System 20), the $4,000 single-family residence systems at

Systems 8, 9, 10, 11, 14, 18, and 19, the $5,000 systems #12 and 13 at the Navy base, the $12,000 commercial laundry system #15, or the $15,000 apartment laundry system #17. The only difference in all those systems is the amount of greywater that is reused, thus the amount of savings from that reuse. Because there is no absolute way to tell how much greywater will be reused by any system, due to various landscape dimensions, plant selection, climate type, soil type, the varying number of people indoors producing greywater, and the landscape irrigation practices on site, there is no way to accurately predict the amount of reuse from any system. Thus, there is no way to accurately assign a cost/benefit ratio to a "generic" greywater system. The only way to know how much any particular system is producing in savings is to have a meter on the greywater that is being reused and to reimburse for the values of that quantity of water based on the selling price of that water.

Not all system owners reported an expectation of a fast pay-back period. In the case of the Laundromat, the owner expressed his belief that his system, the most expensive in the group studied, would eventually pay for itself and return a profit in a reasonable time. In Chula Vista where that Laundromat system is located, water rates have risen from $1.90 per Unit in 2003 to $5.21 per Unit today, which helps to off-set even the $4,500 in repairs and modifications he recently had to make to the system when the filter vessel blew its top and stripped out the vessel's threaded opening for that top.

If all the water, wastewater, energy, and run-of pollution values were reimbursed by the various agencies that currently accrue those values, the benefits of greywater irrigation would far outweigh the capital costs of the systems. I again note that the run-off pollution prevention value of using greywater in underground drip irrigation and thus leaving the surface dry to catch the initial run-off debris of a rain event has not been quantified in this study, and that value is substantial. For new home builders seeking to satisfy California's stringent new run-off prevention laws, that value alone could more than pay for the entire system.

LESSONS LEARNED

Fiberglass Filter Deterioration

At the 60-machine Laundromat in Chula Vista, the pressurized fiberglass sand filter vessel had a mechanical failure this final quarter, as the lid partially blew out of the fiberglass body of the vessel, stopping part way out of the threaded opening, lodged into place cock-eyed. The explosion stripped the threads of that vessel, which are needed to hold the lid correctly in place. Once the fiberglass threads are stripped, those vessels have to be replaced. So, we replaced it.

Pictures are attached of this replacement process. It took a truck-mounted crane to lift the 800 pound sand-filled filter vessel out of the underground concrete vault in which it had resided for approximately 9 years. This process resulted in the second period of down-time in this study for that system.

Upon close analysis and after many discussions with the maintenance foreman about that filter, we believe the threads of the fiberglass filter vessel probably became worn from years of screwing the lid on and off for cleaning the sand, when bits of sand would remain in the threads that are molded in the interior lining of the fiberglass filter vessel. Over time, the threads became sanded down enough that eventually they could not hold the pressure and the lid popped. The obvious solution is to insure there is absolutely no sand in the threads before closing the lid, which can be accomplished by carefully washing the threads out with a garden hose, which was made available during the original construction in 2003 and which has remained available. However, because less skilled workers clean the sand in the vessel, and they can't be counted on to always clean out 100% of any sand in the threads, a preventative solution was deemed necessary.

A pre-filter was created for that system that should allow for less opening and closing of the sand filter vessel over the years. Please view the Youtube video titled "ReWater Filter Repair". That pre-filter consists of an aluminum frame with a cage for a removable polyethylene 300 mesh bag to capture the large debris routinely found in this system's greywater (hair, small sticks, pieces of fabric, bra underwires, small buttons, small legos, and other small plastic pieces of toys, etc.) before the greywater enters the greywater tank. That bag is periodically lifted out of the tank, emptied, and the debris put in the garbage. Please view the Youtube video titled "ReWater Filter Bag Replacement".

Preliminary estimates are that 3-4 months might be the appropriate interval for emptying this bag due to the weight of material being collected and the ease of lifting a light bag out the riser of the buried tank, though the bag is certainly large enough to collect many times that much debris. The next decade will tell if this pre-filter serves its purpose of reducing the frequency of sand cleanings and thus openings and closings of the filter's lid.

On the other systems in this study that use filter bags to remove all the solids in greywater (Systems #16 and #20), it is understood by the owner that the bag must be periodically cleaned or replaced. While such routine maintenance is considered a chore, it is certainly not nearly the chore that replacing a filter vessel proved to be. In a commercial system, bags would need to be changed every week or so, which is felt to be too much maintenance for practical purposes.

Non-Owner Accountability

Despite three trips to San Diego to visit the 32nd Street Navy Base systems for meetings with the general contractor who built the new barracks, and the Base's maintenance personnel, and the Navy Facilities Command (NAVFAC) personnel who oversaw the design and construction of the barracks, and the plumbing company that installed the filter systems, and the electrician who wired the controllers for the systems, and the landscape contractor who installed the irrigation systems that are attached to the filter systems, and despite countless phone calls and emails regarding all of those visits and interactions, one of those two brand new systems never got completely finished and thus never became operable.

As carefully documented in the presence of all involved including the correct Navy and government personnel each time, the only problem at that inoperable system was that the landscaper had installed a faulty irrigation valve common wire from that one system to the valves out in the landscape a couple hundred yards away and refused to locate the fault in that wire and repair it. The Navy personnel became so frustrated with the entire situation that they wanted me to repair the problem, but working on a problem in a buried system that others installed and yet others are responsible for opens up a can of liability worms and I had to decline. I placed numerous calls into NAVFAC to try to get somebody to override their on-site personnel's reluctance to make the landscape contractor simply repair his shoddy work but have learned that getting somebody in government to correct somebody else in government is a very time consuming process. The retirement of the original NAVFAC construction supervisor didn't help either.

In my 23 years in this business, it had always been possible to get an owner to relatively quickly direct their employees and/or contractors to take required actions. This is the first time I've experienced what it's like when there is essentially no owner accountability to rely on. An incentive program for greywater irrigation would ideally include covenants that the greywater irrigation system would actually operate, and a periodic escalating meter reading could serve as empirical prove of that operation. That reading would not have to occur very often, maybe annually. When a system went off line, the owner could be notified and maybe required to reimburse the incentive if repairs were not made.

Kitchen Greywater

All versions of the state greywater code prohibit kitchen water from being included in a greywater system because of the possibiity of dangerous pathogens such as salmonella, botulism, and ecoli entering the soil and somehow being ingested by humans. What ReWater has known and warned of since 1990, but what we only learned firsthand during this study due to System #11, was that the greases in kitchen greywater make it through even sand filters to travel downstream into the underground drip irrigation system to combine with the microscopic solids and minerals in greywater to plug up even ReWater's large 12 GPH emitters.

While there's still the possibility that injecting sulphuric acid under high pressure into the irrigation lines on System #11 might dissolve that type of greasy clog and thereby rejuvenate those emitters, I spent dozens of unpaid hours trouble shooting and rebuilding that system from the pump onward and I finally had to cut my losses when the time-consuming acid wash scenario seemed the only remaining possibility for resusitating that system. Sulphuric acid helps plant life, so when diluted with water immediately after the injection, the process actually helps the plants.

Feasibility of a MWD-wide Greywater Irrigation Incentive Program

As explained above, greywater irrigation provides numerous benefits/values from water reuse, irrigation efficiency, decreased wastewater treatment, energy savings, and though not as fully

explained in this study, run-off pollution prevention. Those values accrue to various entities, and the majority of those values go to other than the entity that paid for the system. This discussion necessarily focuses on how to get those values into the hands of the owner that paid to create them.

Presently, many of the water values accrue to all those who sell water. That includes wholesalers such as the Metropolitan Water District of Southern California and the San Diego County Water Authority (SDCWA), and any of their member agency retailers. It is well known that these wholesale and retail water agencies participate in mutually funded incentive programs for various types of water conservation and reuse programs.

These programs typically rely on a finding of the value of the reused water, such as in Title 22 Tertiary Disinfected water used for cooling towers and irrigation, known as "recycled" water, or on the expected value from a particular method of conservation, such as a low-flow shower head or toilet. When the water is simply sold, as in recycled water, the value is shown as a price per gallon, or Unit (100 cubic feet or 748 gallons), or acre-feet (AF). When water is expected to be conserved, the device has a monetary value assigned to that conservation.

As mentioned, due to various landscape dimensions, plant selection, climate type, soil type, and the varying number of people indoors producing greywater, there is no way to accurately predict the volume of reuse from any particular greywater irrigation system, whether a single-family system or a commercial system. So a hard number (such as 25% for a low-flow shower head compared to an old-style shower head), can't logically be assigned to a greywater irrigation system, though a "ball park" estimate could be made. Only a water meter can tell us how much water has been reused at any system; any incentive program would probably need to recognize that fact.

The object of any incentive program is that it accomplish the goals of the agency that established the program. It is assumed here that an incentive program is to encourage greywater reuse. As with any capital project, 100% of all the system's costs must be incurred by the owner upfront before a drop will be reused. Therefore, the most likely incentive to encourage the installation of greywater irrigation systems would be an upfront payment program or a program that at least quickly reimburses the owner for their investment in a greywater irrigation system. This could be a voucher type program, where the owner receives a reimbursement after installation of the system for some or all of their investment in anticipation of their savings, metered or not.

Another possible type of incentive program would be one that reimbursed the owner for some or all of their investment in the system as the savings accrue over time. This type of incentive program would be less desireable for three reasons. First, it would delay the owner's feeling of having done the right thing at the only time most owners can install a system, when they need money most, during construction. Second, it would require the owner to expend their own capital to save other entities money in the future, which however could be compensated for by those entities increasing the reimbursement to the owner as their savings from the system

become more valuable over time due to inflation. Third, It requires that somebody read the meter over time, which by ltself costs something, though the meter could be read during a regularly scheduled potable water meter reading. Where a water district has installed remote digital read-out meters on their potable service lines, a greywater meter reading would be a nominal additional cost that could be subtracted from the reimbursement.

An incentive program that combined an upfront incentive to take the bite out of the initial cost of installation, with a metered savings reimbursement, perhaps via an annual reduction on thr ccustomer's next water bill, would make sense too.

Most importantly, a greywater irrigation system incentive program should include proportional reimbursements from all the agencies that reap the rewards of greywater irrigation systems. These include the various levels of water agencies as discussed above but also the wastewater treatment agencies that are currently reaping windfall profits from greywater irrigation systems. Wastewater treatment savings from greywater irrigation systems are as large as the wholesale and retail water savings combined and are too important to be left out.

The only real argument from some wastewater agencies against a greywater irrigation incentive program has been that they have no way of knowing how much greywater has been reused, thus how much money is at stake. With a meter, they will get that data. That fact leaves them with the choice of choosing to incentivize upfront or over time, or a combination of both, just like with water agencies.

A greywater irrigation system incentive program should also include monetary recognition from some entities in the energy supply business. Currently, PG&E, Sempra Energy, and other energy providers have programs that incentivize flourescent light bulbs and Energy Star® appiances. Their icurrent ncentive programs pay for the anticipated upfront value of the device.

The ultimate greywater irrigation system incentive program would combine all the water, wastewater, energy, and run-off prevention savings. Run-off prevention values vary basically according to the system's proximity to the coast. The closer the system is to the coast, the more valuable the system becomes. Homes in California typically within 3 miles of the coaqst have very stringent run-off prevention rules imposed by the Coastal Commissioin and/or the local Reggional Water Quality Control District. The Building Industry Association testified all the way up to the State Supreme Court when protesting the new run-off prevention rules that the new rules cost each new home bound by them about $20,000.