# The Cannery Greywater Reuse Analysis

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**Abstract**

Greywater reuse systems can now be feasibly implemented in various urbanization plans as a sustainability measure to conserve water across California. The recent approval of these systems can help reduce the demand for potable water. Greywater systems can now be incorporated in new development projects, including The Davis Cannery Project, a 120 home mixed-use development under construction in the City of Davis, California as a measure to reduce water usage.

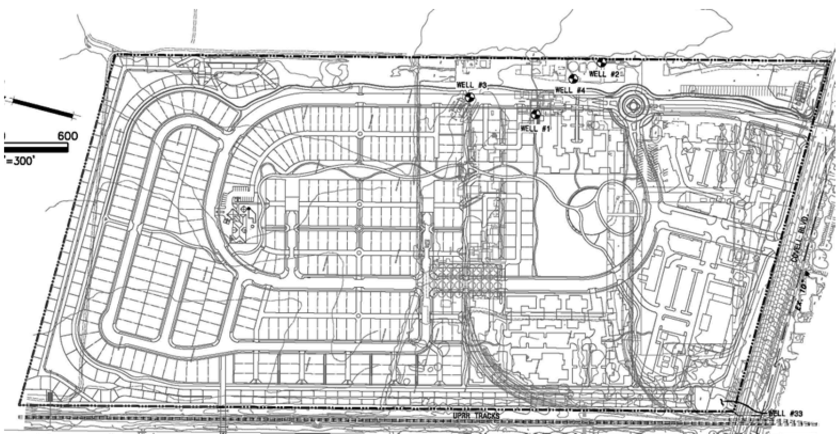
To determine the feasibility and the overall benefits of conserving water over time, we ran a cost-benefit analysis of implementing a greywater plumbing system at The Cannery Project. We calculated how much greywater we would be able to get from each household and then compared this to the amount of water that would be required to irrigate the open spaces in the community. We considered the construction and material costs of building complex and household greywater systems, as well as the benefits from water savings, in addition to other factors.

The Cannery Project can be used as a case example of how new development projects can reuse water with greywater systems. Sustainability measures like these will become more crucial in attaining adequate water demand, especially under the recent drought conditions in California.

**Introduction**

Given recent drought conditions, conserving water is a top priority in California, especially when new developments are being built requiring more water use. The Cannery Project will integrate housing, greenbelts, urban farms, and other land uses on the location of the old Hunt-Wesson Tomato Processing Operation, which shut down in 1999 (City of Davis, 2015). The project plan currently proposes to use an agricultural well to supply the area with non-potable water (DeNovo Planning Group, 2015). Figure 1 below shows a map overview of the project.

Figure 1: The Cannery Project




This feature of the project is expected to reduce potable water usage by an estimated 28%, according to data found in a public comment from the Cannery's Environmental Impact Report (DeNovo Planning Group, 2013). However until one of the agricultural wells is remediated, potable water from the City of Davis will be used to irrigate landscape and agricultural features. The developers plan to require efficient water infrastructure, however the sustainability of this project could be further improved through the implementation of a greywater system that will recycle used household water for irrigation of the parks, greenbelt and urban farm that the Cannery plans to create. Not only will this reduce water demand for landscaping at the Cannery, but it will also increase the long-term security of the aquifer.

It is very important for California to focus on saving water, especially now that we are experiencing our fourth consecutive drought year. Because of the significant quantity of water that California requires to maintain a healthy population, environment, and economy, groundwater usage becomes increasingly more important and heavily relied upon when there is less surface water available. The reduction in surface water leads to groundwater overdraft, which reduces our water sustainability because water is being used faster than it can be recharged. This overuse of groundwater also adds to the problem of land subsidence, which can damage buildings, wells, and other infrastructure. It also can increase the potential of flooding, and because it is irreversible, it reduces the capacity for future groundwater storage, reducing long-term water security. Implementing a greywater reuse system at the Cannery can help lessen these problems by reusing water, which reduces the amount that must be removed from Davis' groundwater resources.

Greywater reuse systems collect water from household sources such as the sink, shower, and washing machine. They do not use toilet water for sanitary reasons and occasionally avoid some sources of kitchen water. The used water is then brought through pipes, where it may be filtered or treated, and would then travel or be pumped out into irrigation pipes. The water must be released slightly underground to reduce runoff and to allow chemicals to be filtered out in the soil.

Support for current greywater reuse in California gained ground in 1989 in Santa Barbara, CA and became adopted as part of the Uniform Plumbing Code in 1992. In 2014 the California Graywater Policy Information Center estimated that two million greywater systems were in use California and that only a small fraction, perhaps 1 in 10,000 of these have been installed legally. In 2009, lawmakers approved changes made to the 2007 California Plumbing

Code, Title 24, Part 5, Chapter 16A, Part I – Nonpotable Water Reuse Systems (Cohen, 2013). In this code three standard types of greywater systems have been defined and the process for local planners to approve new systems has been greatly streamlined. The three types of systems are: laundry only (no permit required), up to 250 gallons per day (permit required), or over 250 gallons per day (permit required) (CPC, 2007). Local jurisdictions can make the requirements more restrictive, however the City of Davis has decided to implement the State standards (Residential Graywater Systems, 2009).

Greywater has several pros and cons. It can lower water use per capita by about 17 gallons per day (GPD), which adds up to almost 15,000 gallons per year for the average household (2.35 people) (Greywater Action, 2015). Water reuse can help us cut back on how much we use, reducing problems such as groundwater overdraft and land subsidence. This also helps lower monthly water bills and reduces the likelihood of chemicals getting into streams and lakes because water goes into the soil where it is filtered instead of going through the sewer (Greywater Action, 2015).

However, there are a few downfalls to greywater systems. They can be costly to implement and their materials such as pipes and pumps have an environmental impact to produce. Additionally, the water is only safe for plants in the long run if residents avoid the use of sodium and boron products, which requires compliance (Greywater Action, 2015). Lastly, greywater cannot be stored for more than 24 hours, or else bacteria can build up and contaminate the water (Greywater Action, 2015). Despite these shortcomings, greywater systems are a great way to reduce water consumption. Although they cannot be used everywhere due to bad soil, weather conditions and various regulations, given the correct circumstances and good implementation, the greywater systems are a very effective way to cut back on water use. A greywater system would help reduce the Cannery's impact on the environment and water resources, which is why we ran a cost-benefit analysis to determine if it would be beneficial with factors such as financial cost considered.

**Objective**

The main goal of this project was to analyze the costs and benefits of including a greywater system in The Cannery Project as a way to conserve water. We ran a cost-benefit analysis that factored in several inputs. We used the water use per capita (WUPC) from the draft Environmental Impact Report and calculated how much greywater could be realistically obtained from each household. Then, we compared this to the demand for non-potable water that would be required to water the open spaces in the community. We also factored in the cost of water in Davis to help determine the amount of money that the greywater system would save. After running the cost-benefit analysis we were able to produce a chart of our incremental evaluation and a table comparing the costs and benefits of the different alternatives. The results of these data led us to conclude that implementing a greywater system in the Cannery would be a beneficial action. The numbers and details behind this data are presented below.

**Hypothesis**

We hypothesized that by running a cost-benefit analysis, we could prove that reusing greywater in the Cannery, a large mixed-used development, would be a feasible and cost-efficient way to conserve water.

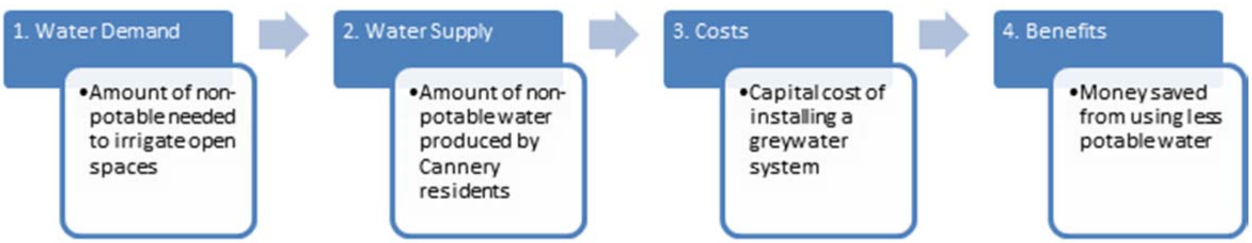
**Data Sources**

From The Cannery Project's Draft Environmental Impact Report (EIR), we acquired data about the population, WUPC, acreage, and water demand. We gathered different estimates for the daily amount of non-potable water produced by one person from the CA Department of

Water Resources, a study by Cahill et al., and a 2012 UC Davis study of Individual Household Water Consumption by Maisie Borg et al.

We gathered product information about a complex greywater system, GreyLink™, from their website. This site provided us with maximum inflow rates, storage capacity, and costs of the system. Information for household system costs was acquired from greywateraction.org.

Legal information was acquired from the California Plumbing Code, California Graywater Policy Information Center, and the UCLA Institute of the Environment and Sustainability.




**Methods and Assumption**

**1. Water Demand (determine the non-potable water demand)**

The draft EIR for the Cannery states that the *total non-potable water needed* to irrigate open spaces was 140 AF/year. This was derived by multiplying the irrigable area of 32.5 acres by the water use of 4.3 AF/acre/year (De Novo Planning Group, 2013).

**2. Water Supply (determine the non-potable water supply)**

Subsequently, we determined if the expected residents (1,500 people) could supply the necessary non-potable water (De Novo Planning Group, 2013). Each of the four greywater systems would derive water from a different set of appliances, so we determined four values for greywater production. For each system, we multiplied the population by the amount of greywater produced per capita per day, which we then converted to AF/year.

Complex system:

Daily greywater produced per capita for the complex system was an averaged value from two estimates—40 and 30 gpd (Wilson et al., 1995; Cahill et al, 2013). Thus, 35 gpd per person multiplied by 1,500 people produces a *daily total greywater production* of 52,500 gallons, or 59 AF/year.

Household systems:

Data from the 2012 Borg et al. study on three Davis households were averaged to find per capita daily percentage usage estimates of high-efficiency appliances.

**3. Costs (determine the costs of a greywater reuse system)**

Complex System:

From the GreyLink website, we determined that the High Debris Load (HDL) Series system would be best for the Cannery project due to its large size. Each system has a storage capacity of 390 gallons and a maximum inflow rate of 60 gallons per minute (gpm). We rounded up the cost of the system to be $19,000. Additional reservoir expansions, with a storage capacity of 165 gallons, sell for $1,500. An unlimited amount of expansions can be attached to a greywater processor (GreyLink, 2015).

First we compared the maximum inflow rate of an HDL Series processor to the peak-hour water demand (1125 gpm) of the Cannery (De Novo Planning Group, 2013). Dividing 1125 gpm by 60 gpm, we concluded that a minimum of 19 systems were needed.

Then, since greywater cannot be stored for more than 24 hours, we determined the necessary reservoir expansions needed to accommodate the daily greywater demand of the Cannery (52,500 gpd) (De Novo Planning Group, 2013). The 19 processors alone would hold 6,840 gallons. The remaining amount (45,660 gallons) would be divided among 277 165-gallon reservoir expansions. The 227 expansions would be distributed equally among the processors, thus each of the 19 HDL series processors would need 15 reservoir expansions. At the aforementioned prices of $19,000 per processor and $1,500 per expansion, the *total cost* for the entire system amounts to $788,500.

<u>Household System:</u>

The prices for an average system were found from greywateraction.org, a website promoting the water savings of greywater reuse. Using these estimates and multiplying by the number of units gave a cost estimate.

**4. Benefits (determine the benefits of saving potable water)**

The City of Davis provides yearly water rates, which are projected to increase over the next years. We multiplied the annual greywater produced by the yearly water rates of potable water. Hence, we determined the *ten-year average financial benefits* gained from reducing the demand of potable water.

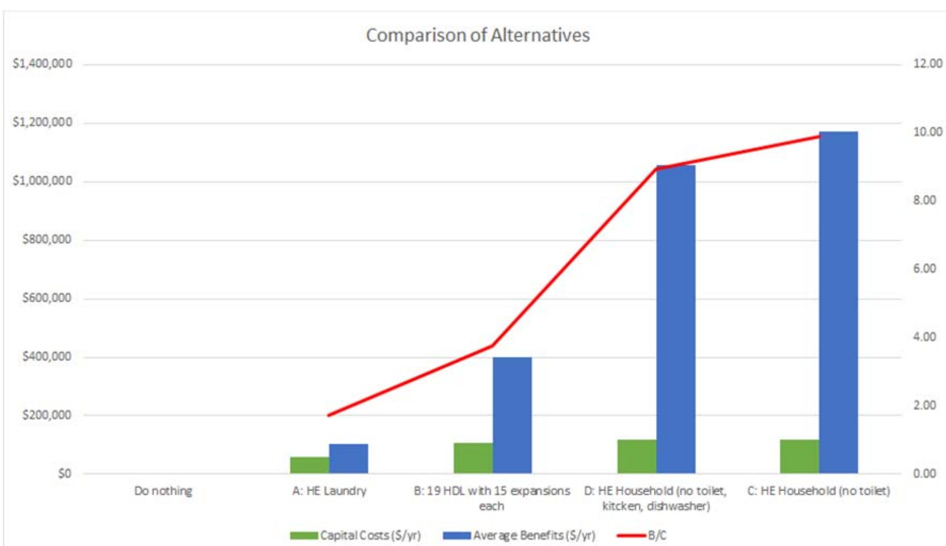
**Calculation/Results**

<u>Figure 2:</u> Incremental Cost-Benefit Analysis

| Compare | Project | Water Saved (AF/yr) | Average Benefits ($/yr) | Capital Costs ($/yr) | B/C | Change in B | Change in C | Change in B/Change in C | Decision |
|---|---|---|---|---|---|---|---|---|---|
| | Do nothing | 0 | $0 | $0 | | | | | |
| 0 -- A | | | | | | $102,122 | 59,103 | 1.73 | A > 0 |
| | A: HE Laundry | 15 | $102,122 | $59,103 | 1.73 | | | | |
| A -- B | | | | | | $299,559 | $48,029 | 6.24 | B > 0 |
| | B: 19 HDL with 15 expansions each | 59 | $401,681 | $107,132 | 3.75 | | | | |
| B -- C | | | | | | $769,321 | $11,073 | 69.48 | C > B |
| | C: HE Household (no toilet) | 172 | $1,171,001 | $118,205 | 9.91 | | | | |
| C -- D | | | | | | -$112,602 | $0 | ---- | C > D |
| | D: HE Household (no toilet, kitcken, dishwasher) | 155 | $1,058,399 | $118,205 | 8.95 | | | | |

For our final results, we performed an *incremental benefit-cost analysis* to determine which, if any, greywater reuse system was the most cost-effective. In order to do so, we annualized all the costs and benefits over a ten-year period with a 6% interest rate. We ordered the 5 alternatives by increasing costs to compare only two alternatives at a time. If the change in benefits divided by the change in costs was greater than one, the more expensive alternative was the preferred alternative. This method was repeated for all of the alternatives. Figure 2, shown above, summarizes these results. Figure 3 below shows yearly costs and benefits and in red a benefit-cost ratio. This illustrates graphically the annual benefits associated with each alternative. However, the data presented in Figure 2 was used to draw our conclusion. We found that the household system that reuses greywater from all high-efficient appliances except toilets is the most cost-effective strategy.

<u>Figure 3:</u> Comparison of Alternatives



Based on our research and calculations pertaining to implementing a greywater system at the Cannery, we can conclude that our hypothesis was true. Our analysis indicates that implementing a greywater system on a per household basis has the greatest benefits. Given the current water situation in California, water savings methods are encouraged. As such our research suggests that greywater systems should be considered as both a water conservation measure and a cost savings improvement. The economic viability of such a system can provide developers and homeowners an incentive to include greywater systems. This has the benefit of reducing water demands and could reduce aquifer drawdown and associated subsidence issues. In a system where surface water is used, the loss of ecosystem services from the wasteful use of water could be mitigated by the installation of greywater systems. In summary, greywater systems provide a simple way to save money, improve ecosystem services, and reduce water use to meet California's 2016 25% water reduction mandate.

**Recommendation/Limitations**

Based on the results of our cost-benefit analysis, we recommend that The Cannery Project implements a greywater reuse system. The agricultural well can be used as a backup system if there is not enough greywater available to irrigate all of the agricultural and green areas. Despite this conclusion, there are a few limitations to our calculations and analysis. Time constraints and data availability proved to be the biggest challenges, which made it difficult to gather reliable data. However, we did our best to estimate accurate costs and benefits using the data that was available to us. These included the costs of implementing and maintaining a greywater system and the amount of water and money saved by each person from reuse, among other values. Furthermore, we were unable to monetize some of the qualitative benefits of reusing greywater in our analysis, such as reduced land subsidence. Despite these data issues, we still believe that a greywater system would be beneficial to the Cannery given the overwhelming amount of benefits compared to the costs.

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