CITY OF MORGAN HILL

2015

RECYCLED WATER FEASIBILITY EVALUATION

Draft

November 2015

AKEL ENGINEERING GROUP, INC.

MWH

Morgan Hill Recycled Water Feasibility Evaluation

Table of Contents

1 INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

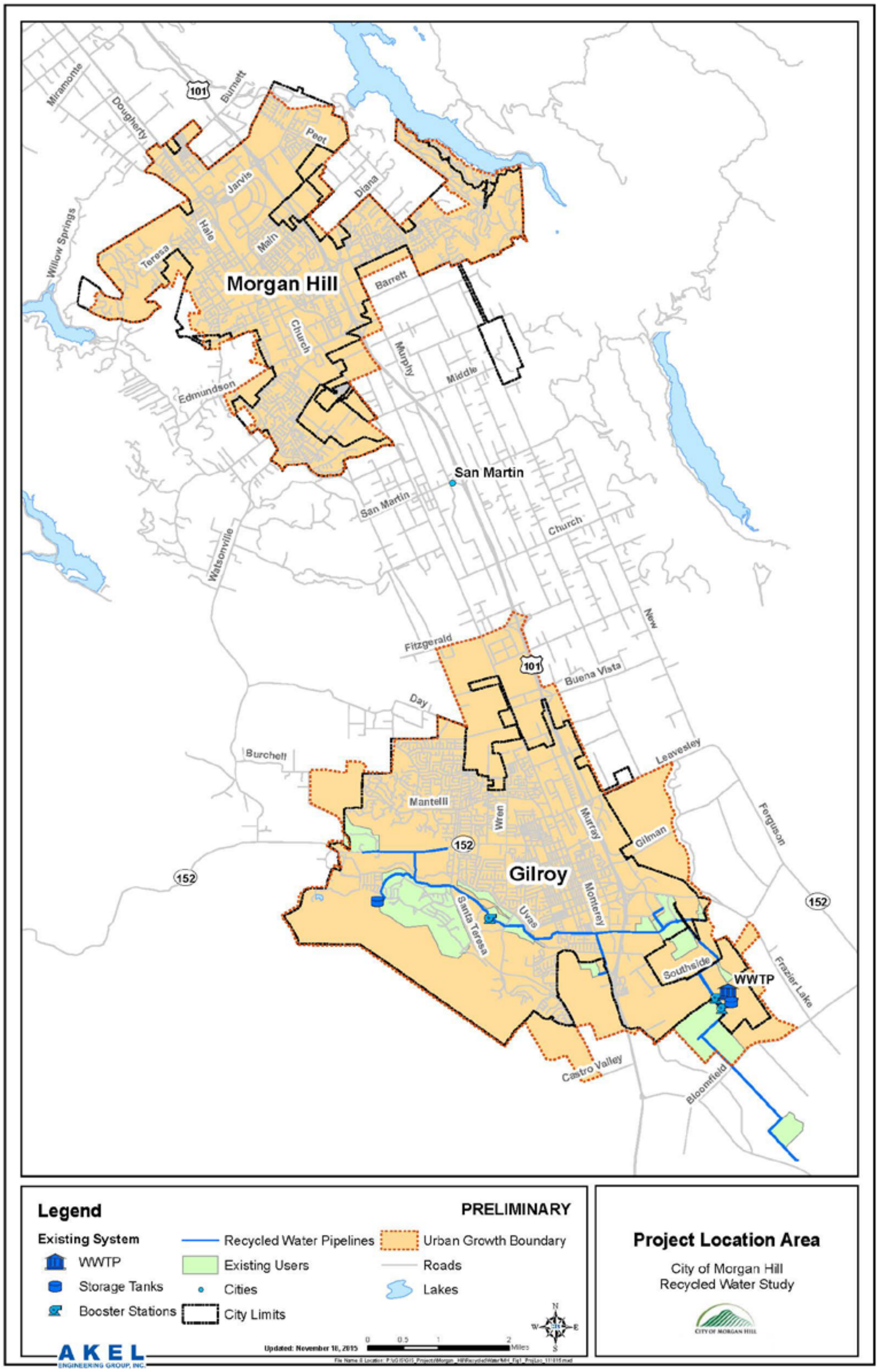
The City of Morgan Hill (Morgan Hill) is exploring options for expanding the use of recycled water, from the Gilroy Wastewater Treatment Plant to Morgan Hill, in order to offset demand for potable water and meet the City's long-term water supply needs. Recycled water is highly treated wastewater treatment plant effluent that can be used in various applications. Recycled water can serve as a reliable water source for non-potable applications and a source of water for groundwater recharge. Increasing the utilization of recycled water improves the resilience of the City's water supply by reducing dependence on groundwater aquifers and imported supplies.

Four project alternatives to increase the utilization of recycled water in Morgan Hill have been identified. Potential recycled water customers were identified and prioritized to develop potential recycled water distribution systems for each alternative. The purpose of this report is to evaluate the feasibility of each alternative recycled water project. This evaluation is being prepared in coordination with the 2015 Santa Clara Valley Water District Master Plan Update and the results will also be reported there.

1.2 STUDY AREA

This report evaluated recycled water alternatives for Morgan Hill. The wastewater treatment plant serving Morgan Hill is the South County Regional Wastewater Authority (SCRWA) wastewater treatment plant (WWTP) located South of Morgan Hill, in the City of Gilroy. In a partnership agreement between SCWRA and the Santa Clara Valley Water District (SCVWD, the District), effluent from the SCRWA WWTP is treated to meet California recycled water standards and distributed to 14 existing customers. Due to the location of the WWTP, the existing recycled water system is located within the City of Gilroy and serves customers in areas surrounding the WWTP. Figure 1 shows the location of the WWTP, the City of Gilroy, and the City of Morgan Hill.

Figure 1: Project Study Area



1.3 MARKET ASSESSMENT

The market assessment identified potential recycled water customers in Morgan Hill. These potential customers are documented in Table 1 and shown in Figure 2. Using the same criteria as the 2015 SCVWD Master Plan Update each potential user was ranked based on the following criteria:

- Year Round/seasonal Use and High/Low Demand
- Flexibility of Water Usage/On-Site Storage
- Proximity to the Baseline System
- Level of Interest /Water Quality
- Capital, Construction, and O&M Annual Costs

The evaluation categories are described on Table 2. The results of the prioritization are documented on Table 3. This table includes two rankings; one that includes the costs of constructing a new recycled water transmission main to Morgan Hill and the other that excludes the Morgan Hill transmission main cost. The total scores range from 15 to 9 with the Morgan Hill transmission main cost and from 16 to 9 without. In comparison to the Gilroy customer rankings that range from 25 to 10 as documented in the 2015 SCVWD Master Plan Update.

Table 1: Potential Recycled Water Customers

PRELIMINARY

Site No.	Site Name	Usage Type	Hours of Operation		Peaking Factors		Usage Estimates		Recycled Water Demand Estimates		
					Maximum Month Demand	Maximum Day Demand			Maximum Month	Maximum Day	Peak Hour
			(period)	(hrs)			(AFY)	(gpm)	(gpm)	(gpm)	(gpm)
M-1	Ann Sobrato High School	Irrigation	10PM-7AM	9	2.0	2.7	84	52	104	141	375
M-2	Morgan Hill Growers	Irrigation	24HR	24	2.3	3.3	78	48	61	85	85
M-3	Park	Irrigation	10PM-7AM	9	2.0	2.7	3	1	2	3	9
M-4	Morgan Hill Orthopedics & Sports Medicine	Irrigation	10PM-7AM	9	2.0	2.7	78	49	97	131	350
M-5	Park	Irrigation	10PM-7AM	9	2.0	2.7	12	7	14	20	52
M-6	Park	Irrigation	10PM-7AM	9	2.0	2.7	5	3	7	9	24
M-7	California Color Growers LLC	Irrigation	24HR	24	2.3	3.3	141	87	216	285	285
M-8	[illegible] Elementary School	Irrigation	10PM-7AM	9	2.0	2.7	21	13	25	35	94
M-9	PA Walsh Elementary School	Irrigation	10PM-7AM	9	2.0	2.7	17	11	21	29	77
M-10	Central High School	Irrigation	10PM-7AM	9	2.0	2.7	5	4	7	10	27
M-11	Park	Irrigation	10PM-7AM	9	2.0	2.7	7	5	9	13	35
M-12	Park	Irrigation	10PM-7AM	9	2.0	2.7	10	6	13	17	46
M-13	Park	Irrigation	10PM-7AM	9	2.0	2.7	8	5	10	13	36
M-14	Park	Irrigation	10PM-7AM	9	2.0	2.7	3	2	3	4	11
M-15	Jackson Elementary School	Irrigation	10PM-7AM	9	2.0	2.7	11	7	16	22	58
M-16	Park	Irrigation	10PM-7AM	9	2.0	2.7	10	6	12	16	43
M-17	Nordstrom Elementary School	Irrigation	10PM-7AM	9	2.0	2.7	17	10	21	28	75
M-18	St Catherine's School	Irrigation	10PM-7AM	9	2.0	2.7	14	9	17	24	63
M-19	Morgan Hill Community and Cultural Center	Irrigation	10PM-7AM	9	2.0	2.7	22	14	27	37	99
M-20	Morgan Hill Community Park	Irrigation	10PM-7AM	9	2.0	2.7	70	44	87	118	314
M-21	Nursery	Irrigation	24HR	24	2.3	3.3	40	25	63	83	83
M-22	Coyote Valley Nursery	Irrigation	24HR	24	2.5	3.5	53	33	83	116	116
M-23	Valley Orchids Inc	Irrigation	24HR	24	2.5	3.5	67	42	104	145	145
M-24	Hoo Gee Nursery	Irrigation	24HR	24	2.5	3.5	65	40	101	141	141
M-25	Hung's Nursery	Irrigation	24HR	24	2.3	3.3	37	23	57	79	79
M-26	Kajike Nursery	Irrigation	24HR	24	2.3	3.3	149	93	231	324	324
M-27	Institute Golf Course	Irrigation	9PM-7AM	10	2.0	2.7	494	307	324	542	2,021
M-28	Gobilan Growers	Irrigation	24HR	24	2.3	3.3	13	8	20	28	28
M-29	Farmer's Market	Irrigation	7AM-1PM	6	2.0	2.7	4	2	5	6	26
M-30	Greenfield Nursery	Irrigation	24HR	24	2.5	3.5	70	43	108	151	151
M-31	Lakeside Nursery	Irrigation	24HR	24	2.5	3.5	19	12	29	41	41
M-32	Paradise Park	Irrigation	10PM-7AM	9	2.0	2.7	15	10	20	27	72
M-33	Morgan Hill Outdoor Sports Center	Irrigation	10PM-7AM	9	1.9	2.5	54	34	67	89	225
M-34	Britton Field (Park)	Irrigation	10PM-7AM	9	2.0	2.7	56	37	73	99	264
M-35	Burnett Elementary School	Irrigation	10PM-7AM	9	2.0	2.7	19	12	23	32	85
M-36	Holiday Lake Meadow (Park)	Irrigation	10PM-7AM	9	2.0	2.7	17	10	21	28	75
M-37	Park	Irrigation	10PM-7AM	9	2.0	2.7	3	2	4	5	14
M-38	Nursery	Irrigation	24HR	24	2.5	3.5	52	32	81	113	113
M-39	Barrett Elementary School	Irrigation	10PM-7AM	9	2.0	2.7	15	10	20	27	71
M-40	Park	Irrigation	10PM-7AM	9	2.0	2.7	5	4	8	11	28
M-41	Del Monte Townhomes	Irrigation	10PM-7AM	9	2.0	2.7	17	11	22	29	77
M-42	Park	Irrigation	10PM-7AM	9	2.0	2.7	2	1	2	3	7
M-43	Park	Irrigation	10PM-7AM	9	2.0	2.7	5	3	7	9	24
M-44	Live Oak High School	Irrigation	10PM-7AM	9	2.0	2.7	81	50	101	135	361
M-45	Park	Irrigation	10PM-7AM	9	2.0	2.7	7	5	9	12	32
M-46	Park	Irrigation	10PM-7AM	9	2.0	2.7	6	4	8	10	27
M-47	Park	Irrigation	10PM-7AM	9	2.0	2.7	3	1	3	4	10
M-48	Park (Coyote Estates)	Irrigation	10PM-7AM	9	2.0	2.7	1	1	1	2	5
M-49	Park	Irrigation	10PM-7AM	9	2.0	2.7	7	4	8	11	30
M-50	Park	Irrigation	10PM-7AM	9	2.0	2.7	9	6	11	15	41
M-51	TenCate Advanced Composites	Irrigation	10PM-7AM	9	2.0	2.7	19	12	24	32	85
M-52	Morgan Hill Library	Irrigation	10PM-7AM	7	2.0	2.7	7	4	9	12	40
M-53	Oak Creek Park	Irrigation	10PM-7AM	9	2.0	2.7	9	6	12	16	42
M-54	Oakwood School	Irrigation	10PM-7AM	9	2.0	2.7	44	28	55	74	195
M-55	Howard Wiechert Park	Irrigation	10PM-7AM	9	2.0	2.7	3	2	4	5	14
M-56	Coyote Valley Sporting Clays	Irrigation	7AM-11PM	4	2.1	2.8	1	0	1	1	7
M-57	Wing Wah Nursery	Irrigation	24HR	24	2.5	3.5	49	31	77	107	107
M-58	Nursery	Irrigation	24HR	24	2.5	3.5	66	41	103	143	143
M-59	Farm	Agricultural	8AM-5PM	9	2.5	3.5	35	22	55	78	207
M-60	Park	Irrigation	10PM-7AM	9	2.0	2.7	3	2	4	5	14
M-61	Stratford School	Irrigation	10PM-7AM	9	2.0	2.7	4	2	5	6	17
M-62	Morgan Hill Bible Church	Irrigation	10PM-7AM	9	2.0	2.7	7	4	8	11	30
M-63	Kawahara Nursery Inc	Irrigation	24HR	24	2.5	3.5	353	219	548	767	767
M-64	Madrone Plaza	Irrigation	10PM-7AM	9	2.0	2.7	4	2	5	7	18
M-65	Diana Park	Irrigation	10PM-7AM	9	2.0	2.7	10	6	12	16	43
M-66	Park	Irrigation	10PM-7AM	9	2.0	2.7	3	2	3	5	12
M-67	Park	Irrigation	10PM-7AM	9	2.0	2.7	2	1	2	3	7
M-68	Park	Irrigation	10PM-7AM	9	2.0	2.7	5	3	6	8	20
M-69	Park	Irrigation	10PM-7AM	9	2.0	2.7	2	1	2	3	9
M-70	Park	Irrigation	10PM-7AM	9	2.0	2.7	2	1	2	3	7
M-71	Park	Irrigation	10PM-7AM	9	2.0	2.7	8	5	10	13	34
M-72	Jackson Park	Irrigation	10PM-7AM	9	2.0	2.7	4	3	5	7	18
M-73	William F. James Boys Ranch	Irrigation	10PM-7AM	9	2.0	2.7	185	115	230	310	827
M-74	Galvan Park	Irrigation	10PM-7AM	9	2.0	2.7	24	14	29	39	103
M-75	Nordstrom Park	Irrigation	10PM-7AM	9	2.0	2.7	14	9	17	23	62
M-76	Park	Irrigation	10PM-7AM	9	2.0	2.7	3	2	4	6	15
M-77	Park	Irrigation	10PM-7AM	9	2.0	2.7	11	7	14	19	51
M-78	Park	Irrigation	10PM-7AM	9	2.0	2.7	9	6	11	15	40
M-79	Paradise Valley Elementary School	Irrigation	10PM-7AM	9	2.0	2.7	24	15	30	40	107
						Total	2,377	1,757	3,067	5,453	

Notes:
1. Demand estimate calculated based on acreages of similar use

AKEL ENGINEERING GROUP, INC.

Figure 2: Location of Potential Recycled Water Customers

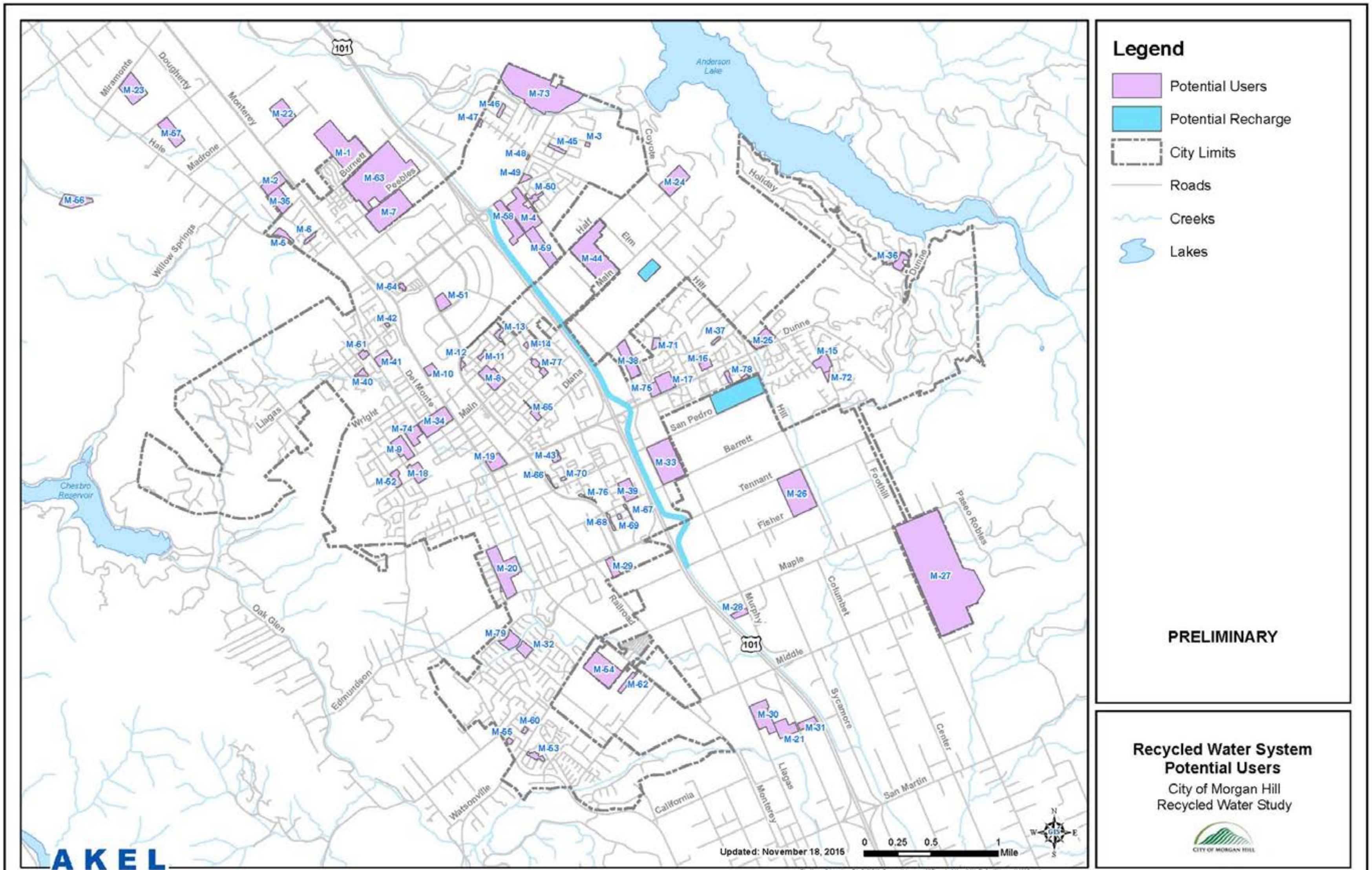


Table 2: Recycled Water Customer Evaluation Criteria

PRELIMINARY

Category 1 - Year Round/Seasonal Use and High/Low Demand

The scores in this category range from 1 to 5:

1. Highly Seasonal with High Demands (Irrigation)
2. Seasonal with High Variable Demand (Irrigation)
3. Seasonal with Low Variable Demand (M&I)
4. Mildly Seasonal with Low Consistent Demand (M&I)
5. Year Round Usage with Consistent High Demand (M&I)

Category 2 - Flexibility of Water Usage/On-site Storage

The scores in this category range from 1 to 5:

1. Strict usage times
2. Flexible usage times with potable water supply back-up required
3. Flexible usage times with ground water supply well back up required
4. Flexible usage times with no back up supply required
5. On-Site Storage (allows off-peak storage filling)

Category 3 - Proximity to Baseline System

The scores in this category range from 1 to 5:

1. System extension greater than 1/4 mile
2. System extension between 500 feet and 1/4 mile
3. System extension less than 500 feet
4. New turnout required
5. Existing turnout available

Category 4 - Level of Interest/Water Quality

The scores in this category range from 1 to 5:

1. No Interest
2. Interested but require high quality water and/or significant on-site infrastructure improvements
3. Interested and willing to meet higher quality requirements at their own expense and/or moderate on-site infrastructure improvements
4. Moderate Interest and not concerned about water quality and/or low on-site infrastructure improvements
5. High Interest and not concerned about quality and/or low on-site infrastructure improvements

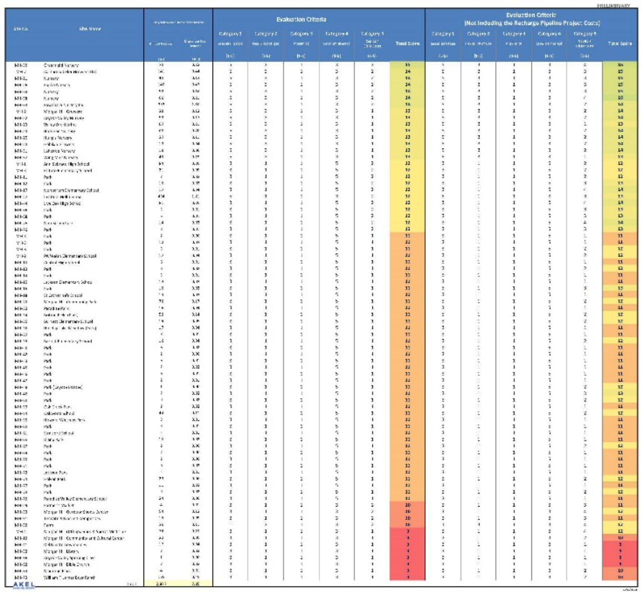
Category 5 - Capital, Construction, and O&M Annual Costs

The scores in this category range from 1 to 5:

1. > $2,500 per acre foot
2. $1,500 - $2,500 per acre foot
3. $1,000 - $1,500 per acre foot
4. $500 - $1,000 per acre foot
5. < $500 per acre foot

AKEL ENGINEERING GROUP, INC. 10/1/2015

Table 3: Results of Recycled Water Customer Prioritization



1.4 ALTERNATIVES EVALUATED

The following recycled water alternatives were evaluated in this report

1) Transport recycled water from existing SCRWA WWTP to users in Morgan Hill

2) Recharge aquifers using recycled water to augment groundwater supply

3) Utilize a satellite treatment plant to produce recycled water in Morgan Hill

4) Promote “gray water” reuse systems in Morgan Hill

These recycled water alternatives are shown on Figure 3, excluding the gray water reuse system which would not require any new piping. A conceptual system buildout is shown in Figure 4. Since this buildout system would demand more recycled water than what is available, potential recycled water distribution systems options were developed for a 1.0 mgd and a 2.25 mgd buildout scenario. These potential distribution system options were developed to distribute recycled water to different users and areas of Morgan Hill and are labeled MH-1 through MH-6. Table 4 presents the users and flows identified for each distribution system option. Class 5 cost estimates for each alternative are shown in Table 5. Distribution system piping alignments are shown for each alternative in the following sections.

Figure 3: Recycled Water Alternatives Overview

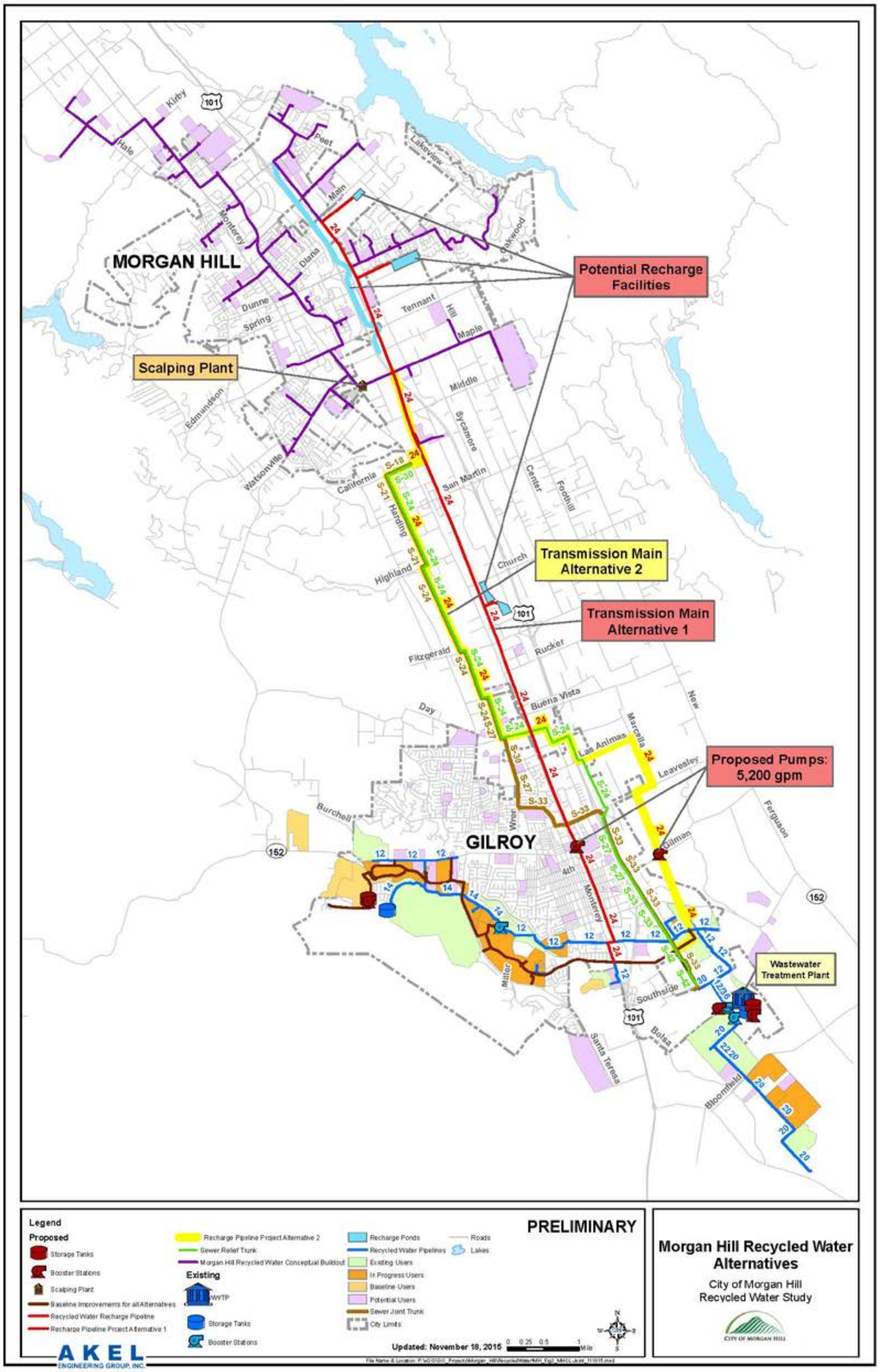


Figure 4: Conceptual System Buildout

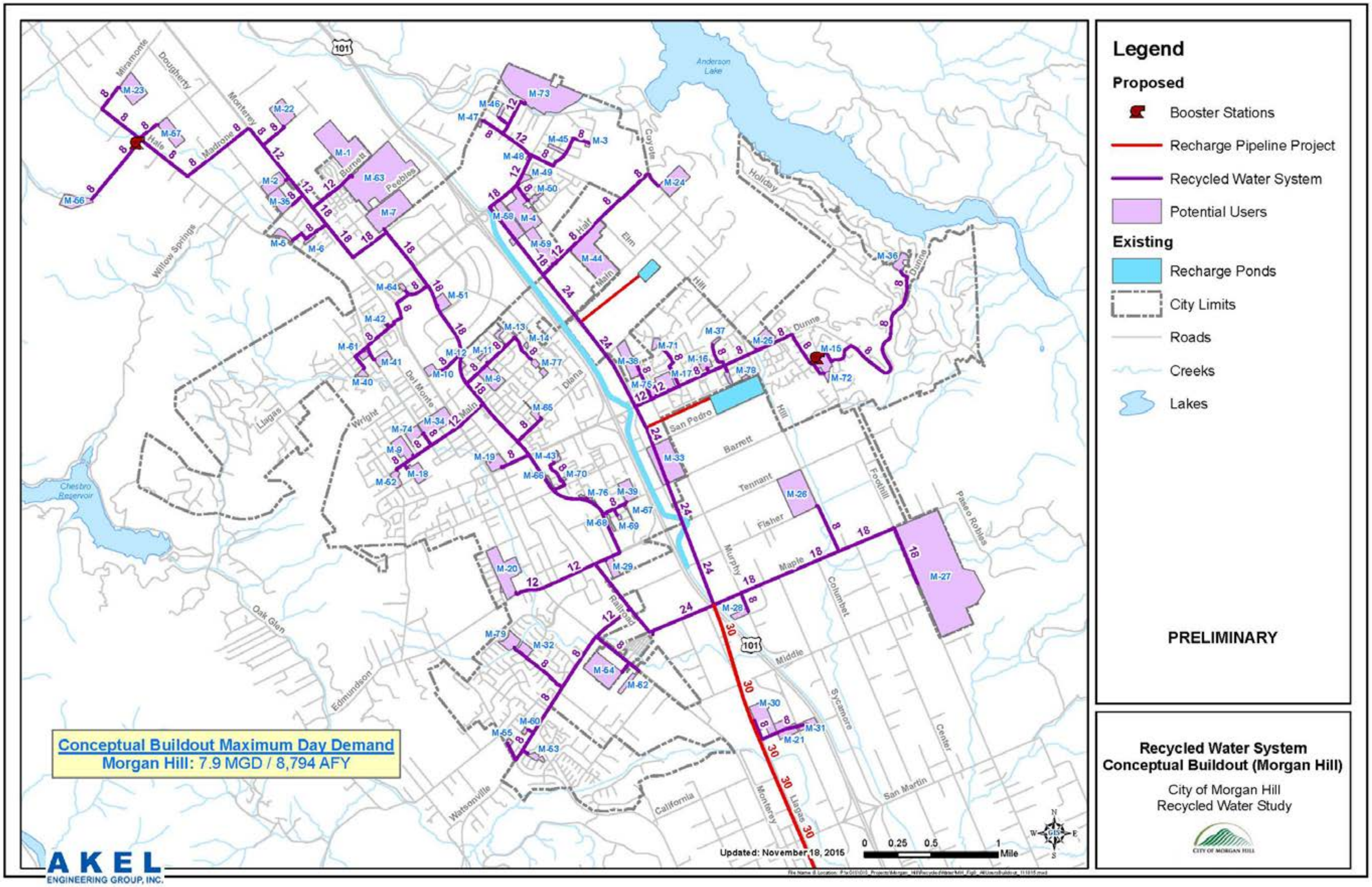


Table 4: Alternatives Users and Demands

PRELIMINARY

Site No.	Site Name	Annual Average (MGD)	Maximum Day Demand (MGD)	Peak Hour Demand (MGD)
Option MH-1[1,2]				
M-27	Institute Golf Course			
	Total	0.4	1.21	2.91
Option MH-2[1]				
M-21	Nursery	M-30	Greenfield Nursery	
M-26	Kajiko Nursery	M-31	Lakeside Nursery	
M-28	Gabilan Growers	M-33	Morgan Hill Outdoor Sports Center	
	Total	0.3	1.03	1.23
Option MH-3[1]				
M-27	Institute Golf Course	M-30	Greenfield Nursery	
M-26	Kajiko Nursery	M-31	Lakeside Nursery	
M-21	Nursery	M-33	Morgan Hill Outdoor Sports Center	
M-28	Gabilan Growers			
	Total	0.7	2.24	4.14
Option MH-4[1]				
M-21	Nursery	M-58	Nursery	
M-26	Kajiko Nursery	M-59	Farm	
M-28	Gabilan Growers	M-15	Jackson Elementary School	
M-30	Greenfield Nursery	M-16	Park	
M-31	Lakeside Nursery	M-17	Nordstrom Elementary School	
M-33	Morgan Hill Outdoor Sports Center	M-25	Hung's Nursery	
M-4	Morgan Hill Orthopedics & Sports Medicine	M-37	Park	
M-44	Live Oak High School	M-38	Nursery	
M-45	Park	M-71	Park	
M-48	Park (Coyote Estates)	M-72	Jackson Park	
M-49	Park	M-75	Nordstrom Park	
M-50	Park	M-78	Park	
	Total	0.7	2.26	3.40
Option MH-5[2]				
M-11	Park	M-54	Oakwood School	
M-18	St Catherine's School	M-62	Morgan Hill Bible Church	
M-19	Morgan Hill Community and Cultural Center	M-67	Park	
M-21	Nursery	M-68	Park	
M-30	Greenfield Nursery	M-69	Park	
M-31	Lakeside Nursery	M-74	Galvan Park	
M-34	Britton Field (Park)	M-76	Park	
M-39	Barrett Elementary School	M-8	El Toro Elementary School	
M-52	Morgan Hill Library	M-9	PA Walsh Elementary School	
	Total	0.3	1.00	2.02
Option MH-6[2]				
M-11	Park	M-62	Morgan Hill Bible Church	
M-18	St Catherine's School	M-67	Park	
M-19	Morgan Hill Community and Cultural Center	M-68	Park	
M-21	Nursery	M-69	Park	
M-30	Greenfield Nursery	M-74	Galvan Park	
M-31	Lakeside Nursery	M-76	Park	
M-34	Britton Field (Park)	M-8	El Toro Elementary School	
M-39	Barrett Elementary School	M-9	PA Walsh Elementary School	
M-52	Morgan Hill Library	M-1	Ann Sobrato High School	
M-54	Oakwood School	M-63	Kawahara Nursery Inc	
	Total	0.7	2.31	3.66
Option MH-7[2]				
M-27	Institute Golf Course	M-33	Morgan Hill Outdoor Sports Center	
M-17	Nordstrom Elementary School	M-37	Park	
M-25	Hung's Nursery	M-38	Nursery	
M-26	Kajiko Nursery	M-71	Park	
M-16	Park	M-75	Nordstrom Park	
M-28	Gabilan Growers	M-78	Park	
	Total	0.8	2.26	4.41
Conceptual Buildout - Morgan Hill				
All Users				
	Total	2.57	7.90	14.20

Notes:

1. Recycled Water Supplied via Recharge Pipe Line Project
2. Recycled Water Supplied via Scalping Plant

10/2/2015

AKEL ENGINEERING GROUP, INC

Table 5: Alternatives Cost Summary

	Pipes (millions)	Pump Stations (millions)	Tanks (millions)	Land/Easement Acquisition (millions)	Scalping Plant (millions)	Planned SCRWA Improvements (millions)	Total[1,2] (millions)
Gilroy Baseline Alternative							
Immediate - Term	$14.7	-	-	-	-	$5.3	**$20.0**
Near/Short - Term	$9.4	-	-	-	-	$8.4	**$17.8**
Long - Term	$2.8	$2.1	$6.0	$0.6	-	$50.0	**$61.5**
Total	$26.9	$2.1	$6.0	$0.6	$0.0	$63.7	**$99.3**
Expansion to Morgan Hill Alternatives							
Recharge Pipeline Project	$23.2 - $30.8	$3.9	-	$7.9 - $7.1	-	-	**$35.0 - $41.8**
Option MH-1/ MH-2 (1.0 MGD)	$4.1 - $5.2	$1.9 - $1.0	-	-	-	-	**$6.0 - $6.2**
Option MH-3/ MH-4 (2.25 MGD)	$3.9 - $11.3	$2.5 - $2.2	-	-	-	-	**$6.4 - $13.5**
Morgan Hill Scalping Plant Alternatives							
Option MH-1/ MH-5 (1.0 MGD)	$5.2 - $10.8	$1.9 - $1.5	-	-	$18.0	-	**$25.1 - $30.3**
Option MH-6/ MH-7 (2.25 MGD)	$6.4- $4.5	$2.3 - $2.6	-	-	TBD	-	**$8.7 - $7.1**

11/17/2015

AKEL ENGINEERING GROUP, INC.

Notes:

1. Costs include contingencies of 20% for estimating, 20% for construction, and 30% for administration
2. Costs listed under each heading are incremental

1.5 RECYCLED WATER STANDARDS, ORDINANCES AND REGULATIONS

Production, discharge, distribution and use of recycled water within the City are subject to several Federal, State, and local regulations for recycled water programs, the primary objectives of which are to protect public health. Should the City decide to implement a recycled water project, a thorough review of all applicable regulations should be done in the earliest stages of planning and re-evaluated during pre-design, then confirmed during the design effort in order to provide the most effective and up to date recycled water program. A summary of existing regulatory requirements is provided in this section.

1.5.1 FEDERAL REQUIREMENTS

Two federal acts regulate the discharge and use of recycled water or wastewater: The Clean Water Act and the Safe Drinking Water Act.

1.5.1.1 Clean Water Act

Federal requirements relevant to the discharge of recycled water or wastewater, and any other liquid waste to "navigable waters," are contained in the 1972 amendments to the Federal Water Pollution Control Act of 1956, commonly known as the federal Clean Water Act (CWA) (public Law 92-500). The CWA created the U.S. Environmental Protection Agency (USEPA) and established the National Pollutant Discharge Elimination System (NPDES), a permit system for discharge of contaminants to navigable waters. NPDES requires that all municipal and industrial discharges of liquid wastes apply for and obtain a permit prior to initiating discharge.

The USEPA has also developed recommended recycled water guidelines in the *2004 Guidelines for Water Reuse* that can be found on the USEPA's website at: http://www.epa.gov/region09/water/recycling/index.html#regs

The guidelines examine opportunities for substituting recycled water for potable water supplies where potable water quality is not required. The recommended recycled water guidelines, along with supporting information, are provided as guidance for the benefit of the water and wastewater utilities and regulatory agencies.

1.5.1.2 Safe Drinking Water Act

Federal requirements relevant to the use of recycled water for groundwater recharge are contained in the 1986 amendments to the Safe Drinking Water Act (SDWA) of 1974 (Public Law 93-523). The SDWA focuses on regulation of drinking water and control of public health risks by establishing and enforcing maximum contaminant levels (MCLs) for various compounds in drinking water. The 1986 amendments also establish requirements for protection of groundwater supplies through wellhead protection programs and regulations of underground injection of wastes.

1.5.1.3 Administration

In the State of California, the administration and enforcement of the NPDES and SDWA programs have been delegated to the state.

1.5.2 STATE REQUIREMENTS

State requirements for production, discharge, distribution and use of recycled water are contained in the following regulations:

1. California Water Code, Division 7-Water Quality, Sections 1300 through 1399.16 (Water Code);
2. California Administrative Code, Title 22-Social Security, Division 4-Environmental health, Chapter 3-Reclamation Criteria, Sections 60301 through 60475 (Title 22); and
3. California Administrative Code, Title 17-Public Health, Chapter 5, Subchapter 1, Group 4-Drinking Water Supplies, Sections 7583 through 7630 (Title 17).

In addition, guidelines for production, distribution and use of recycled water have been prepared or endorsed by state agencies administering the recycled water regulations.

1.5.2.1 Water Code

The Water Code contains requirements for the production, discharge and use of recycled water. The Porter-Cologne Water Quality Control Act (Division 7 of the California Water Code), which was promulgated in 1969, established the State Water Resources Control Board (SWRCB) as the state agency with primary responsibility for the coordination and control of water quality, water pollution, and water rights (Division 7, Chapter 1).

Nine Regional Water Quality Control Boards (RWQCB) were established to represent the SWRCB regionally and carry out the enforcement of water quality and pollution control measures (Division 7, Chapter 4). In addition, each RWQCB was required to formulate and adopt water quality control plans and establish requirements for waste discharge to waters of the state. In 1972, Chapter 5.5 was added to Division 7 to provide the RWQCBs with the authority to carry out the provisions of the federal CWA. The Central Coast RWQCB has jurisdiction over the City.

Division 7, Chapter 7-Water Reclamation, was included in the Porter-Cologne Water Quality Control Act in 1969. Subsequent amendments required SWRCB to establish water reclamation criteria, gave the RWQCB the responsibility of prescribing specific water reclamation requirements for water which is used or proposed to be used as recycled water, provided for the regulation of injection of waste into the ground, and required the use of recycled water, if available, rather than potable water for irrigation of greenbelt areas.

In addition to Division 7, Chapter 7, Sections 1210 through 1212 of the Water Code, added in 1980, focus on ownership of treated wastewater and require that the owner of a wastewater treatment plant obtain approval from SWRCB prior to making any change in the point of discharge, place of use or purpose of use of treated wastewater.

1.5.2.2 Title 22

In 1975, Title 22 was prepared by the CDPH in accordance with the requirements of Division 7, Chapter 7 of the Water Code. In 1978, Title 22 was revised to conform with the 1977 amendment to the federal CWA. The requirements of Title 22, as revised in 1978, 1990, 2001, 2008, and 2014 regulate production and use of recycled water in California. In 2014, the duties of updating and enforcing these regulations was transferred from the CDPH to the SWRCB Division or Drinking Water (DDW).

Chapter 3, Water Recycling Criteria, of the Title 22 regulations contains recycled water quality criteria and treatment requirements based on the type and area of use, e.g., irrigation of food crops, recreational impoundments, and groundwater recharge. Title 22 requirements are summarized in Table 6.

Title 22 establishes the quality and/or treatment processes required for an effluent to be used for a specific non-potable application. The following categories of recycled water are identified:

- Disinfected tertiary recycled water
- Disinfected secondary-2.2 recycled water[1]
- Disinfected secondary-23 recycled water[2]
- Undisinfected secondary recycled water
- Disinfected tertiary recycled water with conventional treatment
- Disinfected tertiary recycled water without conventional treatment.

Table 6: Title 22 Requirements

Recycled Water Use	Minimum Treatment Requirements	Use Distance Requirement from Water Supply Well[2]
Landscape Irrigation		
Food crops where recycled water comes in contact with the edible portion of the crop, including all root crops	disinfected tertiary[3]	50 ft[4,5]
Parks and playgrounds		
School yards		
Residential landscaping		
Unrestricted-access golf course		
Any other irrigation not listed in this table and not prohibited by the California Code of Regulations		
Surface irrigation of food crops where edible portion is above ground and not contacted by recycled water	disinfected secondary-2.2	100 ft[5]
Cemeteries	disinfected secondary-23	100 ft[5]
Freeway landscaping		
Restricted access golf courses		
Ornamental nursery stock and sod farms with unrestricted public access		
Pasture for milk animals for human consumption		
Non-edible vegetation with access control to prevent use as a park, playground or school yard		

[1] The 2.2 refers to the coliform count requirement for the water – 2.2 MPN/100 mL

[2] The 23 refers to the coliform count requirement for the water – 23 MPN/100 mL

Orchards with no contact between edible portion and recycled water	undisinfected secondary	150 ft[5]
Vineyards with no contact between edible portion and recycled water		
Non food-bearing trees, including Christmas tree farms not irrigated less than 14 days before harvesting		
Fodder and fiber crops and pasture for animals not producing milk for human consumption		
Seed crops not eaten by humans		
Food crops undergoing commercial pathogen-destroying processing before being consumed by humans		
Ornamental nursery stock and sod farms not irrigated less than 14 days before harvesting		
Impoundments		
Unrestricted recreational impoundments	disinfected tertiary subject to conventional treatment[6,7]	100 ft
Restricted recreational impoundments and publicly accessible fish hatcheries	disinfected secondary-2.2	100 ft
Landscape impoundments without decorative fountains	disinfected secondary-23	100 ft
Cooling		
Industrial or commercial cooling involving a cooling tower, evaporative condenser, or spraying that creates a mist	disinfected tertiary[8]	n/a
Industrial or commercial cooling that does not involves not involving a cooling tower, evaporative condenser, or spraying that creates a mist	disinfected secondary-23	n/a
Other Uses		
Flushing toilets and urinals	disinfected tertiary[3]	n/a
Priming drain traps		
Industrial process water that may contact workers		
Structural fire fighting		
Decorative fountains		
Commercial laundries		
Consolidation of backfill around potable water pipelines		
Artificial snow making for commercial outdoor use		
Commercial car washes, including hand washes with heated water where the public is excluded from washing process		
Industrial boiler feed	disinfected secondary-23	n/a
Nonstructural fire fighting		
Backfill consolidation around non-potable piping		
Soil compaction		
Mixing concrete		
Dust control on roads and streets		
Cleaning roads, sidewalks and outdoor work areas		
Industrial process water that will not contact workers		

Flushing sanitary sewers	undisinfected secondary	n/a
Groundwater recharge	determined on an individual case basis by Title 22 Regulations[9]	

1. Refer to the full text of Title 22: California Code of Regulations, Chapter 3 Water Recycling Criteria. This chart is only a summary of the criteria as of March 24, 2011. Full text can be downloaded from: http://www.cdph.ca.gov/HealthInfo/environhealth/water/Pages/Waterrecycling.aspx.
2. Applies to recycled water meeting minimum treatment requirements that apply to each use.
3. Filtration pursuant to Title 22 Section 60301.320(a) requirements for coagulation need not be used as part of the treatment process provided that the filter effluent turbidity does not exceed 2 NTU, the turbidity of the influent to the filters is continuously measured, the influent turbidity does not exceed 5 NTU for more than 15 minutes and never exceeds 10 NTU, and that there is the capability to automatically activate chemical addition or divert the wastewater should the filter influent turbidity exceed 5 NTU for more than 15 minutes.
4. Irrigation with disinfected tertiary water may take place within 50 feet of any domestic water supply well if the conditions of Title 22 Section 60310(a) have been met.
5. No spray irrigation of any recycled water, other than disinfected tertiary recycled water, shall take place within 100 feet of a residence or a place where public exposure could be similar to that of a park, playground, or school yard.
6. Disinfected tertiary recycled water that has not received conventional treatment may be used for unrestricted recreational impoundments if it is monitored for the presence of pathogenic organisms in accordance with Title 22 Section 60305(b)(1).
7. The total coliform bacterial concentrations in recycled water used for unrestricted recreational impoundments shall comply with criteria in Title 22 Section 60301.230 (b) when measured between disinfection and impoundment entry.
8. Cooling system must also use a drift eliminator when in operation, and chlorine or other biocide must be used to treat recirculated water.
9. Refer to the article 5.1 of the Title 22 Recycled Water Regulations.

In addition to recycled water uses and treatment requirements, Title 22 addresses sampling and analysis requirements at the treatment plant, preparation of an engineering report prior to production or use of recycled water, general treatment design requirements, reliability requirements, and alternative methods of treatment.

The 2014 revision of the Title 22 regulation includes updated requirements for groundwater replenishment projects. These requirements are described in Section 3.2.

1.5.2.3 Title 17

The focus of Title 17 is protection of drinking (potable) water supplies through control of cross-connections with potential contaminants, including non-potable water supplies such as recycled water. The cross-connection control program and backflow protection required by Title 17 for public water supply protection are discussed in Section 4: Connection Issues Driven by Water Code and City Ordinances.

Recycled water is specifically addressed within Title 17 as follows:

- An air-gap separation is required on “premises where the public water system is used to supplement the recycled water supply”
- A reduced pressure principle backflow prevention device (RPPD) is required on “premises where recycled is used… and there is no interconnection with the potable water system.”
- A double-check valve assembly may be used for “residences using recycled water for landscape irrigation as part of an approved dual plumbed use area established pursuant to sections 60313 through 60316 unless the recycled water supplier obtains approval for

the local public water supplier, or the DDW if the water supplier is also the supplier of the recycled water, to utilize an alternative backflow prevention plan that includes an annual inspection and annual shutdown test of the recycled water and potable water systems pursuant to subsection 60316(a).

1.5.2.4 Administration

In California, reclamation requirements are administrated by the SWRCB and the individual RWQCBs. The direct involvement of each agency in recycled water is summarized below:

1.5.2.5 State Water Resources Control Board

The SWRCB does not have water quality requirements for recycled water other than the Title 22 Recycled Water Regulations. It has adopted Resolution No. 77-1 “Policy with Respect to Water Reclamation in California” that encourages reclamation, reuse, and water conservation. On February 2009, the SWRCB adopted “A Policy for Water Quality Control for Recycled Water.” The policy, which will take effect after approval by the Office of Administrative Law, states goals for use of recycled water, including the substitution of as much recycled water for potable water as possible by 2030.

SWRCB does have the requirement to issue loans (such as those from Proposition 1) in accordance with the Water Code as well as approval of petitions for the change in place and purpose of use of treated wastewater in accordance with the Water Code.

1.5.2.6 State Water Resources Control Board Division of Drinking Water

The DDW has the responsibility to:

1. Review and approve engineering reports as requested by RWQCB
2. Review and approve final plans for cross-connection control and pipeline separations in accordance with Title 17 and inspect the distribution system prior to operation.
3. In conjunction with local health agencies, review and approve final on-site (user) system plans for cross-connection control in accordance with Title 17 and inspect the system prior to operation.

The DDW has delegated a portion of its administrative duties in the past to local health agencies (such as the Long Beach Department of Public Health and the County of Los Angeles Department of Public Health) and becomes more involved at the request of the local health agencies.

1.5.3 ON-GOING DEVELOPMENT TO EXISTING WATER QUALITY REQUIREMENTS

The SWRCB DDW is currently developing regulations for IPR projects utilizing surface water augmentation and regulations for direct potable reuse projects (DPR). Direct potable reuse is the practice of supplying highly treated wastewater effluent to a potable distribution system with an engineered buffer instead of the environmental buffer required in IPR projects. There are currently no DPR projects in California because there are no regulations that allow them at this time.

An expert panel has been formed to advise the DDW on public health issues regarding the development of surface water augmentation and DPR regulations. The panel will also asses what additional research is needed for establishing regulations for DPR.

2 EVALUATE FEASIBILITY OF BRINGING RECYCLED WATER FROM THE SCRWA WWTP

2.1 INTRODUCTION

The SCRWA is a joint powers agency between the Cities of Morgan Hill and Gilroy that operates a WWTP located approximately 3 miles southeast of Gilroy and 10 miles southeast of Morgan Hill. The wastewater treatment plant collects influent from both the Cities of Gilroy and Morgan Hill with a permitted capacity to treat a maximum average dry weather flow (ADWF) of 8.5 mgd. The ADWF over the last three years is reported to be 6.2 MGD. The WWTP utilizes grit removal and two oxidation ditches to provide nutrient removal. Secondary effluent can then be sent to on-site percolation ponds or diverted to tertiary facilities for further treatment.

2.1.1 SCRWA TERTIARY TREATMENT FACILITES

Oxidized wastewater can be diverted to a granular media filtration plant with four filter beds. The filtration rate is limited to 5 gallons per minute per square foot (gpm/sf) by California Title 22 regulations. Given this filtration rate, each of the four filters has the capacity to treat a maximum flow of 3 MGD. Filters are periodically backwashed - one at a time, so the firm filtration capacity of the SCRWA filter plant is approximately 9 MGD.

Disinfection is currently provided to the filter plant effluent by dosing chlorine and sending the effluent through a chlorine contact basin. Under California Title 22 regulations, disinfected tertiary recycled water must have a 450 mg/L-minute of concentration times modal contact time (CT). Additionally, disinfected tertiary recycled water must have a 90 minute modal contact time, based on peak dry weather flow prior to its reuse.

The on-site Reclaimed Water Reservoir can store 3 MG of tertiary disinfected effluent. The purpose of the Reservoir is to supplement the Reclamation System with tertiary disinfected effluent when demand exceeds Chlorine Contact Basin effluent flow rate. The Reservoir is filled when the Chlorine Contact Basin effluent exceeds reclaimed water demand and is drained when reclaimed water demand exceeds Chlorine Contact Basin effluent. This allows the SCRWA Reclamation System to meet peak demands in excess of the tertiary treatment capacity.

2.2 SCRWA RECLAIMED WATER QUALITY

The SCRWA WWTP provides reclaimed water that meets the California Title 22 regulations for tertiary disinfected wastewater. No further treatment of reclaimed water is required prior to any of the uses described in the California Title 22 Recycled Water Regulations for tertiary disinfected wastewater.

2.3 CURRENT SCRWA RECLAIMED WATER USERS

The SCRWA WWTP currently supplies recycled water to users located in Gilroy and the surrounding area. The existing recycled water distribution system and users are shown in Figure 5. Recycled water users are allotted a specific volume of recycled water and specified hours of operation when they can use it. Table 7 lists the current SCRWA recycled water users, the hours when they are permitted to use recycled water, estimated yearly recycled water demands, and year 2014 observed recycled water demand.

Figure 5: Existing Distribution System and Users

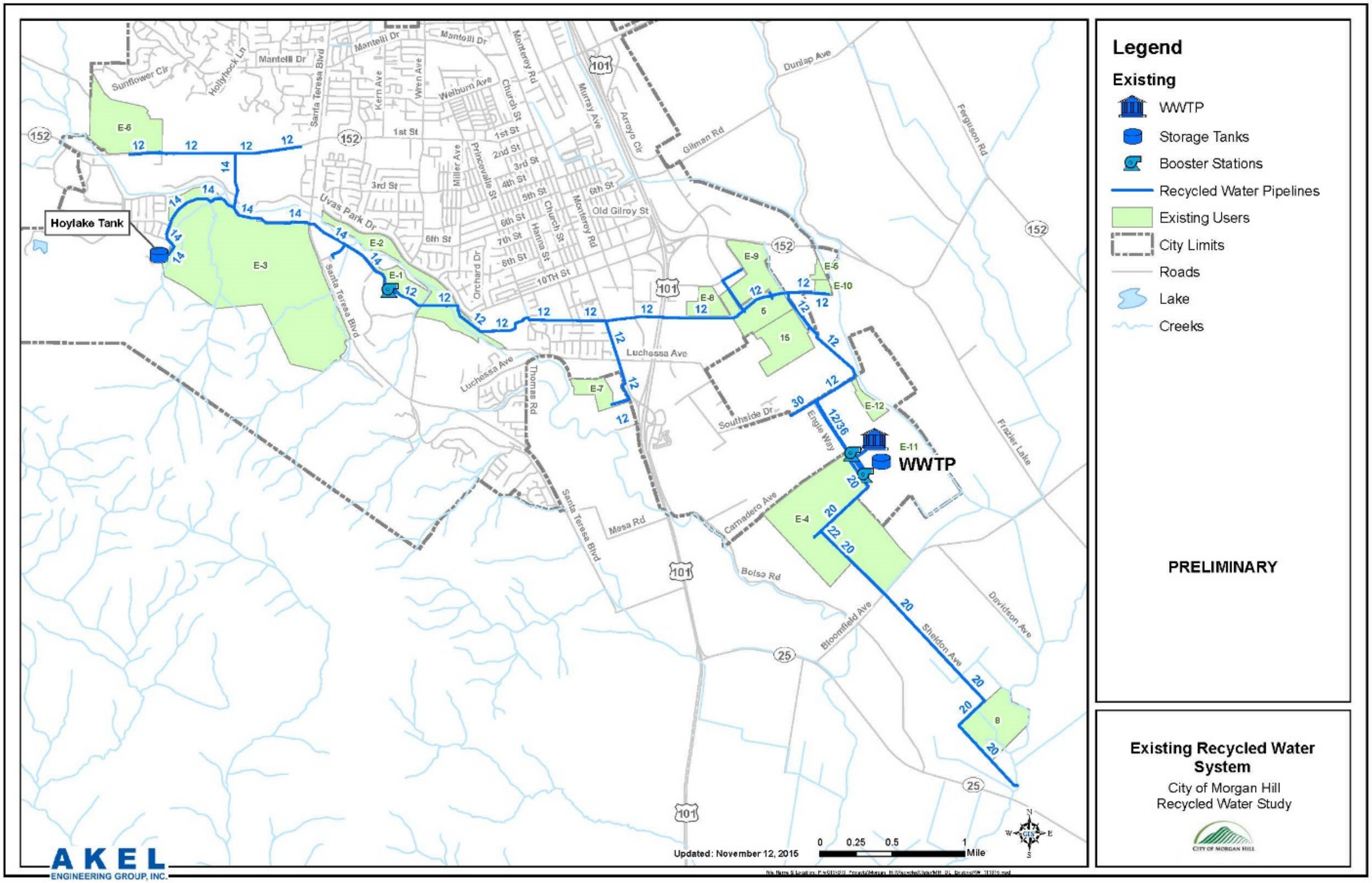


Table 7: Current Recycled Water Customers Hours of Usage

PRELIMINARY

Site No.	Site Name	Recycled Water System	Zone	Usage Type	On-Site Storage	Hours of Usage (period)	(hrs)	Estimated Demands[1] (afy)	Actual Usage (2014)[2] (afy)
Existing Users									
E-1	Christmas Hill Park - Ranch	North	1	Irrigation		10pm - 7am	9	25	7
E-2	Christmas Hill Park - North	North	1	Irrigation		10pm - 7am	9		19
E-3	Eagle Ridge Golf Course	North	2	Irrigation	Pond	9pm - 6am	9	330	455
E-4	SCRWA Farms (Ag Lease) Turnout #1-#6	South	-	Agricultural		7 am-1pm; 7pm-1am	12	150	174
E-8	Obata Farms (North)	North	1	Agricultural		7 am-1pm; 7pm-1am	12		60
E-5	Calpine Power Plant - Peaker	North	1	M&I		24hr	24	260	6
E-10	Calpine Power Plant - Cogen	North	1	M&I		24hr	24		77
E-6	City of Gilroy - Golf Course	North	2	Irrigation		9pm - 7am	10	120	129
E-7	City of Gilroy - Sports Park	North	1	Irrigation		10pm - 7am	9	30	32
E-9	McCarthy Business Park	North	1	Irrigation		9pm - 6am	9	5	15
E-11	WWTP Utility Water	WWTP Utility	-	M&I		24hr	24	1,000	1020
E-12	City of Gilroy - Shooting Range	North	1	Irrigation		7am - 11pm	4	1	1
8	C & E Farms[3]	South	-	Agricultural		8am-5pm	9	150	-
15	Obata (new turnout)[3]	North	1	Agricultural		7 am-1pm; 7pm-1am	12	150	-
5	United Natural Food[3]	North	1	Irrigation		10pm - 7am	9	20	-
	Total							2,241	1,995

Notes:

1. Estimated Demands for existing users obtained from 'Recycled Water Use Permits.'
2. Actual usage per 'SCRWA Reclaimed Water Usage Log' for Calendar 2014 listed (quarter usage received)
3. Not used in 2014 Analysis Scenario, customers will be on-line and receiving water in the near-term.

9/14/2015

AKEL ENGINEERING GROUP, INC

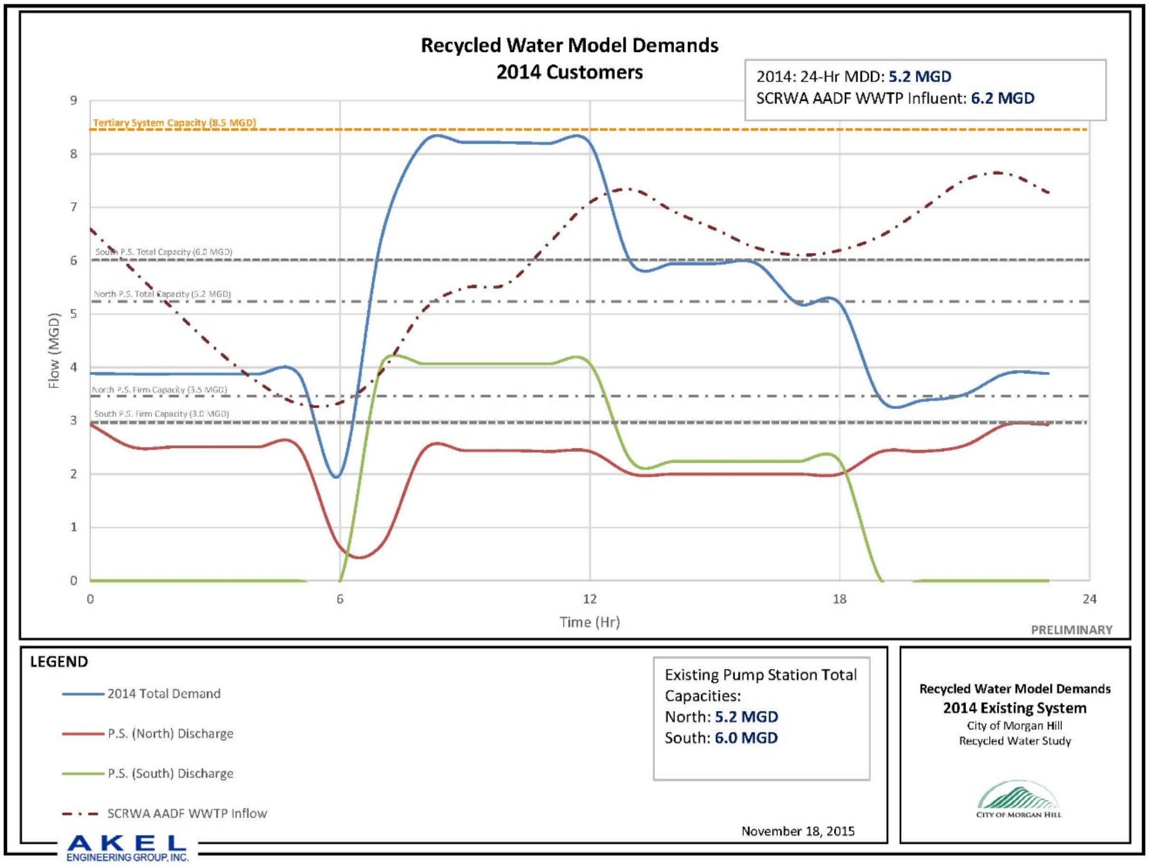
2.4 SCRWA RECYCLED WATER AVAILABLE FOR USE IN MORGAN HILL

Recycled water availability could be limited by any component of the recycled water system: wastewater influent to the SCRWA WWTP, the SCRWA tertiary treatment system, or the recycled water distribution system pump station capacities. On-site reclaimed water storage facilities are used to meat peak demands when recycled water demand exceeds plant influent flows or tertiary treatment system capacities. The plant influent ADWF and tertiary treatment capacities are presented in section 2.1.

Figure 6 provides recycled water use data for existing users along the North Pipeline and South Pipeline and the current capacities of the recycled water distribution pump stations. While current recycled water users are restricted in when they can use recycled water, the capacity of the SCRWA recycled water system can be nearly exceeded during periods of peak demand. This could potentially limit recycled water use by new users in Morgan Hill.

The total volume of water available for use in Morgan Hill can be estimated by subtracting current recycled water use from the permitted plant capacity. This calculation is provided in section 3.5. It is important to note that without storage facilities, Morgan Hill recycled water customers would not be able to take advantage of this entire volume due to time of use demands from existing customers.

Figure 6: Current Recycled Water Time of Use limitations



2.5 ALTERNATIVES FOR CONVEYING RECYLED WATER FROM SCRWA TO MORGAN HILL

The two potential recycled water transmission main alignment alternatives for bringing recycled water from the SCRWA WWTP to Morgan Hill are shown in Figure 3. The two transmission main alignments are described as follows:

- **Alternative 1 - MH High Speed Rail Transmission Main:** This Morgan Hill alignment is to extend a Morgan Hill recycled water transmission main along the future High Speed Rail easement along Monterey Road to service potential customers and/or for potential recharge in Morgan Hill. This alternative was intended to take advantage of construction in conjunction with the High Speed Rail.

  A 24-inch transmission main begins at the intersection of W. Luchessa Ave. and Monterey Rd. From the intersection, the pipeline heads in the north-west direction and parallels the railroad tracks towards Morgan Hill to Maple Avenue. A 1,400 to 5,200 gpm pump station is required in the City of Gilroy and is generally proposed to be near First Street and Monterey Avenue.

- **Alternative 2 - Joint Trunk Transmission Main:** Similar to the MH High Speed Rail Alignment, this transmission main along the existing sewer joint trunk is intended to take advantage of the existing easements to Morgan Hill and the possibility of re-purposing the existing sewer trunk for recycled water purposes.

  A 24-inch transmission main begins at Luchessa Avenue connecting to the proposed 30-inch main and heading north in the future Cameron Boulevard road up to Leavesley Road. The alignment jogs north-east to Marcella Avenue and continues north to Las Animas Aveune. The alignment then turns west along Las Anaimas Avenue and meets the future sewer joint trunk alignment at San Ysidro Avenue. From San Ysidro Avenue the main follows the future joint trunk alignment north-west to Day Road between Santa Teresa Boulevard and Monterey Highway, from here the alignment heads north to Maple Avenue. A 1,400 to 5,200 gpm pump station is required in the City of Gilroy and is generally proposed to be near Gilman Road and the future Cameron Boulevard.

From the end of the transmission main the Morgan Hill recycled water distribution system will begin. For this analysis different system options are presented as customer preference, user interest, or connection viability is based on planning level assumptions. The total demands the hydraulic analysis will focus on are based on 1.0 MGD of recycled water for existing conditions and 2.25 MGD of recycled water for buildout conditions.

The recycled water distribution system options for the transmission main alternatives focus on the east side of Morgan Hill and expand from south to north. The recycled water system expansion options for the alternatives are as follows:

- **Option 1 (1 mgd) and 3 (2.25 mgd):** Option 1 begins with an 18-inch main heading east on Maple from the proposed 24-inch transmission main in Llagas and connects to the Institute Golf Course as shown in purple on Figure 7. Option 3 expands the recycled water system from 1 mgd to 2.25 and includes additional customers along Condit Road as shown in purple on Figure 8.
- **Option 2 (1 mgd) and 4 (2.25 mgd)**: Option 2 begins with a 24-inch main extending from the proposed 24-inch transmission main in Llagas Avenue to connect customers up to Barrett Avenue as shown in green on Figure 8. Option 4 expands the recycled water system from 1 mgd to 2.25 mgd and includes additional customers north along Condit Road and Dunne Avenue up to Cochrane Road as shown in green on Figure 8.

The demands and users for each of the options are documented in Table 4 and costs for the transmission main and distribution system options are in Table 5.

Figure 7: Alternatives for Bringing Recycled Water to Morgan Hill Users, Options MH-1 and MH-2 (1.0 mgd)

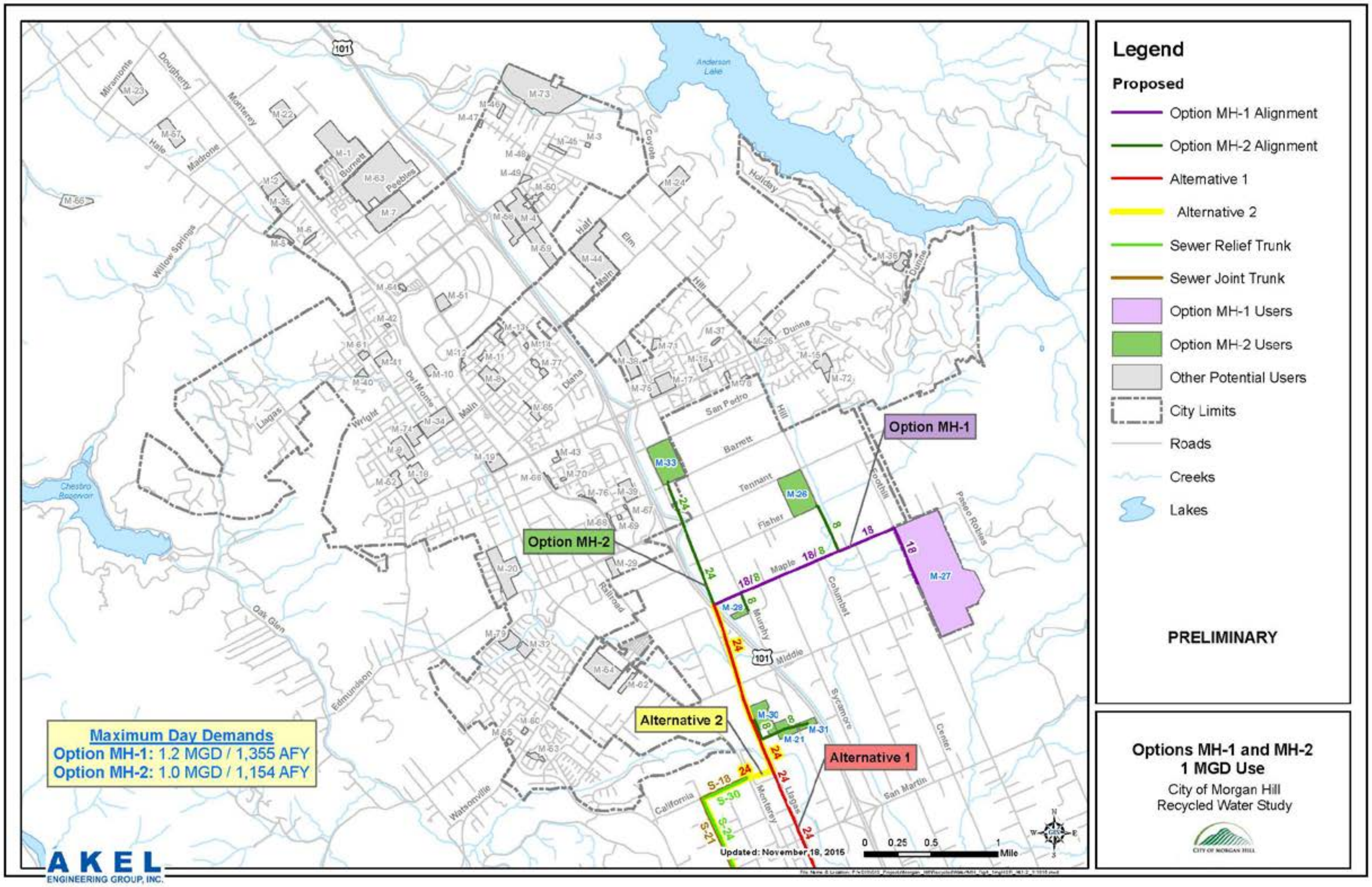
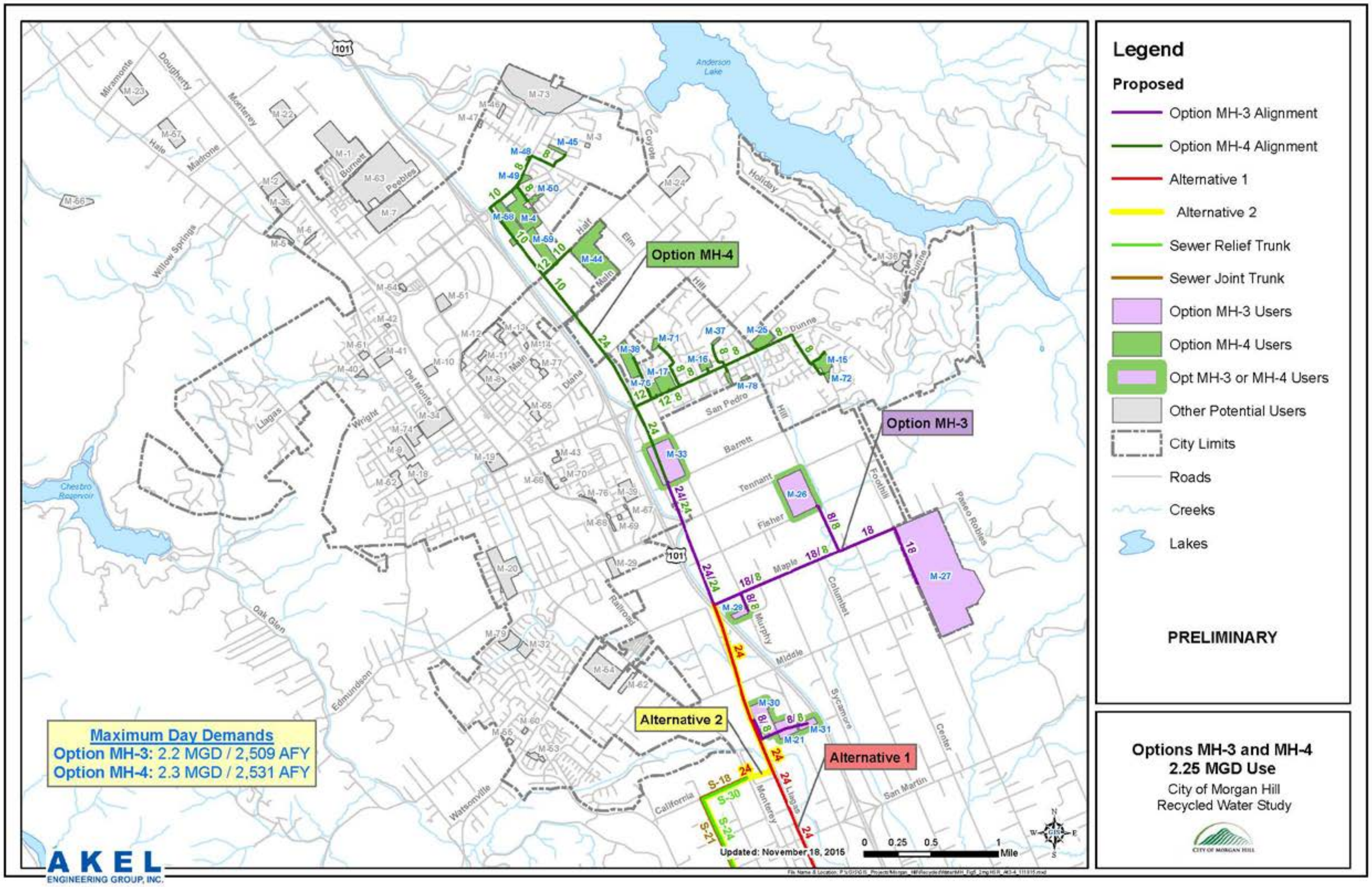


Figure 8: Alternatives for Bringing Recycled Water to Morgan Hill Users, Options MH-3 and MH-4 (2.25 mgd)

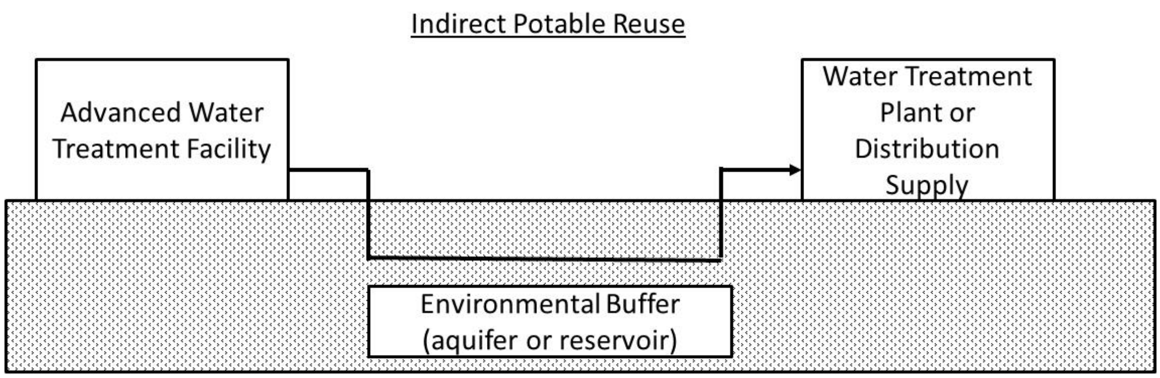


3 EVALUATE FEASIBILITY OF USING RECYCLED WATER FOR RECHARGE

3.1 INTRODUCTION

Recycled water can be supplied to underground aquifers to augment groundwater that is used as a drinking water source. This practice is categorized as indirect potable reuse (IPR), which is illustrated in Figure 9. The underlying aquifer serves as a natural storage reservoir in addition to providing treatment as the recycled water flows through the porous media. Storing recycled water in an aquifer would allow Morgan Hill to take advantage surplus recycled water capacity from the SCRWA WWTP at times when the demand for recycled water is low.

Figure 9: Schematic of major treatment components for indirect potable reuse (adapted from Tchobanoglous, 2014)



Recycled water can be delivered to the aquifer in two ways. It can be spread across the land surface and allowed to percolate through the ground to the aquifer. This method, referred to as surface spreading, works only when the ground beneath the spreading pond is permeable enough to allow water to percolate through to the aquifer at a reasonable rate. Secondly, water can be injected into the groundwater using pressurized injection wells. This technique could be utilized in less permeable conditions.

3.2 TITLE 22 REGULATIONS REGARDING RECHARGING GROUNDWATER WITH RECYCLED WATER

Groundwater replenishment projects that apply treated wastewater to an aquifer that serves as a water supply are referred to as indirect potable reuse projects (IPR) and are regulated by the State Water Resources Control Board Division of Drinking Water (SWRCB DDW) Title 22 Recycled Water Regulations. These regulations were substantially updated in 2014 to include separate requirements for groundwater replenishment projects that use surface spreading and groundwater replenishment projects that use injection wells. The following analysis proposes utilizing surface spreading in existing facilities to apply treated wastewater to the aquifer.

Pathogenic microorganism control for surface application IPR projects requires an acceptable combination of engineered treatment processes and underground retention time to the nearest down gradient drinking water well. This retention time is estimated using tracer studies, numerical modelling, or analytical modelling. The pathogen reduction credited to each month of underground retention time will depend on the level of uncertainty associated with the method used for estimating the underground retention time. Pathogen reduction credits will be given to treatment processes based on validation tests or approved treatment trains specified in the regulations.

Effluent that meets the Title 22 definition for tertiary disinfected wastewater and demonstrates at least six months of underground retention time, as estimated with a tracer study, can be used in IPR surface spreading projects with no further treatment. If six months of underground retention time cannot be demonstrated, additional treatment will be required by California Title 22 regulations.

3.3 POTENTIAL SOURCES OF RECYCLED WATER FOR RECHARGE

3.3.1 SANTA CLARA VALLEY WATER DISTRICT

As part of this feasibility evaluation, Akel Engineering Group and MWH have explored the possibility of importing recycled water from north of Morgan Hill, i.e., from SCVWD's recycled water system. District staff has stated that, at this time, no sources of recycled water from the north are available.

3.3.2 SOUTH COUNTY REGIONAL WASTEWATER AUTHORITY WASTEWATER TREATMENT PLANT

This evaluation identifies the SCRWA WWTP as the most viable source of recycled water. Existing treatment facilities at the SCRWA WWTP can produce tertiary disinfected water as described in Section 2.1.1**.** Additional treatment may be required to achieve compliance with Title 22 regulations or with the water quality objectives for the groundwater basin.

3.4 ADDITIONAL WATER QUALITY REQUIREMENTS FOR GROUNDWATER RECHARGE

In addition to complying with Title 22 Recycled Water Regulations, recycled water being used to recharge groundwater should be consistent with the goals of the 2014 Llagas Subbasin Salt and Nutrient Management Plan (SNMP). The Llagas Subbasin is located in Southern Santa Clara County and is the main drinking water source for the Cities of Gilroy and Morgan Hill. The (SNMP) establishes nitrate and total dissolved solids (TDS) as appropriate indicators for salts and nutrients in the groundwater.

In order to not degrade the quality of groundwater in the Llagas Subbasin, water used for recharge should meet the water quality objectives established by the Central Coast Regional water Quality Control Board for TDS and Nitrate. The median water quality baseline (MWQB) for the Llagas subbasin and the current SCRWA effluent values for TDS and nitrogen are shown in Table 8.

Table 8: Llagas Subbasin Groundwater Quality

Parameter	MWQB	SCRWA Tertiary Effluent
TDS	300	665[1]
Nitrogen	5	2.36[2]

1. 2014 average secondary effluent value.
2. 2014 average tertiary effluent nitrate as N. Note: there will be additional nitrogen as ammonia, but this is a relatively small contribution.

Reducing the TDS of a water source is most often achieved by using a reverse osmosis (RO) membrane treatment process. This is an energy intensive treatment process that could add costs to a groundwater recharge project. Additionally, the reject stream from an RO process, referred to as RO concentrate, is a high salinity brine that requires special consideration for disposal.

Average yearly tertiary water quality is shown in Table 9. SCRWA is required to meet National Pollutant Discharge Elimination System (NPDES) for an emergency discharge to the local Pajaro River and a discharge limit is required for chlorodibromomethane.

Table 9: Average yearly tertiary effluent water quality at SCRWA

	Units	2009	2010	2011	2012	2013	2014
Total flow	MGM	26.65	19.38	16.72	26.04	29.54	30.08
Average daily flow	MGD	0.87	0.64	0.55	0.85	0.97	0.99
pH	-	7.24	7.23	7.23	7.23	7.17	7.20
Biochemical oxygen demand (BOD)	mg/L	2.00	2.25	2.33	2.67	2.58	3
Total suspended solids (TSS)	mg/L	1.00	1.00	1.08	1.50	1.08	1.75
Turbidity	NTU	0.36	0.42	0.40	0.50	0.42	0.35
Coliform	MPN/100 mL	2.00	2.33	2.08	2.00	2.08	<2
Nitrate-N	mg/L	3.18	3.73	3.45	2.92	3.33	2.36
Dissolved oxygen	mg/L	4.08	4.48	3.98	3.93	3.61	3.33

3.5 RECYCLED WATER AVAILABLE FOR RECHARGE

The volume of recycled water that would be available for recharge is calculated by subtracting the baseline recycled water use from the 8.5 MGD permitted capacity of the SCRWA WWTP. Table 10 shows the amount of recycled water that is available for recharge each month versus the projected recycled water use in Gilroy. A majority of this supply is available during off-peak months, when demand for recycled water is low. It should be noted that the volume of recycled water available for recharge could be less if SCRWA plant influent flows do not meet the permitted capacity. Additionally, if RO treatment is required, additional water would be lost in the RO concentrate reject stream.

Table 10: Surplus Recycled Water

Table 11 Potential Recycled Water Recharge
South County Recycled Water System Master Plan
Santa Clara Valley Water District/South County Regional Wastewater Authority

PRELIMINARY

Off-Peak Months			Peak Months							Off-Peak Months		Maximum Day Demand	Annual Average
January	February	March	April	May	June	July Max Month	August	September	October	November	December Min Month		
Potential Recycled Water Avaliable for Recharge[2]													
8,107 afy	7,852 afy	7,822 afy	6,652 afy	4,842 afy	2,957 afy	1,622 afy	1,952 afy	5,040 afy	6,491 afy	8,301 afy	8,417 afy	0 afy	5,838 afy
7.2 mgd	7.0 mgd	6.9 mgd	5.9 mgd	4.3 mgd	2.6 mgd	1.4 mgd	1.7 mgd	4.5 mgd	5.8 mgd	7.4 mgd	7.5 mgd	0 mgd	5.2 mgd
Projected Recycled Water Usage in Gilroy Baseline Long Term Alternative[1]													
1,413 afy	1,668 afy	1,698 afy	2,868 afy	4,678 afy	6,563 afy	7,898 afy	7,568 afy	4,480 afy	3,029 afy	1,219 afy	1,103 afy	9520 afy	3,682 afy
1.3 mgd	1.5 mgd	1.6 mgd	2.6 mgd	4.2 mgd	5.9 mgd	7.1 mgd	6.8 mgd	4.0 mgd	2.7 mgd	1.1 mgd	1.0 mgd	8.5 mgd	3.3 mgd

Potential Recharge Facilities and Estimated Recharge Rates[3]

Recharge Facility	Average Annual Recharge Capacity (afy)
Main Ave Ponds	2,700
Madrone Channel	10,500
Church Avenue Ponds	7,300
San Pedro Ponds	4,700

Notes:
1. Peaking Factors used for the monthly demands per SCRWA Water Reclamation Facility Order No. 98-052, 2014 Annual report, Table 1: 2014 Reclamation Facility-Monthly Averages.
2. Recharge amount assumes 8.5 MGD recycled water treatment and includes the Baseline System Customer Demands.
3. Recharge Facilities and Rates per Screening Level Assessment of IPR Reuse in the Llagas Subbasin, 2015 by Todd Groundwater.

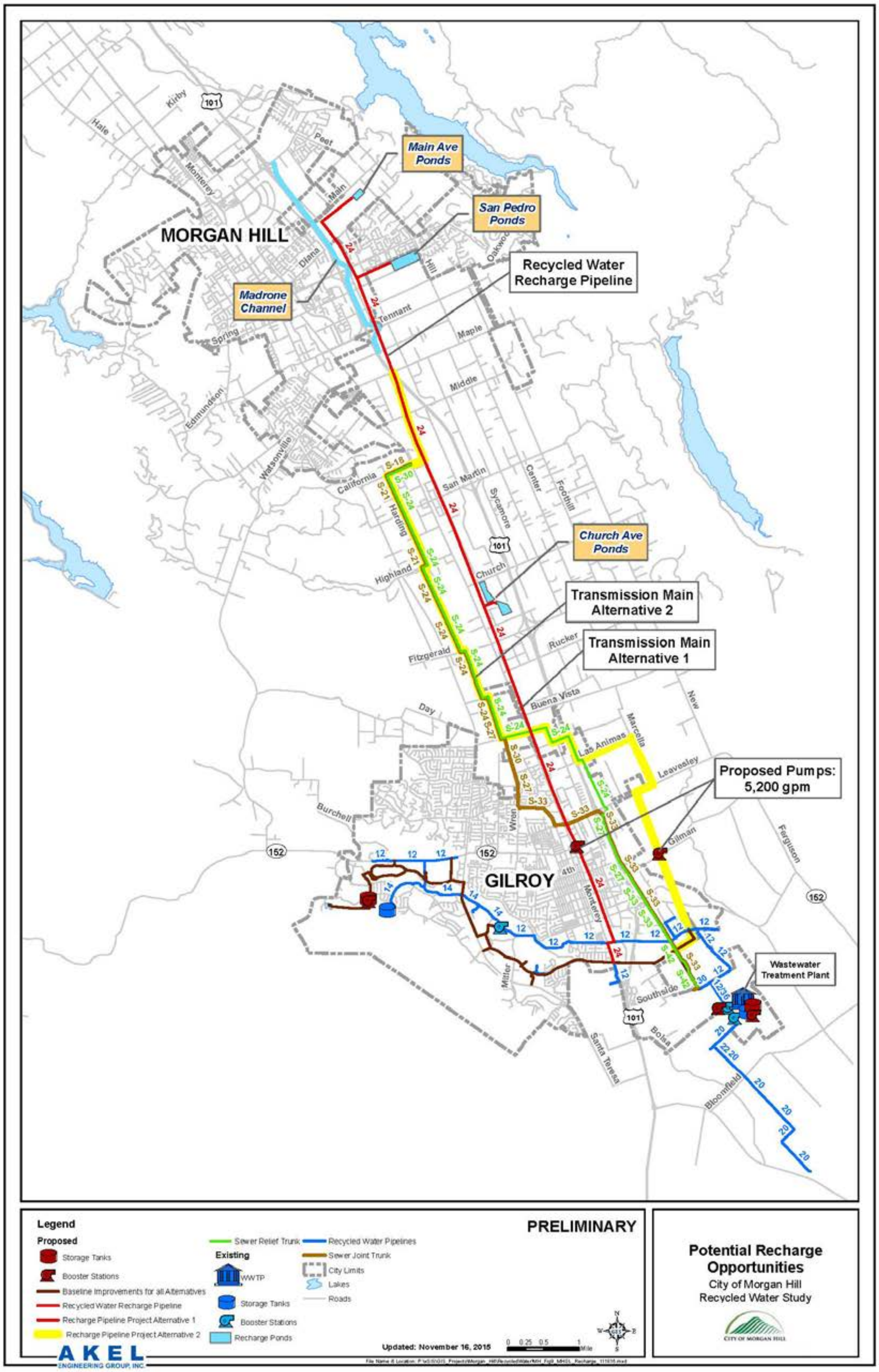
9/16/2015

AKEL ENGINEERING GROUP, INC.

3.6 GROUNDWATER RECHARGE ALTERNATIVES

The transmission mains required for conveying recycled water from the SCRWA WWTP to Morgan Hill for recharge are similar to those as described in Chapter 2.5; Alternative 1 – High Speed Rail Alignment, and Alternative 2 - Joint Trunk Transmission Main Alignment. For the recharge alternative the transmission main will extend from Maple Avenue to the potential recharge facilities. The existing potential recharge sites identified by Todd Groundwater in the 2015 Screening Level Assessment of IPR Reuse in the Llagas Subbasin report (Todd Report) are the Main Avenue Ponds, the Madrone Channel, the Church Avenue Ponds, and the San Pedro Ponds. The Todd Report also identifies other new potential recharge areas near Morgan Hill, if the existing sites cannot be utilized. The existing recharge facilities and proposed transmission mains are shown on Figure 10.

Figure 10: Potential Recharge Locations



4 EVALUATE FEASIBILITY OF SCALPING PLANT

4.1 BACKGROUND

Decentralized wastewater treatment plants, also known as scalping plants, intercept and treat wastewater before it flows to the centralized treatment facility. Scalping plants are typically utilized to produce recycled water in close proximity to both the source of wastewater that feeds the plant and the demand for the treated effluent. This type of decentralized treatment becomes attractive when it is challenging to convey recycled water from the centralized treatment plant to potential users.

The SCRWA operates the South County Regional WWTP, located over nine miles south of the southern boundary for the Morgan Hill. The SCRWA WWTP is currently producing Title 22 recycled water, however, the distance between the plant and potential recycled water users in Morgan Hill warrants the consideration of a scalping plant.

4.2 TREATMENT TECHNOLOGY

The proposed scalping plant would consist of a pretreatment process, a biological treatment process, and a disinfection step. The main treatment process of a scalping plant typically utilizes membrane bioreactor (MBR) technology. Solids from the process are transported to the central wastewater treatment plant via existing sanitary sewers.

4.2.1 MEMBRANE BIOREACTOR

An MBR plant utilizes both a suspended growth biological process and a microfiltration or ultrafiltration process. MBR systems do not rely on a gravity separation reactor to remove solids and can therefore operate at a higher mixed liqueur suspended solids (MLSS) concentration. High MLSS concentration and the lack of clarifiers or solids handling processes allow MBR scalping plants to have a very small footprint relative to a traditional wastewater treatment plant.

MBR systems have additional capital and operational costs associated with purchasing membranes, cleaning membranes, and providing sufficient transmembrane pressure to induce flow across the membranes. Additionally, flows in scalping plants are typically smaller than in centralized treatment plants leading to a high unit cost of water.

4.3 ENVIRONMENTAL AND REGULATORY CONSIDERATIONS

The proposed scalping plant would have no solids handling facilities, instead, returning solids to the central wastewater treatment plant. While this would simplify the environmental and regulatory considerations of this project, there would still be two categories of regulations that would apply to this project.

4.3.1 RECYCLED WATER REGULATIONS

For the uses considered for Morgan Hill's recycled water system, irrigation and industrial, California State Water Resources Control Board, Title 22 regulations would require the effluent from the proposed scalping plant to receive tertiary treatment and disinfection. An MBR at a satellite plant would meet the tertiary treatment requirement and chlorine disinfection was assumed as the disinfection method for this study.

4.3.2 CALIFORNIA ENVIRONMENTAL QUALITY ACT

The construction of a new MBR and associated facilities would be subject to the California Environmental Quality Act (CEQA). The first step in the CEQA process would be to prepare an initial study to evaluate potential impacts of the project, including but not limited to the following:

- Alternative locations for the project
- Footprint
- Mapping for sensitive resources
- Air emissions
- Geology
- Biological Resources
- Time to construct the facilities
- Estimate of costs
- Land use conflicts
- Permitting requirements

Based on the findings of this initial study, it would be determined if an Environmental Impact Review (EIR) or Mitigated Negative Declaration would be required for the project.

4.4 SCALPING PLANT COST ESTIMATE

Assessing the costs of implementing a MBR scalping plant requires considering capital costs and O&M costs for both the scalping plant and the recycled water distribution system. A 1 mgd scalping plant was assumed for this estimate. This capacity was selected based on the current dry weather minimum daily sewer flows from the Morgan Hill service area. It was further assumed that the scalping plant would be sited on a trunk line carrying half of the total Morgan Hill flows and that the process would have a 15% reject rate.

A treated water storage facility would also be required to allow recycled water users some flexibility in when to use recycled water. A 500,000 gallon storage facility (1 half day) is assumed for this estimate.

4.4.1 SCALPING PLANT CAPITAL COST ESTIMATE

A class 5 capital cost estimate was performed for the construction of a 1 mgd scalping plant with the following major components: pre-treatment process, MBR, a chlorine contact basin, and a treated water storage facility with one half day of capacity. The total capital cost for this scalping plant is estimated at $15.5 Million.

Table 11 provides a breakdown of the components of this capital cost.

Table 11: Estimate of Scalping Plant Capital Costs

Process Cost Summary		Subtotal
Sitework		$ 1,110,000
Structural		$ 2,520,000
Mechanical		$ 5,600,000
Electrical		$ 509,000
I&C		$ 255,000
Total Direct Costs		**$ 9,994,000**
Contractor's Overhead &Profit (17%)	17%	$ 1,699,000
Subtotal 1 (Direct Costs plus O&P)		**$ 11,693,000**
Mobilization/Bonds/Insurance (3% of Subtotal 1)	3%	$ 351,000
General Conditions (8% of Subtotal 1)	8%	$ 935,000
Subtotal 2		**$ 12,979,000**
Contingencies (20% of Subtotal 2)	20%	$ 2,596,000
Subtotal 3		**$ 15,575,000**
Administrative Costs (10% of Subtotal 3)	10%	$ 1,557,500
Permitting Costs (5% of Subtotal 3)	5%	$ 778,750
Real Estate (1 acre)	L.S	$ 100,000
Total Capital Costs		**$ 18,011,250**

4.4.2 O&M COST ESTIMATE

Table 12 provides a planning-level O&M cost estimate for the operation of a 1 mgd scalping plant consisting of a pre-treatment process, MBR, and a chlorine disinfection step. Electrical demands are due primarily to the power required to pump across the membranes and into the distribution system. Chemical costs include sodium hypochlorite for disinfection, membrane cleaning chemicals, and alum for coagulation.

Table 12: Scalping Plant O&M Cost Estimate

Description	Total ($/year)
Power Requirements	$ 76,000
Chemical Costs	$ 727,000
Equipment Replacement Cost	$ 126,000
Staffing Costs	$ 572,000
Total Annual Cost	***$ 1,500,000***

4.5 SCALPING PLANT FOOTPRINT

Dimensions for the MBR scalping plant components are based on past project experience and are provided in Table 13.The potential site layout is also shown in Figure 11.

Table 13: Dimensions for 1 mgd MBR Scalping Plant

Facility	SF
Intake & Screens	100
Pumps & Blowers	800
MBR Facility	1,200
Chemical Storage & Feed	1,600
Electrical/Control Room	600
Clearwell and Pumps	1500
Total Building Area Requirement	5,800
Total Area Required[1]	15,000

[1] Depends on Site Layout

Figure 11: Potential Scalping Plant Layout

4.6 PROJECT TIMELINE

Implementing a scalping plant would involve planning, permitting, design, construction, and commissioning phases. Completing these phases would require a minimum of three years.

4.7 ALTERNATIVE SCALPING PLANT RECYCLED WATER DISTRIBUTION SYSTEMS

The two proposed distribution system alignment options for the scalping plant alternative are to either serve customers on the east or west side of Highway 101. Similar to the transmission main analysis, different system options are presented as customer preference, user interest, or connection viability is based on planning level assumptions. The total demands the hydraulic analysis will focus on are based on 1.0 MGD of recycled water for existing conditions and 2.25 MGD of recycled water for buildout conditions. The 2.25 MGD scalping plant alternative is based on the sewer flows for the general plan buildout of Morgan Hill (approximately 4.5 MGD).

The recycled water distribution system expansion options for this alternative are as follows:

- **Option 1 (1 mgd) and 7 (2.25 mgd):** Option 1 serves customers on the east side of Highway 101 and begins with an 18-inch main heading east on Maple from the proposed scalping plant and connects to the Institute Golf Course as shown in purple on Figure

12. Option 7 expands the recycled water system from 1 mgd to 2.25 and includes additional customers along Condit Road and Dunne Avenue as shown in purple on Figure 13.

- **Option 5 (1 mgd) and 6 (2.25 mgd)**: Option 5 serves customers on the west side of Highway 101 and begins with as 18-inch main extending north from the proposed scalping plant to connect customers along Butterfield Boulevard up to Main Street as shown in green on Figure 12. Option 6 expands the recycled water system from 1 mgd to 2.25 mgd and includes additional customers north along Butterfield Boulevard up to Burnett Avenue as shown in green on Figure 13.

The demands and users for each of the options are documented on Table 4 and costs for the distribution system options are on Table 5.

Figure 12: 1 MGD Scalping Plant Distribution System

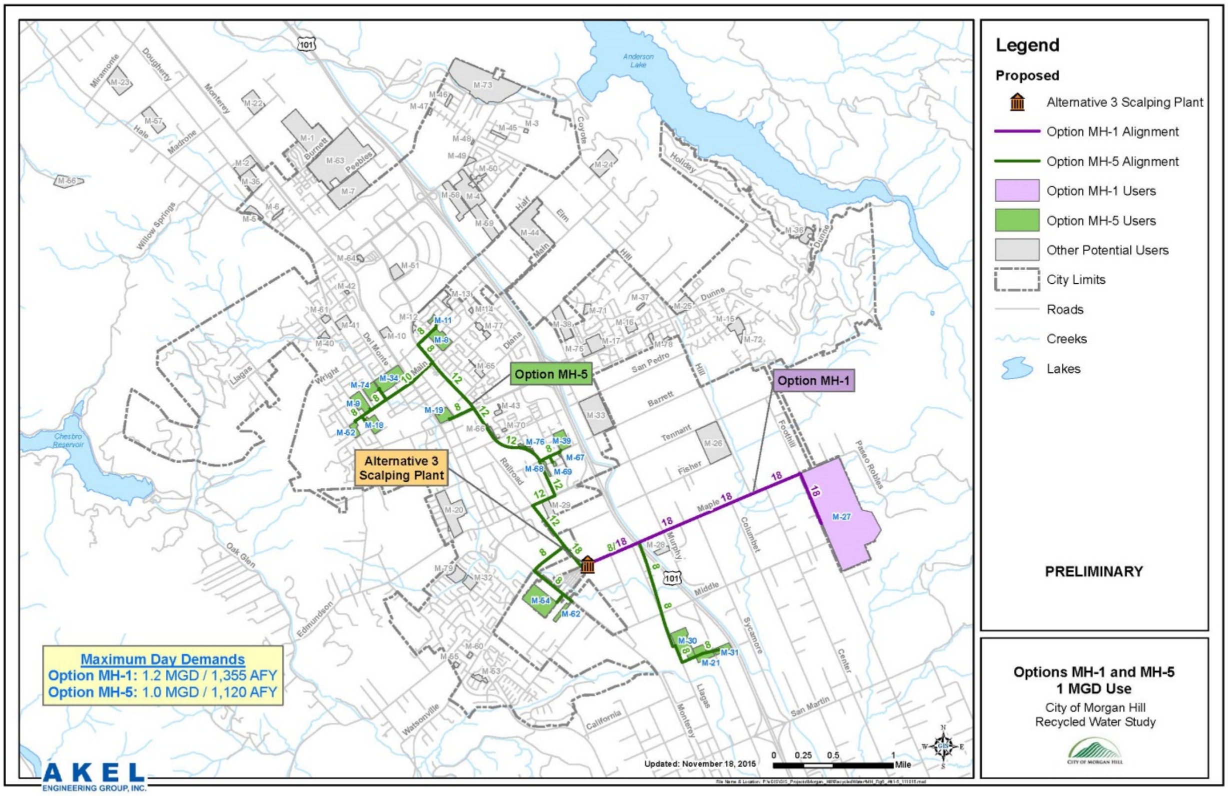
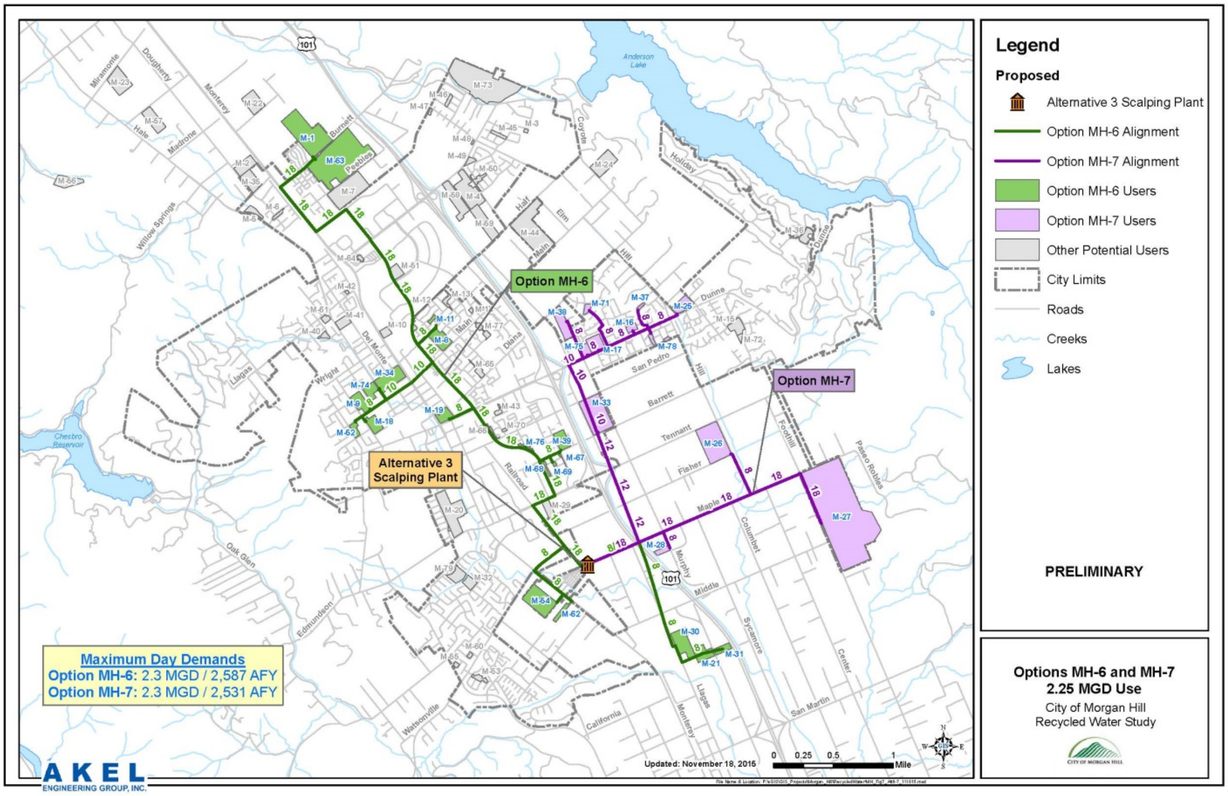


Figure 13: 2.25 MGD Scalping Plant Distribution System



4.8 COLLECTION SYSTEM IMPACTS

A scalping plant diverts flow away from the sewer line for use in recycled water applications. This can cause substantial reductions in sewer system flows downstream of the scalping plant. If flows drop too low odor issues can arise from the anaerobic decomposition of organics. Clogging can also become an issue when flows are so low that debris does not get flushed through the system. A successful scalping plant would be designed to maintain minimum flows in the sewer line at all times, even during hourly minimums resulting from the diurnal flow pattern typical of collection systems.

Membranes are not well suited for large variations in flow rates. Large diurnal variations in sewer flows could therefore limit to the capacity of the MBR to an unacceptably small value, or influent flow equalization would be required. The scalping plant also would need to be sized so as to leave adequate flow in the sewer during times of minimum sewer flows.

4.9 IMPACTS TO SCRWA WWTP BIOLOGICAL

Returning waste activated sludge to the collection system, while eliminating the need for on-site solids treatment, could cause negative impacts on the SCRWA WWTP. The biological processes that would occur in a scalping plant would reduce BOD loadings to the SCRWA WWTP but could substantially change the composition of the influent wastewater. Inconsistent sludge wasting at the scalping facility could also cause downstream problems with the biological processes. Small changes in the influent wastewater composition could cause major problems with the SCRWA WWTP.

Before progressing with the planning of a satellite scalping plant, the potential effect to the biological processes at the existing central WWTP would need to be carefully evaluated. If it is determined that downstream effects would be unacceptable, on-site solids processing may be required. This would substantially increase the capital and operational costs.

4.10 IMPACTS TO CURRENT RECYCLED WATER USERS

The SCRWA WWTP maintains and operates a recycled water treatment and distribution system. During peak recycled water demands, SCRWA utilizes a majority of the plant influent to produce recycled water. A scalping plant that diverts flow from the collection system would negatively impact the SCRWA recycled water system by reducing plant inflows during critical periods of peak recycled water demand (i.e., summer months). This could result in an inability to meet current recycled water demands.

5 EVALUATE EFFECTIVENESS OF GRAY WATER PROGRAM

5.1 BACKGROUND

Gray water systems collect residential wastewater from clothes washing machines, baths/showers, and bathroom wash basins for onsite irrigation. Utilizing gray water for onsite irrigation can offset potable water demand and allow for increased irrigation during times of water scarcity.

5.2 REGULATIONS

Title 24, Part 5, Chapter 16 of the California Department of Housing and Human Development Plumbing Code establishes the legal framework for permitting gray water systems in the State of California.

5.3 GRAY WATER DEFINITIONS

Gray water is defined as untreated wastewater that has not been contaminated by any toilet discharge, has not been affected by infectious, contaminated, or unhealthy bodily wastes, and does not present a threat from contamination by unhealthful processing, manufacturing, or operating wastes. In practical terms gray water generally includes discharges from clothes washing machines, showers, and bathroom washbasins but does not include discharges from toilets, kitchen sinks, or dishwashing machines. A gray water system collects and transports gray water for use in onsite landscape irrigation or disposal in a leaching field or mulch basin.

5.4 GRAY WATER SYSTEM TYPES

Gray water systems vary in complexity from inexpensive systems designed by homeowners to complex systems requiring professional design and installation. This section explores the most common types of residential onsite gray water recycling systems.

5.4.1 LAUNDRY-TO-LANDSCAPE

The simplest type of gray water system is known as a Laundry-to-Landscape System. A Laundry-to-Landscape System transports gray water from the washing machine discharge hose to the receiving landscape without altering any existing plumbing or utilizing pumps or storage devices. This type of gray water system can be installed by the home owner and does not require a permit. Several local agencies promote Laundry-to-Landscape gray water systems because of their relative simplicity and inexpensive installation and operation.

5.4.2 BRANCHED DRAIN

A Branched Drain System diverts gray water from shower/bath, wash basin, and clothes washing machine drainage pipes to the receiving landscape via a series of branching pipes under the force of gravity alone. This type of system requires a permit from the local enforcing agency.

5.4.3 PUMPED

A pumped system transports gray water from showers/baths, wash basins, and clothes washing machines to a small storage tank. A pump is used to transport the gray water to the receiving landscape. This type of system also requires a permit.

5.5 GRAY WATER SYSTEM REGULATIONS

The following is a listing of some of the relevant gray water regulations. For a complete list of gray water regulations see Chapter 16 of the California Plumbing Code, available online at: http://www.hcd.ca.gov/codes/state-housing-law/preface_et_emergency_graywater.pdf

- Gray water cannot pool or run off the receiving landscape
- Gray water systems must be designed to allow the user to direct flow to the sewer system to avoid pooling and runoff
- Gray water cannot be used in spray type irrigation methods (sprinklers)
- Gray water must not be used to irrigate root crops or food crops that touch the soil
- An owner's manual must be kept with a gray water system so future users can maintain and operate the system correctly
- The gray water system must be completely contained on the lot where the gray water is produced
- Any gray water system that is connected to the potable water distribution system must have a backflow prevention device

5.5.1 GRAY WATER CONSTRUCTION PERMIT

Section 1603A.0 of the California Plumbing Code requires a written construction permit issued by the local enforcing agency prior to the construction of any gray water system other than a Laundry-to-Landscape type system. To provide residents with a legal way to construct gray water systems, the Morgan Hill Community Development Division would need to establish a system to issue permits.

5.5.2 MODEL WATER EFFICIENT LANDSCAPE ORDINANCE

The Model Water Efficient Landscape Ordinance (MWELO) mandates local agencies to place restrictions on new and renovated landscapes in an effort to reduce water use to the lowest practical amount. In response to the current drought, the California Department of Water Resources has updated the MWELO to improve water savings. This update is pending final approval from the Office of Administrative Law. The revised ordinance includes an exemption from a majority of the MWELO requirements for certain landscapes irrigated entirely with gray water.

5.6 IMPLEMENTATION OF GRAY WATER SYSTEM IN MORGAN HILL

Large scale participation in a City wide gray water program would require homeowners and property managers to assume the responsibility of installing, maintaining, and operating gray water systems on their property. Neglected or improperly installed systems pose an environmental and public health risk.

5.6.1 EXISTING GRAY WATER PROGRAM

Morgan Hill residents are currently eligible for a $200 rebate to cover gray water system costs through the Santa Clara Valley Water District Laundry to Landscape Program provided they meet the program requirements. These requirements include conforming to the California Plumbing Code regulations for laundry to landscape gray water systems and an assessment by Santa Clara Water District officials. The assessment may include a series of questions or inspections before and after the installation of the gray water system.

5.6.2 OTHER LOCAL GRAY WATER REBATE PROGRAMS

Currently, many jurisdictions, including the City of Santa Cruz, the City of Santa Rosa, San Francisco Public Utilities Commission, and the City of Tucson, AZ, offer rebates from $150 to $1000 for customers who install a gray water system. Santa Cruz and San Francisco specify that the gray water system must be a Laundry-to-Landscape System while Tucson and Santa Rosa do not place this restriction on the rebate. These agencies also offer workshops, informational resources, and assistance to customers.

5.6.3 GRAY WATER IMPEDIMENTS

Major barriers to large scale participation in onsite gray water reuse systems include the potentially costly and time consuming permitting process, complex and expensive installation, maintenance costs, and environmental and public health concerns. A city-wide gray water incentive program that addresses all of the barriers stated above would be required to maximize participation.

5.6.4 EDUCATION AND OUTREACH

The first component of a successful gray water incentive program is education and outreach aimed at informing residents what a gray water system is and how they can implement one to conserve water. The information could present the benefits to users who install a gray water system including reduced water costs and the ability to irrigate landscaping more frequently without violating of the City’s Level II Water Supply Shortage Water Use Restrictions. Workshops and brochures could be used to distribute this information.

5.6.5 TECHNICAL GUIDE

A technical manual could provide residents information including the types of gray water systems available, the laws and regulations associated with operating a gray water system, detailed instructions on how to install and operate a gray water system, and assistance in navigating the permitting process. The attached San Francisco Public Utilities Commission Gray Water Design Manual, published in 2012, could serve as an example.

5.6.6 REBATES

The City could offer additional rebates to residents who install a gray water system on their property to offset construction costs and encourage participation in the program.

5.6.7 LOCAL PERMITTING

A streamlined permitting process would reduce the time and cost of installing a gray water system and encourage participation. Laundry-to-Landscape systems do not require a permit and could be advertised as an easier method for homeowners to implement a gray water system.

5.7 IMPACT OF GRAY WATER SYSTEM ON ACHIEVING CONSERVATION GOALS AND IRRIGATION NEEDS

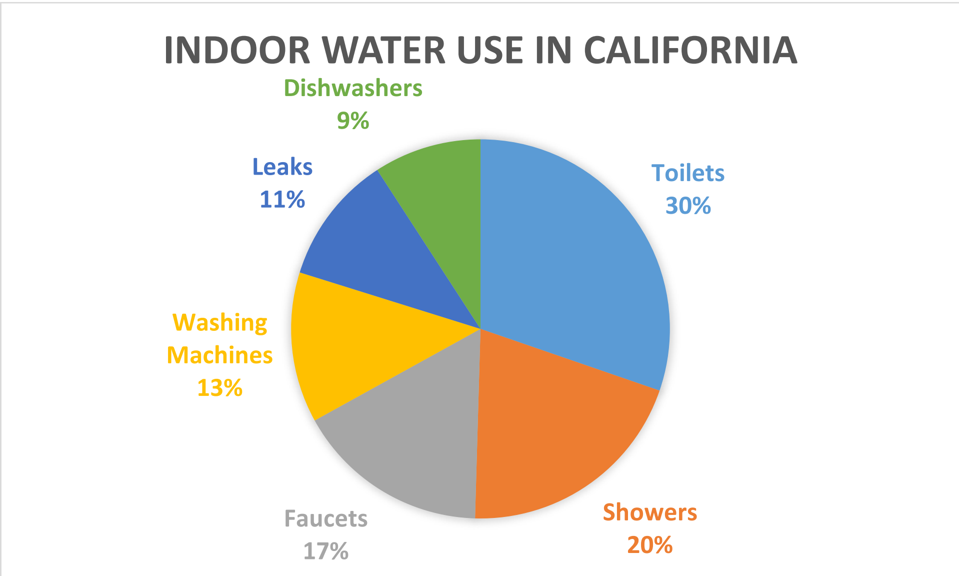
Utilizing gray water for landscape irrigation can offset potable water demand. The extent of potable water demand reduction will heavily depend on the participation rate, the type of gray water systems in use, and the method of irrigation.

5.7.1 RESIDENTIAL WATER REDUCTIONS

Predicting residential water demand reductions resulting from the installation of a gray water system is challenging because of the variety of gray water systems available and because the installation of the system may correspond to changes in landscaping practices or increased water conservation efforts.

The California Department of Water Resources estimates that indoor water accounts for approximately 31% of total urban water demand. Of that water, Figure 14 shows that 13% is recoverable as gray water in a Laundry-to-Landscape System and 45% is recoverable as gray water in a more comprehensive system (assuming half of faucet effluent comes from kitchen sinks and is not gray water.)

Figure 14: Indoor Water Use in California



Multiplying the percent of indoor water use that is recoverable as gray water by the percent of total urban water demand that is used indoors gives an estimate of the percent of urban water that is recoverable as gray water. Multiplying by the participation rate provides an estimate for the actual fraction of water that could be recovered as gray water.

Table 13 shows the percent of urban water that is available for onsite gray water reuse approximated using the method described above. It is important to note that not all of this gray water will displace potable water demand. Time of use and distribution issues may lead to some gray water not being utilized. Therefore, the actual urban water demand reductions achieved from a gray water incentive program would likely be lower than these values.

Table 13: Estimates of Water Available for Gray Water Reuse

Percent of Urban Water Available for Grey-Water Reuse				
Gray Water System Type	Participation Level			
	1%	10%	50%	100%
Laundry-to-Landscape	0.04%	0.43%	2.17%	4.34%
Comprehensive	0.14%	1.40%	6.98%	13.95%

5.8 EFFECT OF GRAY WATER SYSTEMS ON SCRWA WWTP AND CURRENT RECYCLED WATER CUSTOMERS

A gray water system diverts water that would otherwise be destined for the sewer system to the receiving landscape. This will cause a reduction in the influent flows of the South County Regional Wastewater Authority (SCRWA) Wastewater Treatment Plant.

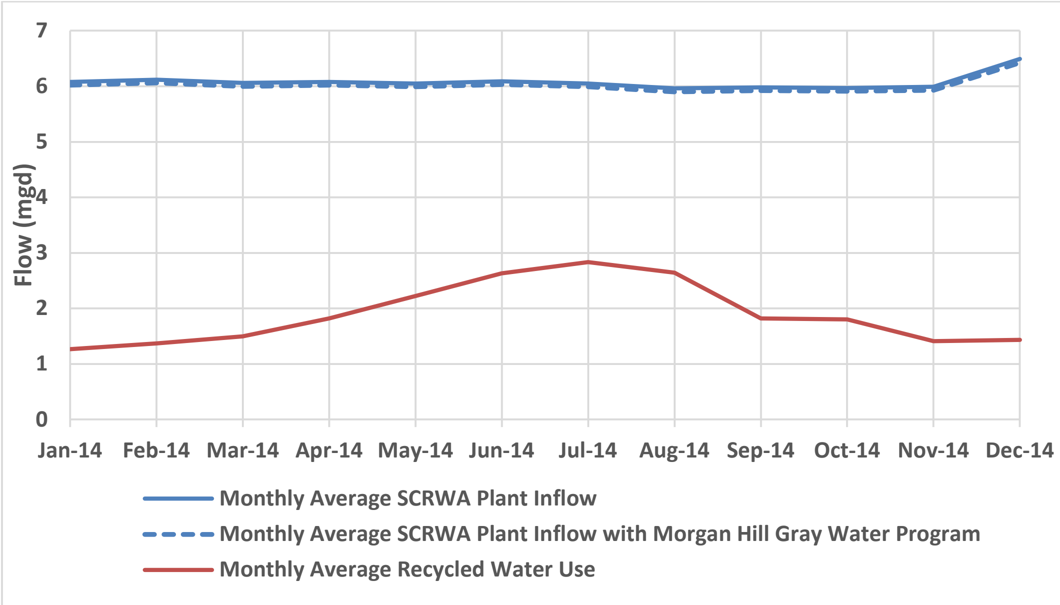
5.8.1 SEASONAL REDUCTIONS IN WWTP INFLUENT

Gray water systems will not reduce wastewater treatment plant inflows uniformly throughout the year. During the wet season more gray water will be routed through the sewer system to avoid pooling and runoff in the receiving landscape. If 50% of Morgan Hill Residents implement a Laundry-to-Landscape type gray water system, Table 11 indicates there would be up to a 2% reduction in urban water demand. Assuming all of this flow is redirected away from the sewer system and 40% of SCRWA WWTP influent comes from the Morgan Hill service area, a reduction in SCRWA WWTP influent flows of around 1% would be expected.

5.8.2 CURRENT SCRWA RECYCLED WATER USE

Figure 15 shows that the SCRWA WWTP currently recycles approximately 40% of its inflow during dry weather periods. This figure shows the effect of a gray water program on SCRWA plant influent assuming approximately 25% of residents implement a Laundry-to-Landscape type gray water system. At times of peak recycled water demand nearly 100% of the plant inflow is recycled. During these time periods the reduction in SCRWA WWTP inflows resulting from a gray water program in Morgan Hill could reduce recycled water supply to SCRWA customers.

Figure 15: SCRWA Plant Inflow and Recycled Water Demand



5.9 BENIFITS AND COSTS OF PROMOTING GRAY WATER SYSTEMS

This section presents a summary of the benefits and challenges associated with promoting gray water systems in Morgan Hill.

5.9.1 BENIFITS OF PROMOTING A GRAY WATER SYSTEM

Potential to offset potable water demand:

Large scale participation in a gray water program could offset the demand for potable water by utilizing gray water instead of potable water of irrigation needs.

Allow for continued irrigation during water restrictions:

Implementation of a gray water system would allow residents to continue irrigation beyond allowable levels under a water restriction. Current water restrictions allow for irrigation only on specific days of the week.

Fulfill obligations of California Model Water Efficient Landscape Ordinance:

Utilizing a gray water system at landscapes regulated by the California Model Water Efficient Landscape Ordinance would exempt the landscape from a majority of the restrictions of the ordinance.

5.9.2 COSTS OF PROMOTING A GRAY WATER SYSTEM

Costs to water district associated with rebates:

While offsetting potable water demand could reduce variable costs associated with delivering potable water and potential future expansion costs, any agency providing rebates would be required to fund this upfront expense.

Installation and maintenance costs for homeowners:

Any installation or maintenance costs of a gray water system not covered by rebates would have to be assumed by homeowners.

Improperly installed systems can create environmental and health risks:

Given the distributed nature of residential gray water systems, installation and maintenance requirements would largely be assumed by homeowners. If systems are not installed or maintained properly, gray water can pool or runoff into the stormwater system or water bodies. This could pose and environmental or public health risk.

Permitting process could be a barrier to installation of gray water system:

Permitting gray water systems, while important for maintaining environmental and public health, could potentially induce costs and tie up resources to the enforcing agency.

6 COST AND FEASIBILITY ANALYSIS

6.1 EVALUATION CRITERIA

The four recycled water utilization alternatives are evaluated based on the following criteria

- Technical feasibility
- Capital costs
- Operation and maintenance costs
- Regulatory considerations
- Value of recycled water supply

6.1.1 TECHNICAL FEASIBILITY

This section presents the anticipated technical challenges associated with each of the recycled water alternatives.

6.1.1.1 Bringing Recycled Water from SCRWA

There are no exceptional technical challenges identified for this alternative.

6.1.1.2 Using Recycled water for Recharge

The major technical challenge identified for using recycled water for groundwater recharge is the potential need for additional treatment. As described in Section 3, recycled water used for groundwater recharge could require additional treatment to meet the California Title 22 regulations. These treatment facilities would like include an RO process which would necessitate the development of a RO concentrate disposal solution.

6.1.1.3 Scalping Plant

Several technical challenges are identified for this alternative. Firstly, operating a satellite treatment facility requires additional staff with wastewater treatment plant operations experience on a part time or full time basis. Secondly, a scalping plant could cause odor and clogging problems in the downstream collection system. Lastly, scalping flow off of the sewer main could create process performance issues at the SCRWA WWTP due to the change in composition of the incoming wastewater.

6.1.1.4 Gray Water System

The major technical challenge identified with promoting gray water systems is gray water systems are installed and maintained properly. Because gray water systems would be installed and maintained by homeowners, the City would need to make an effort to ensure systems remain functional.

6.1.2 CAPITAL COSTS

The purpose of this section is to provide a summary of the recommended recycled water system improvements and to provide cost estimates for future system expansion to Morgan Hill.

Costs developed in this study should be considered “Order of Magnitude” and have an expected accuracy range of **-30 percent** and **+50 percent**. Final costs of a project will depend on several factors including the final project scope, costs of labor and materials, and market conditions during construction.

Table 14 documents the cost estimating criteria used to develop the alternative costs. Included in this table are the unit costs for pipelines, a pump station cost equation, storage reservoir costs, land acquisition costs, O&M costs for the distribution system, and the cost estimating contingencies.

The capital costs for the projects identified for all alternatives are summarized on Table 15, Table 16, and Table 17.

Table 14: Cost Estimating Criteria

Pipe Size (ID) (in)	Unit Costs[1] ($/lineal foot)
8	132
10	159
12	174
14	198
16	210
18	215
24	261
30	352
36	412
Pump Stations	
Estimated Pumping Station Project Cost = 2.03 * 10^(0.7583*log(Q)+3.1951); where Q is in gpm	
Storage Reservoirs ($/gal)	
≤ 1.0 MG	$1.40
1.1 MG - 3.0 MG	$2.12
3.1 MG - 5.0 MG	$3.23
> 5.0 MG	$4.33
Land and Easement Acquisition Costs ($/sqft)	
Land Acquisition Cost	$15 per sqft
Easement Fees	30% of Land Acquisition Costs
Lot Size for Storage or Pump Stations	0.5 Acres
Operation and Maintenance Costs	
Purchased Power Costs[2]	
Per Kilowatt Hour	$0.20
Distribution System Maintenance Costs[3]	
Per Mile of Pipe	$3,500
General Administration Costs[3]	
Per Mile of Pipe	$1,900
Costs Estimating Contingencies[4]	
Estimating	20%
Construction	20%
Administration	30%

AKEL ENGINEERING GROUP, INC. 10/22/2015

Notes:

1. Unit Cost estimates per recent bid tabs and are based on the Engineering News Record (ENR) construction cost index (CCI) of 10037 for the 20 cities for July 2015.

2. kWh cost per PG&E rates

3. System maintenance and administration costs per 2004 SCRWA Master Plan and escalated based on the Engineering News Record (ENR) construction cost index (CCI) for the 20 cities for July 2015.

4. Contingencies:
   - Estimating contingency of 20% to account for unforeseen events and unknown conditions.
   - Construction contingency of 20% to account for engineering design and construction management and inspection.
   - Administration contingency of 30% to account for administration and legal costs.

Table 15: Alternative 1 Distribution System Costs

PRELIMINARY

Recycled Water from SCRWA WWTP to Morgan Hill - System Option Costs

Item No.	Description	Size/Length	Unit	Unit Price	Total
Morgan Hill Transmission Main - Alternative 1[1]					
1	**Distribution System Pipelines**				
	24-inches in Diameter	47,500	ft	$261	$ 12,398,000
	Sub-Total				$ 12,398,000
2	**Land Acquisition**				
	Easement	1,425,000	sq. ft.	30% of $15	$ 6,413,000
	Pump Station	21,780	sq. ft.	$15	$ 327,000
	Sub-Total				$ 6,740,000
	Total				$ 19,138,000
			Contingencies		
			Estimating	20%	$ 3,828,000
			Construction	20%	$ 4,593,000
			Administration	30%	$ 8,268,000
			Project Cost		**$ 35,827,000**
Option 1 (1 MGD)					
1	**Distribution System Pipelines**				
	18-inches in Diameter	10,200	ft	$215	$ 2,193,000
	Sub-Total				$ 2,193,000
2	**Pump Station**				
	Pump Capacity (firm)	2,025	gpm		$ 1,023,000
	Total				$ 3,216,000
			Contingencies		
			Estimating	20%	$ 643,000
			Construction	20%	$ 772,000
			Administration	30%	$ 1,389,000
			Project Cost		**$ 6,020,000**
	Total Project Cost + Transmission Main to Maple Avenue				**$ 41,847,000**
Option 2 (1 MGD)					
1	**Distribution System Pipelines**				
	8-inches in Diameter	11,100	ft	$132	$ 1,465,000
	24-inches in Diameter	5,100	ft	$261	$ 1,331,000
	Sub-Total				$ 2,796,000
2	**Pump Station**				
	Pump Capacity (firm)	860	gpm		$ 532,000
	Total				$ 3,328,000
			Contingencies		
			Estimating	20%	$ 666,000
			Construction	20%	$ 799,000
			Administration	30%	$ 1,438,000
			Project Cost		**$ 6,231,000**
	Total Project Cost + Transmission Main to Maple Avenue				**$ 42,058,000**
Option 3 (2.25 MGD)					
1	**Distribution System Pipelines**				
	8-inches in Diameter	5,700	ft	$132	$ 752,000
	18-inches in Diameter	10,200	ft	$215	$ 2,193,000
	24-inches in Diameter	5,100	ft	$261	$ 1,331,000
	Sub-Total				$ 4,276,000
2	**Pump Station**				
	Pump Capacity (firm)	2,900	gpm		$ 1,343,000
	Total				$ 5,619,000
			Contingencies		
			Estimating	20%	$ 1,124,000
			Construction	20%	$ 1,349,000
			Administration	30%	$ 2,428,000
			Project Cost		**$ 10,520,000**
	Total Project Cost + Transmission Main to Maple Avenue				**$ 46,347,000**
Option 4 (2.25 MGD)					
1	**Distribution System Pipelines**				
	8-inches in Diameter	28,600	ft	$132	$ 3,775,000
	10-inches in Diameter	5,400	ft	$159	$ 859,000
	12-inches in Diameter	2,000	ft	$174	$ 348,000
	24-inches in Diameter	14,800	ft	$261	$ 3,863,000
	Sub-Total				$ 8,845,000
2	**Pump Station**				
	Pump Capacity (firm)	2,400	gpm		$ 1,164,000
	Total				$ 10,009,000
			Contingencies		
			Estimating	20%	$ 2,002,000
			Construction	20%	$ 2,402,000
			Administration	30%	$ 4,324,000
			Project Cost		**$ 18,737,000**
	Total Project Cost + Transmission Main to Maple Avenue				**$ 54,564,000**

AKEL ENGINEERING GROUP, INC

11/18/2015

Notes:

1. Morgan Hill Transmission Main Limits: From SCRWA to Maple Ave.

Table 16: Alternative 2 Distribution System Costs

PRELIMINARY

Item No.	Description	Size/Length	Unit	Unit Price	Total
Recharge Pipeline Project					
Recharge Pipeline - Alternative 1[1]					
1	**Distribution System Pipelines**				
	24-inches in Diameter	59,900	ft	$261	$ 15,634,000
	Sub-Total				$ 15,634,000
2	**Pump Station**				
	Pump Capacity (firm)	5,200	gpm		$ 2,091,000
	Sub-Total				$ 2,091,000
3	**Land Acquisition**				
	Easement	1,797,000	sq. ft.	30% of $15	$ 8,087,000
	Pump Station	21,780.0	sq. ft.	$15	$ 327,000
	Sub-Total				$ 8,414,000
	Total				$ 26,139,000
			Contingencies		
			Estimating	20%	$ 5,228,000
			Construction	20%	$ 6,273,000
			Administration	30%	$ 11,292,000
			Total Project Cost		**$ 48,932,000**

AKEL ENGINEERING GROUP, INC.

1. Recharge Pipeline Project Limits: From SCRWA to Main Ave.

11/18/2015

Table 17: Alternative 3 Distribution System Costs

PRELIMINARY

Scalping Plant - Distribution System Option Costs

Item No.	Description	Size/Length	Unit	Unit Price	Total
Option 1 (1 MGD)					
1	**Distribution System Pipelines**				
	18-inches in Diameter	12,900	ft	$215	$ 2,774,000
	Sub-Total				$ 2,774,000
2	**Pump Station**				
	Pump Capacity (firm)	2,025	gpm		$ 1,023,000
	Sub-Total				$ 1,023,000
	Total				$ 3,797,000
			Contingencies		
			Estimating	20%	$ 759,000
			Construction	20%	$ 911,000
			Administration	30%	$ 1,640,000
			Total Project Cost		**$ 7,107,000**
Option 5 (1 MGD)					
1	**Distribution System Pipelines**				
	8-inches in Diameter	22,400	ft	$132	$ 2,957,000
	10-inches in Diameter	2,700	ft	$159	$ 429,000
	12-inches in Diameter	11,700	ft	$174	$ 2,036,000
	18-inches in Diameter	1,500	ft	$215	$ 323,000
	Sub-Total				$ 5,745,000
2	**Pump Station**				
	Pump Capacity (firm)	1,400	gpm		$ 775,000
	Sub-Total				$ 775,000
	Total				$ 6,520,000
			Contingencies		
			Estimating	20%	$ 1,304,000
			Construction	20%	$ 1,565,000
			Administration	30%	$ 2,817,000
			Total Project Cost		**$ 12,206,000**
Option 6 (2.25 MGD)					
1	**Distribution System Pipelines**				
	8-inches in Diameter	21,500	ft	$132	$ 2,838,000
	10-inches in Diameter	2,700	ft	$159	$ 429,000
	12-inches in Diameter	100	ft	$174	$ 17,000
	18-inches in Diameter	27,400	ft	$215	$ 5,891,000
	Sub-Total				$ 9,175,000
2	**Pump Station**				
	Pump Capacity (firm)	2,550	gpm		$ 1,218,000
	Sub-Total				$ 1,218,000
	Total				$ 10,393,000
			Contingencies		
			Estimating	20%	$ 2,079,000
			Construction	20%	$ 2,494,000
			Administration	30%	$ 4,490,000
			Total Project Cost		**$ 19,456,000**
Option 7 (2.25 MGD)					
	Distribution System Pipelines				
	8-inches in Diameter	12,700	ft	$132	$ 1,676,000
	10-inches in Diameter	4,300	ft	$159	$ 684,000
	12-inches in Diameter	5,100	ft	$174	$ 887,000
	18-inches in Diameter	12,900	ft	$215	$ 2,774,000
	Sub-Total				$ 6,021,000
2	**Pump Station**				
	Pump Capacity (firm)	3,100	gpm		$ 1,399,000
	Sub-Total				$ 1,399,000
	Total				$ 7,420,000
			Contingencies		
			Estimating	20%	$ 1,484,000
			Construction	20%	$ 1,781,000
			Administration	30%	$ 3,206,000
			Total Project Cost		**$ 13,891,000**

AKEL ENGINEERING GROUP, INC

11/18/2015

6.1.3 OPERATIONS AND MAINTENANCE COSTS

The operations and maintenance (O&M) costs for the distribution system include the following three components:

- **Purchased Power**: The purchased power accounts for the pump station power consumption. The average yearly flow and a power cost of $0.20 per kilowatt-hour (per PG&E rates) was used to calculate the annual power costs for the pump stations.
- **Distribution System Maintenance**: The annual distribution system maintenance costs were based on $3,500 per mile of pipe. This cost is based on the 2004 Master Plan and escalated based on the ENR-CCI.
- **General Administration**: The annual general administration cost is based on $1,900 per mile of pipe. This cost is based on the 2004 Master Plan and escalated based on the ENR-CCI.

The O&M cost estimates are documented on Table 18 for the Morgan Hill Recycled Water Alternatives.

Table 18: Alternatives O&M Costs

PRELIMINARY

Description	SCRWA WWTP to Morgan Hill[1]			
	Option 1 (1 MGD)	Option 2 (1 MGD)	Option 3 (2.25 MGD)	Option 4 (2.25 MGD)
Purchased Power	$110,000	$89,000	$200,000	$236,000
Distribution System Maintenance	$7,000	$11,000	$14,000	$34,000
General Administration	$4,000	$6,000	$8,000	$18,000
Estimating Contingency (20%)	$24,000	$21,000	$44,000	$58,000
Annual O&M Costs	$145,000	$127,000	$266,000	$346,000
Description	**Morgan Hill Transmission Main - Recharge Pipeline**			
	SCRWA To Maple Avenue			
Purchased Power	$841,000			
Distribution System Maintenance	$31,000			
General Administration	$17,000			
Estimating Contingency (20%)	$178,000			
Annual O&M Costs	$1,067,000			
Description	**Scalping Plant Alternatives**			
	Option 1 (1 MGD)	Option 5 (1 MGD)	Option 6 (2.25 MGD)	Option 7 (2.25 MGD)
Purchased Power	$100,000	$97,000	$214,000	$207,000
Distribution System Maintenance	$9,000	$25,000	$34,000	$23,000
General Administration	$5,000	$14,000	$19,000	$13,000
Estimating Contingency (20%)	$23,000	$27,000	$53,000	$49,000
Annual O&M Costs	$137,000	$163,000	$320,000	$292,000

AKEL ENGINEERING GROUP, INC.

11/18/2015

Note:

1. Not including Morgan Hill Transmission Main

6.1.4 REGULATORY CONSIDERATIONS

The following sections provide a summary of the regulatory challenges associated with each of the alternatives.

6.1.4.1 Bringing recycled water from SCRWA WWTP

This alternative comes with very limited regulatory considerations because the recycled water produced at the SCRWA WWTP is already permitted as disinfected tertiary effluent according to the Title 22 Recycled Water Regulations.

6.1.4.2 Using Recycled Water for Recharge

Regulatory requirements for using recycled water for recharge include complying with Article 5.2 of the Title 22 Recycled Water Regulations. Actions would include developing an engineering report for the RWQCB and the DDW to demonstrate compliance with Title 22 regulations and potential tracer studies, analytical modelling, or numerical modelling, to demonstrate sufficient underground detention time for the recycled water.

6.1.4.3 Scalping Plant

Recycled water from a scalping would need to be designated as tertiary disinfected recycled water by the DDW. The treatment processes at the scalping plant would need to be validated to show they provide sufficient bacterial and virus removal. Additionally, a CEQA review process would be required prior to the construction of a scalping plant.

6.1.4.4 Promoting Gray Water Systems

The regulatory framework is already in place for gray water systems in California. The only challenge would be creating a permitting system with the City of Morgan Hill to approve and regulate gray water systems.

6.1.5 VALUE OF RECYCLED WATER SUPPLY

The value of the recycled water provided by each alternative will depend on its quality, quantity, and availability of the recycled water.

6.1.5.1 Bringing recycled water from SCRWA WWTP

Recycled water delivered from the SCRWA WWTP to customers in Morgan Hill, would be of lower value because recycled water availability would not correspond with recycled water demand. This is because current customers already use a majority of the recycled water supply during peak demand periods. Recycled water use in Morgan Hill would be limited to times when there is a surplus supply of recycled water, like wet months and during off demand times of the day.

6.1.5.2 Using Recycled Water for Recharge

Using recycled water for recharge would provide the highest value recycled water. This is because all surplus recycled water can be stored in the groundwater aquifer and then used during peak demand periods. Additionally, if the Title 22 Recycled Water Regulations for Groundwater Replenishment Projects are met, this water would be suitable for potable use.

Groundwater is sold by the City as part of its drinking water supply which means recycled water supplied to the aquifer would provide increased revenue when it is sold as drinking water. This revenue would be greater than the revenue expected from the sale of recycled water.

6.1.5.3 Scalping Plant

The quantity of recycled water produced by a scalping plant would be limited by the amount of wastewater produced upstream of the scalping plant. Wastewater intercepted by a scalping plant would likely otherwise be diverted to the tertiary treatment facilities at the SCRWA WWTP. Typically, recycled water is sold to customers for less than the price of drinking water, but the cost to produce it, based on the estimates provided above, would be far higher. For this reason, there is little value associated with operating a scalping plant to produce recycled water.

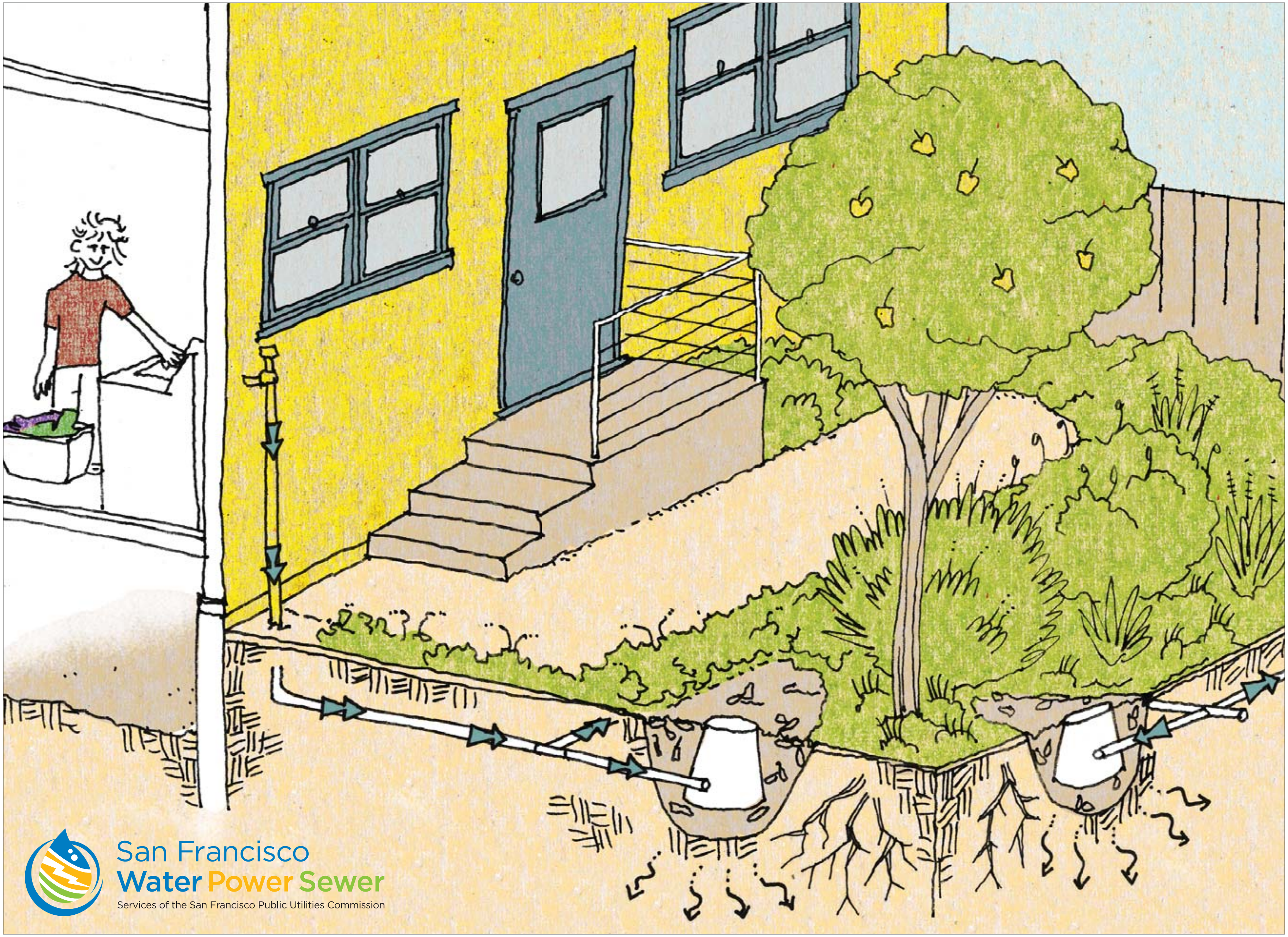
6.1.5.4 Promoting Gray Water Systems

Recycled water produced from gray water systems is of low value. This is because it is only available during times when the gray water is being produced, it is only available on the site where it is produced, and it is only a fraction of the total wastewater that is produced.

6.2 RECOMMENDEDED ALTERNATIVES

Should the City wish to pursue the use of recycled water, the recommended alternative, based on technical feasibility, capital costs, operation and maintenance costs, regulatory considerations, and value of recycled water supply is to use recycled water for groundwater recharge. This alternative would provide a large supply of water during off-peak periods that could be stored when available and utilized when needed. This alternative does have challenges associated with meeting the water quality requirements for groundwater recharge; however, the supply of high quality drinking water warrants consideration of this challenge.

Attachment 1: San Francisco Public Utilities Commission Gray Water Manual



SAN FRANCISCO

graywaterdesignmanual

for OUTDOOR IRRIGATION

June 2012 Version - Updates will be published as necessary

SAN FRANCISCO

graywater design manual

FOR OUTDOOR IRRIGATION

City of San Francisco

Edwin M. Lee, Mayor

San Francisco Public Utilities Commission

PROJECT TEAM

San Francisco Public Utilities Commission

Bart Broome
Rosey Jencks
Marla Jurosek
Paula Kehoe
Rachel Kraai
Julie Ortiz
Sarah Rhodes

San Francisco Department of Building Inspection

Vivian Day
Steven Panelli

San Francisco Department of Public Health

June Weintraub

Water Resources Engineering, Inc.

Laura Allen
Stephanie Knott

The project team would like to thank Jeff Parker and Raphael Garcia for providing valuable peer review of the San Francisco Graywater Design Manual.

CONTENTS

This guide gives an overview of the design, construction, permitting, and operation of graywater systems for outdoor irrigation, including laundry-to-landscape, branched-drain, and pumped systems.

Introduction

Overview of Guide

Why send your laundry water to be treated at a sewage treatment plant when you could use it to water plants and trees in your own yard instead? Sending water that's clean enough for other uses out of the house with the sewage doesn't make sense. That's why many Californians use their laundry and shower water to keep their landscapes green, even during times of drought.

The *San Francisco Graywater Design Manual for Outdoor Irrigation* is an educational resource for homeowners and professionals who want to install residential graywater systems for subsurface outdoor irrigation. In this guide, you'll learn about the benefits of graywater, when and where to use it, when not to use it, permitting requirements, what products to use, and suggested plants to irrigate.

The guide provides suggested methods for designing and installing a laundry-to-landscape system and a basic overview of the design and installation of branched-drain and pumped systems. The methods described in this guide may not be the only acceptable procedures for designing and installing systems that meet current requirements. Each homeowner's circumstances are different: you must ensure that a graywater system on your property is designed and installed safely, is consistent with applicable code requirements, and is operated in a manner that causes no harm or damage to yourself or neighbors. If at any time you have doubts about undertaking the installation of a graywater system, please consult a professional installer.

San Francisco's Water Supply

Residents of San Francisco receive some of the highest quality tap water in the nation. Sierra snowmelt flows into the Tuolumne River, is stored in the Hetch Hetchy Reservoir, and travels 167 miles by gravity to San Francisco. Our regional water system carries pristine water to 2.5 million customers throughout San Francisco and the Bay Area. The San Francisco Public Utilities Commission (SFPUC) , provider of San Francisco's water, power and sewer, is committed to preserving this precious resource through conservation and by using local alternative supplies—such as recycled water, rainwater, and graywater—for non-potable purposes. Using laundry water for irrigation is one of many ways to conserve our drinking water supply and reduce flows to our wastewater system.

What is Graywater?

Graywater is water from washing machines, showers, bathtubs, and bathroom sinks. It is wastewater that can contain some soap, salts, hair, suspended solids and bacteria, but that is clean enough to water plants. Water from toilets, kitchen sinks, or wash water from diapers is not considered graywater in California.

Graywater (treated or untreated) is not the same as recycled water, which is highly treated wastewater from a centralized treatment facility. Recycled water is commonly used in other Bay Area cities, and the SFPUC is working on several recycled water projects in San Francisco.

Benefits of Graywater

Reusing graywater is an important component of sustainable water practices. There are many benefits of using graywater instead of potable water for irrigation.

Reusing graywater can:

- Decrease potable water use by 16 to 40 percent, depending on the site (Cohen 2009).
- Decrease water and wastewater utility bills.
- Diversify the City's water portfolio and provide an alternate source of irrigation water, reserving treated potable water for high-quality water needs.
- Reduce the energy (approximately 2 watt-hours per gallon of water) and chemicals needed to treat wastewater.

Another benefit of using graywater is that it connects us to our water supply, helping us understand where our water comes from and where it goes. Becoming conscious of our water supply encourages healthier product choices and engagement with our landscape. By reusing household graywater, we preserve water resources for other living things. In concert with water-wise landscaping, rainwater harvesting, and conservation, using graywater as a resource helps reduce dependency on imported water and protects watersheds.

Inform Your Gardener or Landscaper About Your Graywater System

Be sure to inform anyone who works in your yard about your new graywater system. Show him or her where the pipes and irrigation points are so that the pipes don't get accidentally punctured or the mulch basins altered or buried. Otherwise, your system could be unintentionally damaged by people who don't understand how it functions.

Graywater Basics

Graywater is a unique source of water and must be used differently from potable water and rainwater. These are some basic guidelines for residential graywater systems:

- Do not store graywater more than 24 hours. If you store graywater, the nutrients in it start to break down and create bad odors.
- Minimize contact with graywater. Graywater can contain pathogens. All systems must be designed so that water soaks into the ground and is not accessible to contact by people or animals.
- Infiltrate graywater into the ground; do not allow it to pool or run off. You'll need to know how fast water soaks into your soil to properly design your system. Pooling graywater can provide opportunities for mosquitoes to breed, as well as for human contact.

- Keep your system as simple as possible. Simple systems last longer, require less maintenance, use less energy, and cost less. Keep in mind that systems with pumps and filters require more commitment and regular maintenance.
- Install a diverter valve at a convenient location to allow for easy switching between the graywater system and the sewer system.
- Match the amount of graywater directed to your plants with their irrigation needs. See Appendix C for information about plant-friendly products; many products contain salts and boron, which harm most plants.

Graywater Regulations

Graywater use is legal in California. In August 2009, California's graywater regulations changed, allowing for lower-cost graywater systems to be installed legally, including some without the need for a permit. In San Francisco, a permit is not required for a laundry graywater system that meets the conditions listed in the next section, "When a Permit Is Not Required." For information about systems that do require permits, see the following section, "When a Permit Is Required." California's regulations for residential graywater systems can be found in Chapter 16A of the California Plumbing Code.

When a Permit Is Not Required

You can install a graywater system for outdoor irrigation without a permit if you meet **all** of the following requirements:

- Graywater comes from the washing machine only.
- Graywater system does not alter the household plumbing (you access graywater from the hose of the machine, not by cutting into the plumbing).
- Graywater system is for a one- or two-unit residential building.
- Graywater system follows 12 guidelines set forth in the California Plumbing Code (see Appendix B, "Operation and Maintenance Manual for Laundry-to-Landscape Graywater System").

When a Permit Is Required

You **need** a permit for a graywater system for outdoor irrigation that includes **any** of the following conditions:

- Graywater system collects water from showers, sinks, or baths.
- Graywater system alters the plumbing (you cut into the drainage plumbing to access the graywater).
- Graywater system is installed in a building that is not a one- or two-unit residential building.
- Graywater system includes a pump (besides the washing machine's internal pump) or a tank.

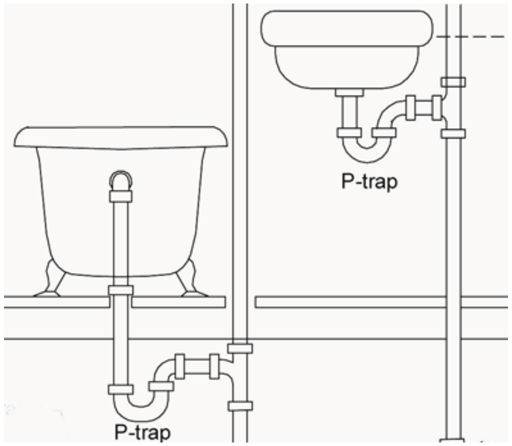
For additional information about permitting a graywater system, contact the Department of Building Inspection at 415-558-6088.

References

California Residential Graywater Code: California Plumbing Code, California Code of Regulations Title 24, Part 5, Chapter 16A. Available at http://www.hcd.ca.gov/codes/shl/2007CPC_Graywater_Complete_2-2-10.pdf

Cohen, Yorem, 2009. Graywater—A potential source of water. UCLA Institute for the Environment. Available at http://www.ioe.ucla.edu/reportcard/article.asp?parentid=4870

The shower p-trap is the copper pipe shaped like an upsidedown and sideways letter "p." In this example, the p-trap and shower drainage pipes are located below the shower/tub. Photo: Josh Lowe.



Developing a Graywater System

Graywater systems can range from the very simple to the very complicated. Follow these steps to create a well-functioning and safe system.

1. Start with conservation! Conservation is always the most economical and environmentally beneficial place to begin. You might find that your landscape doesn't require as much water as you've been giving it, or that there are easy ways to greatly reduce the amount of water your household uses. See the SFPUC's resources for conservation information to learn about ways to save water and money.

    - Before planning a graywater system, consider scheduling a free home water conservation consultation by contacting the SFPUC Water Conservation Section at 415-551-4730 or by visiting *http://conserve.sfwater.org/*. This evaluation can help you to assess your indoor and outdoor water use and to identify ways you can lower both by fixing leaks and taking other measures.
    - If you are not able to install a graywater system, you can still reuse water by collecting shower water in a bucket as the water heats up and using it to water your plants.

2. Determine which fixtures in your home are candidates for graywater capture.

    - Washing machines are usually the easiest place to begin. If your machine is in a room with an exterior wall, it's usually simple to send a pipe outside. If your machine is in an interior room, you'll need a way to run the pipe outside, either through a crawl space or basement.
    - Another potential fixture for graywater capture is the shower and bathtub faucet. Identify the shower drain pipe by going beneath the shower (for example, in the basement), looking for a "p-trap" (see image on left). The p-trap prevents sewer gases from entering the home. Run hot water in the shower and observe which pipe heats up. Make sure you do not tap into the toilet drain! A plumber can help reroute shower pipes. If your shower is

on the second story, and the pipes run inside the wall, the drain is probably combined with the toilet drain in the floor, making the shower graywater inaccessible without a major plumbing remodel.

3. Estimate the quantity of graywater your chosen source produces using the "Estimating Graywater Flows" section of this manual.

4. Analyze how water drains on your site and find out your soil type with a "soil ribbon test" and/or a low-cost laboratory analysis (required if your system needs a permit). In combination with your flow calculations, this analysis will help you determine how large your landscape distribution area will need to be.

5. Read about types of graywater systems and decide which is best for you. Figure 1 provides some guidance for your selection.

6. Read about setback requirements to determine your system layout.

7. Draw a sketch of your proposed system. If a permit is required, you'll need to submit a plot plan and details about the system to the San Francisco Department of Building Inspection (DBI). For more information, contact DBI at 415-588-6088. Note: If your current plumbing is not up to code, you'll need to upgrade the part of the plumbing affected by the installation of the graywater system. For example, if the shower drain is undersized, you will need to upgrade to 2-inch pipe.

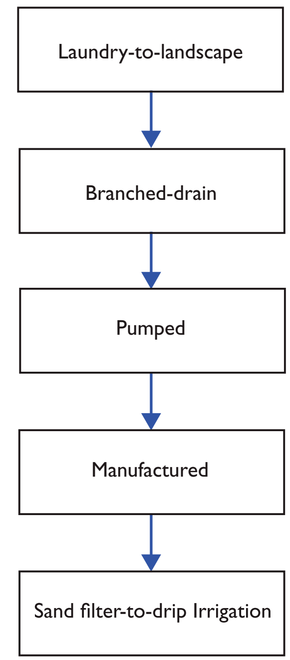
8. Find an installer or install the system yourself.

9. Remember to label the system (3-way valve and all above-ground graywater pipes) and keep an operation and maintenance manual with it. If you sell your home, the manual must stay with the residence.

10. Operate and maintain your system.

System Complexity and Cost

(In order of increasing complexity and $)



System Types	**Fixture Choices**
Laundry-to-landscape	Washing machine only
Branched-drain	All fixtures [1]
Pumped system	All fixtures [1]
Manufactured systems	All fixtures [1]
Sand filter-to-drip irrigation	All fixtures [2]

1 Systems can use graywater from washing machine, shower, tub, or bathroom sink.

2 System typically only used for high graywater volumes.

All systems require a permit except the laundry-to-landscape system.

Figure 1. *Guidance for choosing your graywater system.*

Sizing Your Graywater System

There are three steps to sizing your graywater system. It is important to follow these steps so that you can design a system that has adequate landscape distribution. Remember, state law requires that graywater irrigation systems never cause pooling or runoff.

Step 1: Estimate your graywater flows. There are different methods for estimating your graywater flows based on whether your system requires a permit or not. Follow the steps in the "Estimating Graywater Flows" section to estimate your graywater flows (page 9).

Step 2: Estimate the absorption capacity of your soils based on the methods outlined in the "Soil Absorption and Distribution Area" section (page 11).

Step 3: Use your graywater flow calculations and your soil absorption estimate to calculate the necessary size of your mulch basins (page 14).

After calculating the necessary size of your landscape distribution area (as described in the next section), record this information in the operation and maintenance (O&M) manual for your system (templates in Appendix B). Be sure to include the assumptions you used in your calculations. That way, if you sell your home and move out, the new owner will know how much water the system was designed for. If the new household produces more or less water, the new owner might need to make alterations to the system.

Notes on Requirements for Calculating Graywater Flows

For Permitted Systems: The California Code of Regulations describes a specific method that must be used to calculate graywater flows for systems that require permits (Title 24, Part 5, Chapter 16A). This method is described on page 9 of this manual.

For Systems That Do Not Require a Permit: Laundry-to-landscape systems can be sized using the method described for permitted systems OR the method described in the section of this manual titled Irrigation Supply Calculations, found on page 10.

Start by Saving Water!

Saving water and money is easy! You can reduce your water use by about 35 percent just by installing water-efficient fixtures and appliances (see *http://conserve.sfwater.org/*).

You can obtain free high-efficiency showerheads and aerators and possibly qualify for a rebate on a water-efficient washing machine from SFPUC. Call 415-551-4730 for more information.

Estimating Graywater Flows

Permitted System Calculations

The California Code of Regulations indicates that graywater flows for permitted systems in single- and multi-family dwellings can be estimated based on records of water use, calculated based on local daily per-person interior water use, or calculated using a default method listed in the code (Title 24, Part 5, Chapter 16A). The following is the method listed in the code:

Step 1) The number of occupants in your household must be calculated as:

2 occupants in the First Bedroom

1 occupant in Each Additional Bedroom

Step 2) Graywater flows must be calculated as follows:

Showers, Bathtubs, and Washbasins (combined): 25 gallons per day (gpd)/occupant

Washing Machines: 15 gdp/occupant

Step 3) Multiply the number of occupants (as calculated above, not the actual number of people who live in the home) by the estimated graywater flow in gpd per occupant to calculate the total estimated daily graywater flow.

Number of occupants x graywater flow per occupant
= total estimated daily graywater flow

In San Francisco, you must present calculations based on this default method to DBI when you apply for a permit (see Appendix E for an example). However, you may be able to reduce your graywater flow calculations if you consistently use less water in your home and can produce documentation of reduced graywater production for DBI's review. Please contact DBI if you would like to make alternate calculations based on reduced graywater production in your home. Note that it is best to contact DBI early in the process so staff can assist you in creating a well-designed graywater system that works for you and future occupants of your home.

Example Graywater Flow Estimate for Permitted Systems Using the Default Code Method

In a three-bedroom home of three people, the following volumes of graywater would be produced:

Number of occupants: Four. The three-person home would have four occupants using the permitted systems calculation method (two in the first bedroom plus one for each additional bedroom).

Shower graywater: 25 gpd x 4 people
= 100 gpd

Washing machine graywater: 15 gpd x 4 people
= 60 gpd

Total graywater produced: 100 + 60 gpd
= 160 gpd

Design for Highest Calculated Flow

Note that if your irrigation supply calculations (page 10) yield a higher flow than the permitted system calculations, you should size your system based on the irrigation supply calculations.

Irrigation Supply Calculations

(can also be used to size laundry-to-landscape systems)

Calculating how much graywater your home actually produces is an important step for all graywater systems. These calculations determine how much water is flowing to your plants, regardless of whether you have a permitted or non-permitted system. These calculations will help you ensure that your plants are not getting over- or under-watered.

Irrigation supply calculations can also be used instead of the permitted systems method to size the landscape distribution area for systems that do not require a permit. Hence, they can only be used to size the landscape distribution area for laundry-to-landscape systems.

> **Washing machines (weekly flow):** __ gallons/load (the rating of your machine) x __ loads per week = __ gallons per week
>
> **Washing machines (daily flow):** __ gallons/load (the rating of your machine) x __ loads on a typical laundry day = __ gallons per typical laundry day
>
> **Showers:** __ gallons per minute (the flow rate of your showerhead) x __ minutes you shower x __ showers per day x actual number of home occupants = gallons per day

Note that if you regularly produce higher amounts of graywater in a single day, you'll need to consider this when you design your system. Examples include multiple loads of laundry in one day or baths. You will also need to consider situations where you produce atypical amounts of graywater. If you sometimes do five loads of laundry in one day, rather than spread them out over the week, you'll need to consider this when you design and operate your system. In cases of high flows, one option is to redirect the laundry water to the sewer system using the 3-way valve. Remember that you must design and operate your system to avoid graywater pooling and runoff.

Note that performing these calculations for your specific household fixtures yields the most accurate estimate of the amount of graywater available for your plants, yet it does not consider future changes. Volumes could vary if the size or habits of your household change over time or if a new owner moves in.

Example Graywater Flow Estimate Using the Irrigation Supply Calculation Method

In a three-bedroom, three-person household with a laundry-to-landscape system, each person does one load of washing a week, plus there is an extra load for towels, totaling four loads per week. Washing machine use is spread out across the week, sometimes two loads of laundry in one day. The household's front-loading washing machine is rated at 20 gallons per load.

Washing machine graywater (weekly flow): 4 loads per week x 20 gallons per load = 80 gallons per week

Washing machine graywater (daily flow): 2 loads per day x 20 gallons per load = 40 gallons per day

Irrigation during Vacations

Keep in mind that most types of simple graywater systems only irrigate when you are at home producing graywater. If you take frequent summer vacations or are away every weekend, you might want to plan for back-up irrigation, or you could simply ask a housesitter to water the plants. More complex systems, like sand filter-to-drip irrigation, typically include back-up irrigation (see page 31).

Soil Absorption and Distribution Area

Understanding the infiltration capacity of the soils in your yard is critical for designing your graywater system and sizing your landscape distribution area. The distribution area must be sized to allow the graywater to soak into the soil without pooling or runoff.

If your system requires a permit, you must provide DBI with the results of a laboratory soil analysis to confirm your soil type. See page 12 for details. To learn the basics about the soil in your yard, you should also conduct a simple soil "ribbon test," described below.

After you have identified your soil type via laboratory analysis (required for permitted systems) and/or a ribbon test, conduct a simple drainage test to find out how well water drains on your property. This drainage test will help ensure that you choose a good location for your graywater outlets.

Soil Ribbon Test

To conduct the soil ribbon test, take a small handful of soil in your hand, slowly moisten it with water, and knead it. Try to form the soil into a ball. Squeeze it to see if you can make a cast (an impression of your fingers). Place the ball of soil in your hand between your thumb and forefinger, gently squeeze the soil, and push it upwards into a ribbon (see image at right). Let the ribbon break from its weight. Don't try to mold the soil into a ribbon by rolling it in

Table 1. *Identifying Soil Type Using the Ribbon Test*

Characteristics of Soil Sample	Soil Texture or Soil Type
Soil does not stay in a ball. Loose and gritty feeling when moistened.	*Sand*
A cast, or molded imprint of your fingers, forms, but it breaks easily. It does not form a ribbon. Soil feels slightly gritty.	*Sandy loam*
A short ribbon can be formed but breaks when about ½ inch long.	*Loam*
A ribbon can be formed. It is moderately strong until it breaks at about ¾ inch length. Soil feels slightly sticky.	*Clay loam*
The soil can easily be formed into a ribbon that is an inch or more long. Soil feels very sticky and gritty.	*Sandy/silty clay*
The soil can easily be formed into a ribbon that is an inch or more long. Soil feels very sticky and smooth.	*Clay*

Source: Adapted from Alameda County Waste Management Authority and Source Reduction and Recycling Board (StopWaste.org), 2010, and Thein, S.J., 1979.

Soil forms a "cast," an impression of your fingers. Photo: Josh Lowe.

Soil ribbon being squeezed between thumb and finger. Photo: Josh Lowe.

your palms, as this will give inaccurate results. See Table 1 to identify the texture or type of soil you have. You should conduct a ribbon test at several locations on your property to understand the variability of soil characteristics.

Laboratory Test

If your system requires a permit, you must provide DBI with the results of a soil analysis. This requirement can be fulfilled by submitting a soil sample to a laboratory for an inexpensive soil texture analysis (see Appendix F for local laboratories) or by providing an existing soil analysis to DBI. The soil sample must be taken from the area to be irrigated with graywater. If there is more than one type of soil, representative samples from different areas must be taken. An example of an existing soil analysis is a geotechnical study done for your property. Note that the geotechnical report must be signed and stamped by a licensed engineer or geologist.

Drainage Test

Identifying your soil type (either by ribbon test or laboratory analysis) does not always provide enough information about how well water will infiltrate in a particular location, as deeper soils could differ from surface soils, or hardscape (for example, an old cement patio) might be buried under your yard. Urban yards can be full of surprises! To ensure that water drains properly in the location you would like to irrigate with graywater, you should conduct a simple drainage test, as described below.

This drainage test is optional, as it is not required by the code. If you plan to use graywater to irrigate sections of your yard that you already irrigate, and you know that water drains well, you might not need to conduct the drainage test. If you are unsure about how water drains, the drainage test can help you choose appropriate locations for irrigating with graywater. Remember, pooling and runoff of graywater is never allowed, so if you have poor drainage with pooling, you will have to redesign your system.

1. Dig a hole, approximately 1 foot deep, in the area where you plan to infiltrate graywater. Insert a ruler or stick marked with inches into the hole (Figure 2).

2. Fill the hole with water and let it soak in. Repeat this several times so that the surrounding soil is saturated when you take your reading.

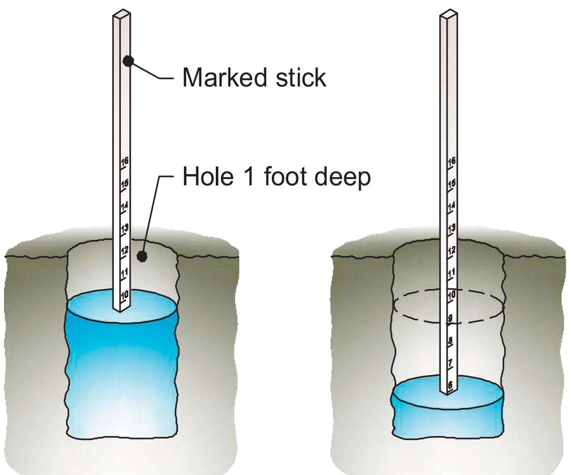


Figure 2. *Drainage test.*

3. Fill the hole with water again; this time record how long it takes for the water level to go down a few inches. If it drains approximately 1 inch per hour or faster, you have adequate drainage for irrigating the area with graywater.

4. If it takes longer than two hours for the water level to go down 1 inch, or the hole doesn't drain all day, don't use graywater to irrigate this area. Try another location to see if the drainage is better. If you irrigate an area that does not have adequate drainage, you could have pooling and runoff. Plants could also be damaged by water-logged soil, so make sure to irrigate only properly draining soils, or amend your soil by adding compost to improve drainage.

Calculating Your Landscape Distribution Area

Once you know how many gallons per day your home produces (see the Estimating Graywater Flows section), have identified your soil type (either by ribbon test or laboratory analysis), and know that water drains well in the area you wish to irrigate, you can calculate how large an area you need to ensure proper drainage of graywater.

To calculate your landscape distribution area, you will need the following information:

- Gallons of graywater generated each day
- Soil type (to be used with Table 2)

Table 2. *Minimum Irrigation Area for Different Soil Types*

Soil Type	Square Feet of Area Needed to Infiltrate Each Gallon of Graywater (per day)
Coarse sand or gravel	0.2
Fine sand	0.25
Sandy loam	0.4
Sandy clay	0.6
Clay with considerable sand or gravel	0.9
Clay with small amounts of sand or gravel	1.1

Source: Table 16A-2, Design Criteria of Six Typical Soils, California Plumbing Code Section 16A.

Example: Calculating Minimum Infiltration or Irrigation Area

If you identified your soil type as sandy loam, you would need 0.4 square feet per gallon of graywater (Table 2). If you produce 100 gallons of graywater per day, you'd multiply 0.4 square feet/gpd by 100 gpd to get 40 square feet, the minimum area needed for your graywater to infiltrate.

100 gpd x 0.4 square feet per gpd (from Table 2)
= 40 square feet of total irrigation area

This irrigation area can be spread across different locations in your yard. For example, if you want to irrigate 10 trees and your total irrigation area must be 40 square feet, each mulch basin would need to be at least 4 square feet.

This calculation does not take into consideration the appropriate amount of water necessary for the plants; refer to Appendix D for plant water requirements.

Note: If your system incorporates drip irrigation, there is a different way to size the irrigation area; refer to Chapter 16A of the California Plumbing Code, Table 16A-3.

Multiply your gallons of graywater per day by the number corresponding to your soil type in Table 2. This calculation gives you the minimum area, in square feet, needed to infiltrate your graywater.

When you design your system, make sure that the total area (not volume) of your mulch basins is at least as large as the minimum distribution area calculated above. Your irrigation area can be larger, but not smaller. Record your system specifications in your O&M manual for future reference.

Protecting Groundwater

Graywater must be discharged a minimum of three feet above the groundwater table. Groundwater occurs deeper than three feet on most of the western side of San Francisco, but some areas, especially on the eastern side, can have shallower groundwater. If you don't know how deep groundwater is beneath your property, you can check by digging a hole three feet deep below your lowest anticipated graywater discharge point. If no water enters the hole, then it is safe to irrigate the area with graywater. If water enters the hole, the groundwater table is too shallow, and graywater may not be used for irrigation. If you dig a hole to check the depth to groundwater, do so during the irrigation season, as this is the time you'll be using graywater. During the rainy months, with any signs of pooling or runoff from rainfall, or in places where the groundwater table rises, all graywater systems must be shut off and graywater must be diverted back to the sewer.

References

Alameda County Waste Management Authority and Alameda County Source Reduction and Recycling Board, 2010. Bay-Friendly Gardening. Available at http://www.stopwaste.org/home/index.asp?page=8.

Thein, S.J., 1979. A Flow Diagram for Teaching Texture by Feel Analysis. Journal of Agronomic Education, 8:54-55.

Setback Requirements: Where Not to Put Your Graywater!

Your graywater system should irrigate plants without causing problems for you or your neighbors. A setback is a required distance between structures, such as between a building and another building, other structure, or property line. The purpose of setbacks is to avoid potential problems caused by nearby land uses. For example, you'll need to keep graywater a certain distance from your house to avoid damaging its foundation, from your neighbor's yard to maintain good neighborly relations, and from creeks to prevent contamination of freshwater. Table 3 lists setback requirements in San Francisco.

Table 3. *Setbacks Required in San Francisco*

	Minimum Distance (Horizontal) from	
	Irrigation Field (Feet)	Tank (Feet)
Building structures (not including porches and steps or covered walkways, patios, driveways, etc.)	2	5
Private property lines	1.5	5
Water supply wells	100	50
Streams and lakes	100	50
On-site domestic water service line	0	5
Pressurized public water main	10	10
Water table	3 feet above (see note 1).	NA
Retaining wall[2]	2	NA

Notes:

Unless otherwise noted, setbacks are from the California Plumbing Code (California Code of Regulations, Title 24, Part 5, Chapter 16A, Table 16A-1).

1. A test hole 3 feet deep without water can demonstrate that the site is far enough above the ground water table. The graywater system must be shut off in the rainy season.
2. Requirement specific to San Francisco.

Laundry-to-Landscape System

Description: The washing machine pump sends graywater from the drain hose out to the landscape through 1-inch tubing. The system does not alter the existing plumbing and does not require a permit. Best suited for irrigating trees, bushes, shrubs, small perennials and larger annuals.

Installation: Easy to install for the do-it-yourselfer or a professional.

Cost: Ranges from a few hundred dollars (installed by homeowner) to $1,000 to $2,000 (professional installation).

Laundry-to-Landscape System

System Overview

A laundry-to-landscape graywater system captures graywater from the discharge hose of your washing machine, enabling you to reuse the water without altering the existing plumbing in your home.

In this system, the hose leaving the washing machine is attached to a valve that allows for easy switching between the graywater system and the sewer. It is important to be able to switch to the sewer anytime you don't want to send the water outside, for example if you're using bleach, which could harm plants, or if the soil is saturated during the rainy season. The graywater is distributed through a 1-inch irrigation line with outlets directing water to specific plants (Figure 3). This system is low-cost, easy to install, and very flexible if you need to make future changes to your home or landscaping.

Parts You Will Need

You can purchase most of the parts you need from large irrigation stores; 1-inch brass 3-way valves are available from some plumbing supply stores, and complete laundry-to-landscape kits can be found online. See Appendix F for more information.

Assemble these parts:

1. 3-way valve
2. PVC 1-inch male adapter
3. 1-inch barbed male adapter
4. Hose clamp
5. PVC 1-inch x 1½-inch bushing
6. PVC 1½-inch female adapter (slip by FPT)
7. Auto vent (or air admittance valve)
8. 1-inch PVC tee
9. 1-inch barbed x slip adapter

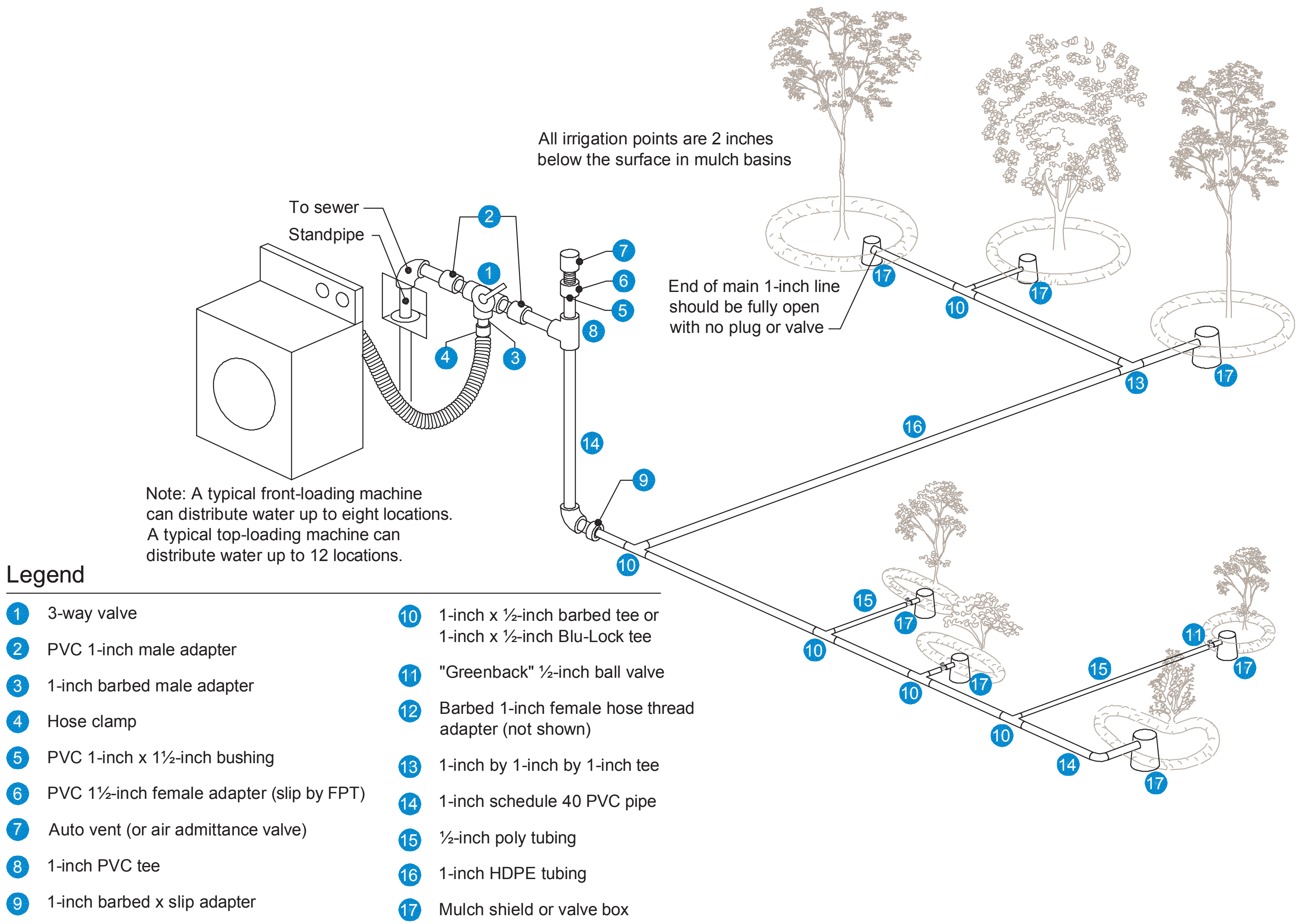


Figure 3*. Laundry-to-landscape overview. Source: Clean Water Components.*

Legend

1. 3-way valve
2. PVC 1-inch male adapter
3. 1-inch barbed male adapter
4. Hose clamp
5. PVC 1-inch x 1½-inch bushing
6. PVC 1½-inch female adapter (slip by FPT)
7. Auto vent
8. 1-inch PVC tee

3-way valve for diverting laundry graywater to the landscape. Auto vent shown at right. Photo: Laura Allen.

Cleaning the Pump Filter

If your washing machine is not pumping out the water properly, the most frequent cause is objects (for example, coins or paperclips) getting stuck in the pump filter and blocking the flow of water. It is a good idea to check the pump filter before installing your graywater system. See the references at the end of this section for more information about how to clean a washing machine pump filter.

10. 1-inch x ½-inch barbed tee or 1-inch x ½-inch Blu-Lock tee
11. "Green or purple back" ball valve (as needed)
12. Barbed 1-inch female hose thread adapter
13. 1-inch by 1-inch by 1-inch tee
14. 1-inch schedule 40 PVC pipe
15. ½-inch poly tubing
16. 1-inch HDPE tubing
17. Mulch shield or valve box
18. Garden staples

Tools you will need:

- Measuring tape
- PVC cutting tools (ratcheting cutters or a saw)
- Two pairs of channel locks
- Level
- Tubing cutters
- Drill
- 1½-inch hole saw
- ¼-inch pilot bit
- ¼-inch masonry bit (if the wall is stucco)
- Caulking gun and adhesive caulk
- Hammer
- Chisel
- Tin snips
- Shovel and pickaxe

How to Build a Laundry-to-Landscape System

Step 1: Assess Your Site

Where is the easiest area to irrigate? Usually this area is closest to the washing machine and not uphill. Does this area need irrigation? If not, are there plants that need irrigation that you'd like to grow in this area? If not, is there another area needing irrigation where you could send the graywater?

Once you have identified the best place to irrigate, you'll need to figure out how to get the graywater to this landscape. Start in the laundry room. Imagine a pipe leaving the house near the machine. Is the machine on an exterior wall? If so, you'd drill through the wall to exit the building. Is the machine in an interior room? If so, is there a crawlspace or basement where you could drop down through the floor and run the pipe outside? Look for obstacles, such as doorways, sidewalks, patios, driveways, etc., on the way out. A narrow sidewalk can be cut with a concrete saw, or dug under, but a large driveway between the washer and the landscape could potentially be an insurmountable barrier.

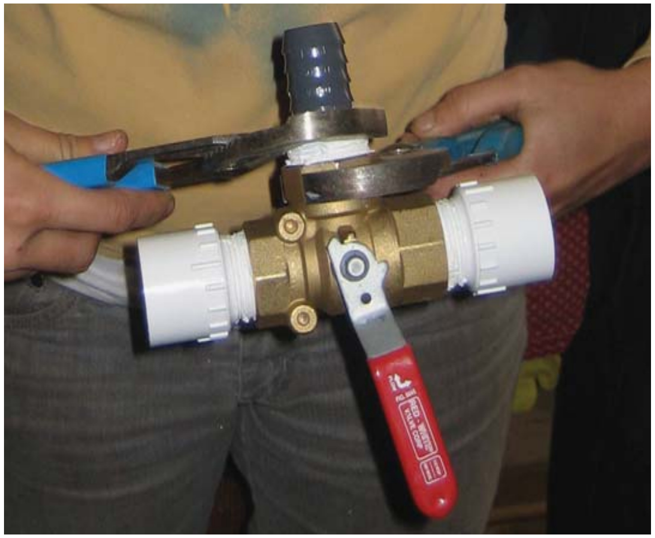
Below are general guidelines to help you select appropriate locations to irrigate using a laundry-to-landscape system. It is your responsibility to determine what is safe for your particular situation. If your washing machine is not operating properly or draining well, it is probably not a good idea to install a laundry graywater system. When in doubt, contact a pump specialist or graywater professional.

- Sloped yards: Don't distribute water uphill. The washing machine has an internal pump, but it is not designed to pump up a hill.

  If your yard slopes downhill from the location of the washing machine, the graywater distribution piping can extend as far as needed. On steep slopes, the tubing should be installed in a serpentine pattern (S-shape, like a switch-back trail) to slow down the water. Otherwise it will rush to the bottom of the hill, and you won't be able to irrigate the upper plants.

- Flat yards: For most machines, it is generally safe to distribute graywater up to 50 feet across a flat yard. Greater distances could result in damage to the washing machine pump, since friction losses increase with distance and put more pressure on the machine's pump.

Drilling a 1½-inch hole for pipe. Note: A pilot hole was drilled first. Photo: Laura Allen.



Tightening fittings onto the 3-way valve with channel locks. Photo: Laura Allen.

Important Considerations for Exterior Walls

Exterior walls within 3 feet of the property line must be fire-rated. If your pipe exits a fire-rated wall, then you must comply with applicable building and plumbing codes to ensure that the integrity of the wall is not compromised. Consult a professional or contact DBI with questions.

Gluing pipes on either side of a 3-way valve. Photo: Laura Allen.

Draw a simple sketch of your system, from the washing machine to the plants. Graph paper is provided in Appendix B. Collect the tools and parts needed.

Now you're ready to start building the system.

Step 2: Make an Exit for the Pipe

Identify where the pipe will exit the building. Be careful not to cut into electrical wires, pipes, or studs. Drill a ¼-inch pilot hole with a thin, long drill bit that can pass through the entire wall. Ensure you are not hitting anything in the wall. You may need to try more than one location if you hit a stud or other obstacle.

If the drill path is clear of electrical wires, pipes, and studs, and the hole exits in a good location on the outside of the building, use the pilot hole as a guide and drill with a 1½-inch hole saw to make a hole large enough for the 1-inch PVC pipe (#14). The type of bit you'll need depends on what the wall is made of: use stucco bits on stucco walls and wood bits on wooden walls. To make a clean hole on both sides, drill from both the outside in and from the inside out. After you finish installing your system, you will need to seal the hole with a waterproof adhesive, such as Sikaflex®, to prevent moisture from entering the wall.

If your washing machine is in an interior room and the pipe will exit the house through a crawlspace or basement, go under the house and look for potential obstacles. Then follow the same instructions for drilling as described above, although you only need to drill from the top down, since it won't matter what the hole looks like in the crawlspace.

Step 3: Prepare the 3-Way Valve

Note that numbers in parentheses refer to the parts list above.

1. Wrap Teflon® tape clockwise around the threaded fittings (two male adapters [#2] and one barbed male adapter [#3] fitting).

2. Insert the male adapters into the threads on both sides of the 3-way valve and turn gently, by hand, making sure not to cross-thread the plastic threads. Do the

same with the barbed male adapter, inserting it into the middle of the valve. Turn clockwise with your hands as tightly as you can.

3. With two pairs of channel locks, continue to tighten the fittings until very tight.

4. Remove the laundry drain hose from the sewer connection (utility sink or standpipe) and place a hose clamp (#4) over the end of the hose. Connect the hose to the barbed fitting on the tee and use the hose clamp to tighten and secure the hose in place, making a watertight seal. (If the hose is rigid plastic, heating the plastic can soften it and make it easier to slip over the barbed fitting. You can use a blow dryer or cup of hot water to heat the hose.) After the system is complete, you will check this seal by running the machine.

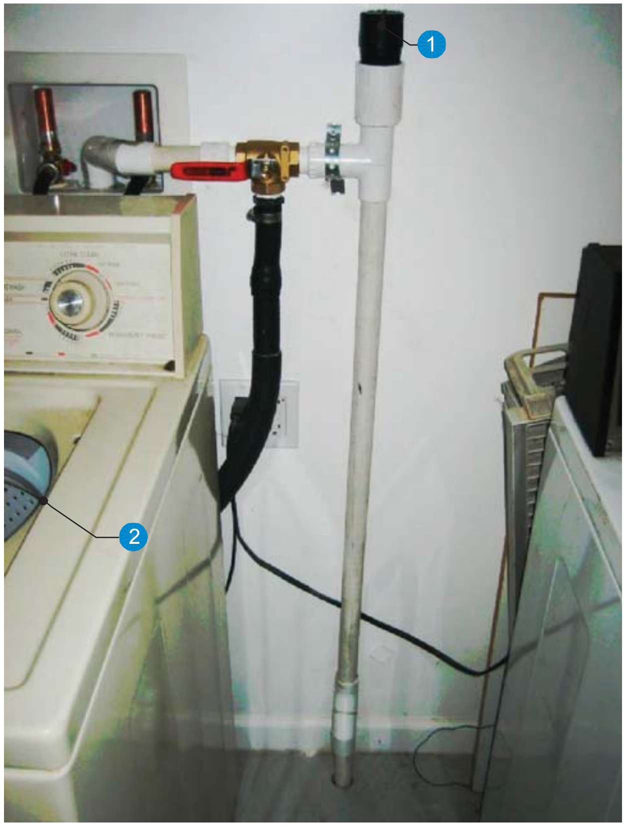
Note: These directions are written for a 1-inch laundry drain hose, which is the most common size. Some of the newer, ultra-efficient hoses are ¾-inch. If your hose is non-standard, you'll need to use a barbed fitting that fits your hose and then adapt it to a 1-inch male pipe thread fitting to attach to the 3-way valve. For example, if your hose is ¾-inch, you'll use a ¾-inch barbed male adapter threaded into a ¾-inch by 1-inch threaded bushing.

Step 4: Plumbing to and from the 3-Way Valve

1. Hold the 3-way valve (#1) up and look for a good place on the wall to mount it so that the handle can turn freely and is accessible. The valve MUST be above the flood rim of the washing machine: don't put it lower than the machine (see photo at right).

2. Choose the most direct route for plumbing one side of the valve to the sewer, and orient the other side of the valve towards the hole in the side of the house, or the floor, depending on your situation.

   Note: If your system exits through the floor, the auto vent will be inside the home, since you must put the auto vent at the high point in the system, usually directly above the hole in the floor. See Step 7 for instructions on installing the auto vent.



Legend

1 Auto vent (or air admittance valve)

2 Flood rim

The 3-way valve is slightly above the sewer connection (behind the machine), while the auto vent is about a foot higher than the flood rim of the machine. Photo: Laura Allen.

1-inch Blu-lock HDPE tubing laid out in trenches. All tubing was buried after system was finished. Photo: Laura Allen.

Mulch basin around a dwarf peach tree being filled with wood chips. Photo: David Glover.

3. Measure all the pipe pieces you need, cut the 1-inch PVC (#14), and connect the piping and fittings without any glue. Once glued, the pipe will slide farther into the fitting to a lip on the interior, so take this into account when measuring. Leave a few inches of pipe sticking out of the hole on the outside of the building.

4. Mark all of the fittings and pipe so that when you glue them together, they are in the position you would like them to be.

5. One at a time, glue the pipe sections and fittings together with PVC glue, being sure to protect underlying surfaces from dripping glue. "Gorilla PVC" is a less toxic PVC glue (do not confuse "Gorilla PVC" with "Gorilla Glue").

6. Go outside and glue the branch of the tee onto the pipe sticking out of the wall. While the glue is wet, adjust the tee with a level so the long axis of the tee is pointing straight up and down. Remember, if the pipe goes through the crawl space or basement, the auto vent must be located inside the laundry room. Make sure the auto vent (see next step below) is accessible so that it can be changed if it wears out and needs replacement. If water ever leaks out of the auto vent, it must be replaced.

7. The auto vent should be at least 6 inches above the flood rim of the washing machine and, when possible, located outside in case it fails and leaks. To assemble the auto vent, follow these steps. Glue the bushing (#5) into the slip portion of the 1½-inch female adapter (#6). Wrap Teflon® tape on the threads of the auto vent (#7), and then thread the auto vent into the threaded side of the female adapter (#6) and tighten. Glue one end of a small 2-inch piece of 1-inch PVC pipe (#14) into the 1-inch side of the bushing (#5). Then glue the other end into the top of the tee (#8).

8. Measure, cut, and glue a piece of PVC pipe to extend from the bottom part of the tee to the ground. If there is a deck or other obstacle between your washer and the irrigation area, you will have to route the pipe around the obstacles. Try to maintain a downward slope whenever possible. Put a 90-degree bend at the bottom of the vertical pipe section and direct the pipe towards the landscape. Place the 1-inch barbed x slip adapter (#9) on the end of the pipe. This is where the 1-inch HDPE tubing (#16) will connect.

Step 5: Preparing the Landscape and Running the Irrigation Tubing

1. Dig mulch basins around the drip line of all the plants you wish to irrigate. The drip line is the exterior boundary of the plant, where the branches end. Mulch basins are created by removing soil and filling the empty space with mulch. If you can't dig a basin around the entire plant, dig a semi-circle, or trench on one side of the plant. The mulch basins should be between 6 and 12 inches deep, depending on the mature size of the plant. Smaller plants need less water and smaller basins.

2. Dig a trench, about 4 inches deep, from the PVC pipe to the first mulch basin. Continue the trench to all the basins, taking the most direct route possible while avoiding sharp turns. If possible, maintain a slight downward slope or at least a level gradient. If the system has dips and rises, it will be harder to get even distribution of water when you tune the system.

3. Make or buy a "valve box" or "mulch shield" for each graywater outlet (Figure 4). Mulch shields can be made out of 1- or 3-gallon flower pots. Put the pot upside down (so the bottom is on top) and make a "lid" by cutting the bottom of the pot so that it can be flipped up like a lid on a can (leaving a section intact to hold the "lid" in place). Drill a hole 2 inches below the "lid" for the graywater tube to enter. Then cut off the rest of the pot 4 inches below the hole you made for the graywater tube. If a more sturdy shield is needed, a valve box can be purchased and altered in a similar way.

4. Place each box or shield in a mulch basin. Make sure there is 2 to 4 inches of mulch underneath the mulch shield. The graywater outlet must enter the shield at least 2 inches below the ground surface.

5. Roll the HDPE tubing (#16) out in the trench to all the mulch basins, staking the tubing so it stays in place. At each irrigation point, cut the tubing and insert a 1-inch by 1/2-inch barbed tee (#10) into the tubing. Attach a short section of ½-inch poly tubing (#15) as needed to reach each basin, and insert it into the mulch shield.

6. Take a photograph of the yard before you bury the tubing! Put this picture in your O&M manual (templates in Appendix B) for future reference. After taking the

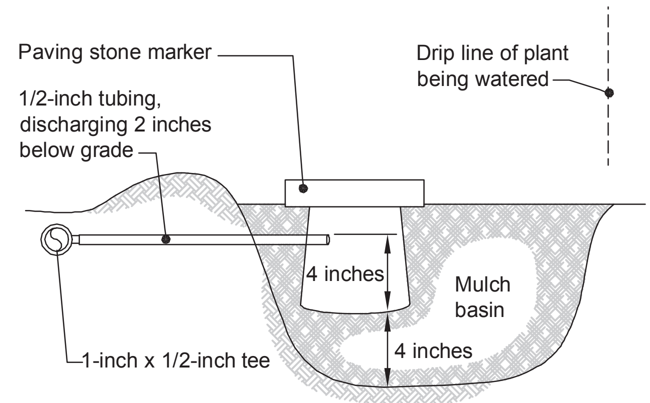


Figure 4. *Mulch shield placement.*

Homemade mulch shield. Photo: Laura Allen.

This 3-way valve creates two zones in the landscape. Water can be redirected from one zone to another zone by turning the handle. Photo: Laura Allen.

Adjusting flow by rotating the tees. Ball valves can be added to the ends of small tubes, if necessary.
Photo: David Glover.

photograph, bury most of the tubing so it is securely in place. Leave the areas with 1 x ½-inch tees (#10) exposed, as you might need to adjust them while tuning the system.

7. Multiple irrigation zones: If your site produces a lot of water and your plants are spread out in different sections of your yard, you might want to set up two irrigation zones. Having separate zones allows you to spread the water out to more places but requires someone to manually switch the system between zones. To install a second zone, add another 3-way valve at the desired location in the system, threading a male adapter by barb into each side of the tee. Run separate 1-inch tubes to different areas of the landscape. The valve directs water to each area as desired.

Step 6: "Tuning" the System

After you have laid out all the tubing, you need to test it to ensure that water flows out evenly from the multiple outlets. To do this, temporarily insert a barbed 1-inch female hose thread adapter (#12) into the tubing, where it would normally connect to the PVC pipe. Then connect a garden hose to this fitting. Turn the hose on, about medium-high flow, and then monitor the outlets.

If you notice that more water is exiting the first outlet and none is reaching the end, you can adjust the angle of the tees, turning them up or down depending on whether there is too much or too little water coming out. If the flow is still uneven after you've done that, add a ½-inch green or purple back ball valve (#11) to the first outlet and shut off the flow slightly. Do not use other types of ball valves, as they clog quickly. Is water coming out evenly among outlets now? If not, you may need to add another valve and repeat the process until water flows evenly from all the outlets. Avoid adding extra ball valves, because they are a point of potential clogging. NEVER put a valve or plug into the end of the main 1-inch line. If you restrict the end of the main line and your outlets clog, the washing machine pump could get damaged. If you have more than one 1-inch line, as when you use a 1-inch by 1-inch by 1-inch tee, and send two 1-inch lines in different directions, then it is okay to restrict one end, since there is a second end fully open.

Step 7: Testing the System

After you have tuned the part of the system outside your home, disconnect the hose and connect the tubing to the PVC pipe. Now you'll test the system with the washing machine. Run a load of laundry with the 3-way valve turned to the graywater system. As the water flows out, check the glued joints, making sure they are all watertight. Check the connection from the washer hose to the 3-way valve; this is a common place to have leaks. You might need to tighten the hose clamp or add a second clamp. Next, go outside and observe how water flows through the system. You might need to readjust the ball valve(s), since the water pressure from the machine will be different from that of the hose. After testing is complete, paint exposed PVC pipe with regular house paint, usually the same color as the building (to protect it from UV damage), and waterproof any holes.

Exposed PVC pipe is painted to protect it from UV degredation. The hole is sealed with an adhesive sealant to prevent moisture from entering. Photo: David Glover.

Step 8: Labeling the System

Label the 3-way valve and aboveground graywater pipes (Appendix A). The 3-way valve must be labeled with clear instructions for changing the direction of graywater flow (to sewer or landscape). Aboveground pipes must be labeled with the words "CAUTION: NONPOTABLE WATER, DO NOT DRINK" at intervals of 5 feet or less.

Key Points

- Put the 3-way valve above the flood rim of the machine, in an accessible location inside the home.
- Put the auto vent at the high point of the system, at least 6 inches above the flood rim of the washing machine in an accessible location in case it needs to be replaced. If possible, locate the auto vent outside.
- Use 1-inch pipe and tubing, with 1-inch x ½-inch tees to send graywater to specific plants; do not use larger or smaller pipe for the main graywater line.
- Always leave one end of the 1-inch main line tubing fully open, with no valves or caps.
- Don't overwork your washing machine. Remember not to use the pump to send water uphill or too far across a flat yard (50 feet across a flat yard is typically a safe distance).

Table 4. *Laundry-to-Landscape System: Operation and Maintenance Checklist*

Component	Inspection Schedule	O&M Activity	Action Needed
3-way valve	*Annual*	*Check for leaks at washer hose and that label is in place*	☐ *Condition good* ☐ *Action needed* • *If leaking, tighten hose clamp.* • *Replace label if needed.*
Auto vent	*Annual*	*Check for leaks from auto vent*	☐ *Condition good* ☐ *Action needed* • *If leaking, replace the auto vent.*
Piping and tubing	*If you notice water in an unusual place*	*Check for leaks*	☐ *Condition good* ☐ *Action needed* • *If piping or tubing is damaged, cut out damaged section and reconnect with a 1-inch barbed coupling.*
	Annual	*Check for even distribution from outlets*	☐ *Condition good* ☐ *Action needed* • *Unclog hair or lint built up in the outlets. Open ball valves, check for clogs. If needed, flush the system with a hose: temporarily disconnect the tubing from the PVC fitting, attach the garden hose by barb fitting, and connect the hose to the system.*
Mulch basins	*Annual*	*Check to see if mulch has decomposed and water is pooling under graywater outlets*	☐ *Condition good* ☐ *Action needed* • *Remove decomposed mulch and add new mulch.*

Operation and Maintenance

Table 4 summarizes O&M activities for laundry-to-landscape systems. Templates for O&M manuals are provided in Appendix B.

Second Standpipe Option for Laundry Graywater

Another option for a washing machine system is to install a second standpipe next to the existing standpipe (Figure 5). A standpipe is a vertical pipe into which the washing machine hose discharges. The existing standpipe should be plumbed to the sanitary sewer. The second standpipe can be plumbed to a graywater irrigation system.

In a second standpipe graywater system, the exterior graywater irrigation system should be identical to the branched-drain system described in the section titled "Branched-Drain System." There is no 3-way valve inside the house at the washing machine, and the hose from the washing machine is moved manually from one standpipe to the other. The second standpipe method adds no extra strain on the washing machine pump. If your machine is old or has any problems, and you are worried that a laundry-to-landscape system might not be good for the machine, you can install a second standpipe graywater system instead. This method does make it harder to distribute the water to plants than the laundry-to-landscape system, because it is a gravity-based system and does not take advantage of the washing machine's pump to distribute graywater.

The second standpipe option does not require a permit as long as the graywater system is for a one- or two- unit residential building and follows the 12 guidelines set forth in the California Plumbing Code (see Appendix B).

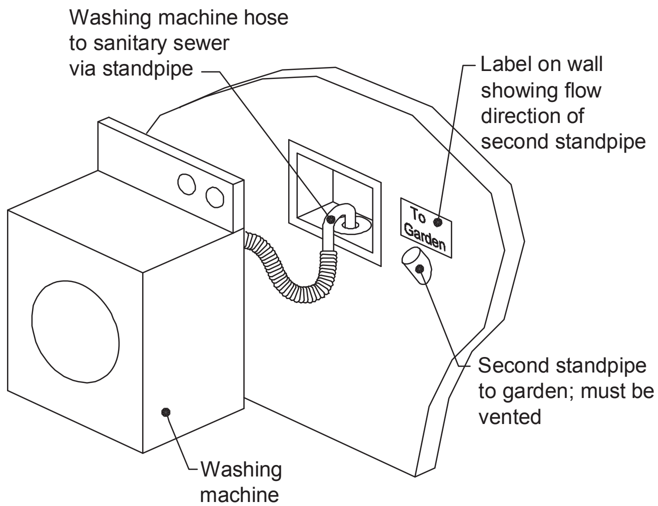


Figure 5. *Second standpipe option.*
Source: City of Berkeley.

References

Clean Water Components.: http://www.cleanwatercomponents.com/education/greywater/laundry-landscape-greywater-system/

Create an Oasis with Greywater 5th Ed.: http://oasisdesign.net/greywater/laundry/index.php

How to clean the filter of your washing machine pump: http://www.ehow.com/how_6161420_clean-front-load-washing-machine.html

Branched-Drain System

Description: Graywater drains through a series of branching pipes and is dispersed into the landscape via mulch basin outlets. Branched-drain systems are typically installed on shower drains and/or sinks; however, they can also be installed on washing-machine systems that use the second standpipe variation. When installed on shower drains or sinks, branched-drain systems alter the existing plumbing and require a permit. A branched-drain system is best suited for irrigating trees, bushes, shrubs, and other larger perennial plants.

Installation: Installation difficulty varies greatly depending on the existing household plumbing. A solid understanding of plumbing is needed, as well as basic landscaping skills. Installation is more time-consuming than for a laundry-to-landscape system.

Cost: Costs can range from a few hundred dollars (installed by homeowner) to a few thousand dollars (professional installation).

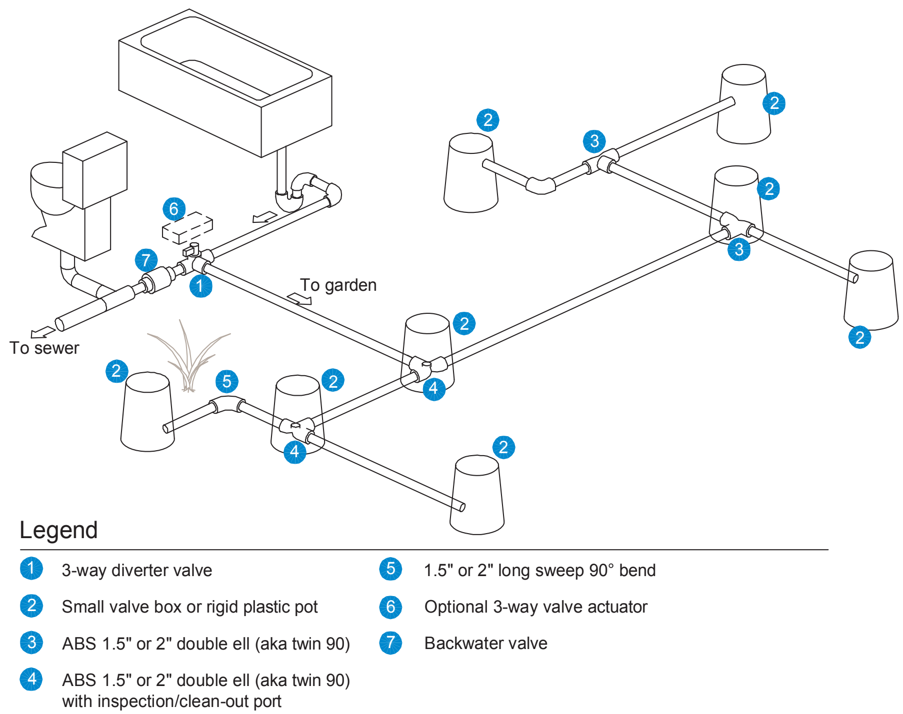


Figure 6. *Branched-drain system. Source: Cleanwater Components.*

Branched-Drain System

System Overview

A branched-drain system allows a homeowner to use graywater from other sources besides the washing machine. The system is simple and requires no electricity. A branched-drain system is driven by gravity flow; no pressure is provided by a washing machine pump or any other pump. This type of system usually distributes graywater from showers and/or sinks, although it is often used in the second standpipe system (for washing machines) described on the previous page. A branched-drain system distributes graywater to the landscape using standard 1½-inch or 2-inch drainage pipe (Figure 6). The irrigated area must be lower in elevation than the graywater source, and the entire distribution system must have a downward slope of 2 percent (¼ inch per foot). The graywater irrigation zone must be downhill relative to the graywater source. Branched-drain systems are best suited to irrigating trees or large shrubs. This kind of system can be time-consuming to construct, but once complete, it requires little maintenance and lasts a long time, since it has no moving parts to break.

How to Build a Branched-Drain System

Note that the following description provides a basic outline of the steps for installing this type of system, but you will need to consult other resources when you plan and install your system.

1. Assess your site: Identify the graywater pipes (shower, sink, or laundry), make sure that you can

access them, and install a 3-way valve before the pipes combine with the toilet drain. Think about how the pipe could be directed to your landscape, considering obstacles like driveways or patios. Identify appropriate plants to irrigate: this type of system is best for trees, shrubs, vines, and other large perennials.

2. Obtain a graywater permit from DBI. See Appendix E for more details.

3. Install a 3-way diverter valve in the drainpipe of the fixture you will be collecting graywater from (Figure 7). The valve must be installed after the p-trap and vent but before the connection to a toilet or kitchen sink drain. If you must install the valve in an inaccessible area because of space considerations, for example, in a small crawlspace, you can add a motor (called an actuator) to the valve and connect it to a switch in the bathroom or other convenient location.

4. Plumb the graywater pipe to your landscape, following standard plumbing techniques, strapping, maintaining a ¼-inch-per-foot gradient, using clean-outs (pipe fittings with a removable plug to allow access to the interior of a pipe, for example, for removing clogs) when needed, and properly sealing the hole you created to exit the building. When exiting the building, make sure not to damage electrical, gas, or plumbing pipes that could be located in the wall, and avoid structural beams and the building foundation. If you have any doubts about plumbing and/or drilling through floors or walls, call in a professional! Chapter 7 of the California Plumbing Code contains the drainage

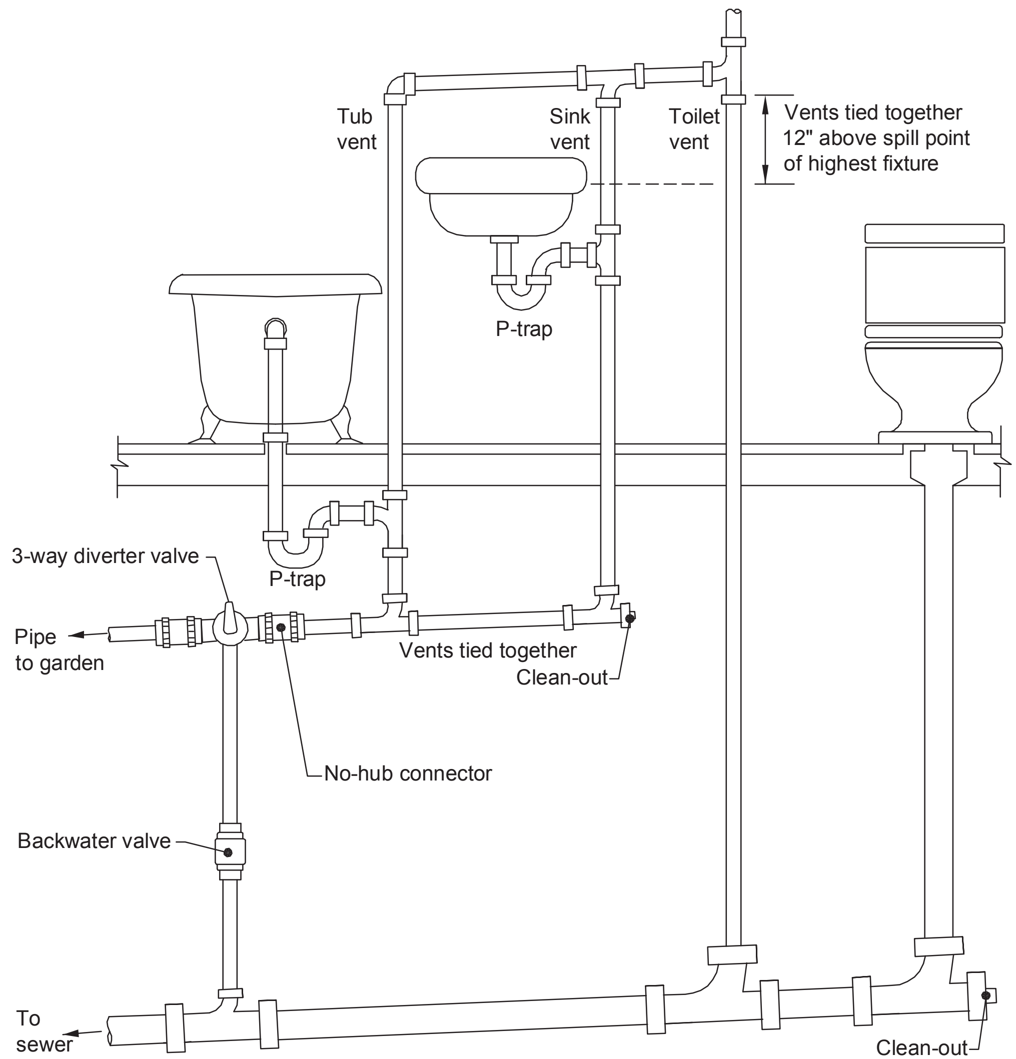


Figure 7. *Location of the 3-way valve in a shower or sink system. Source: Art Ludwig, Oasis Design.*

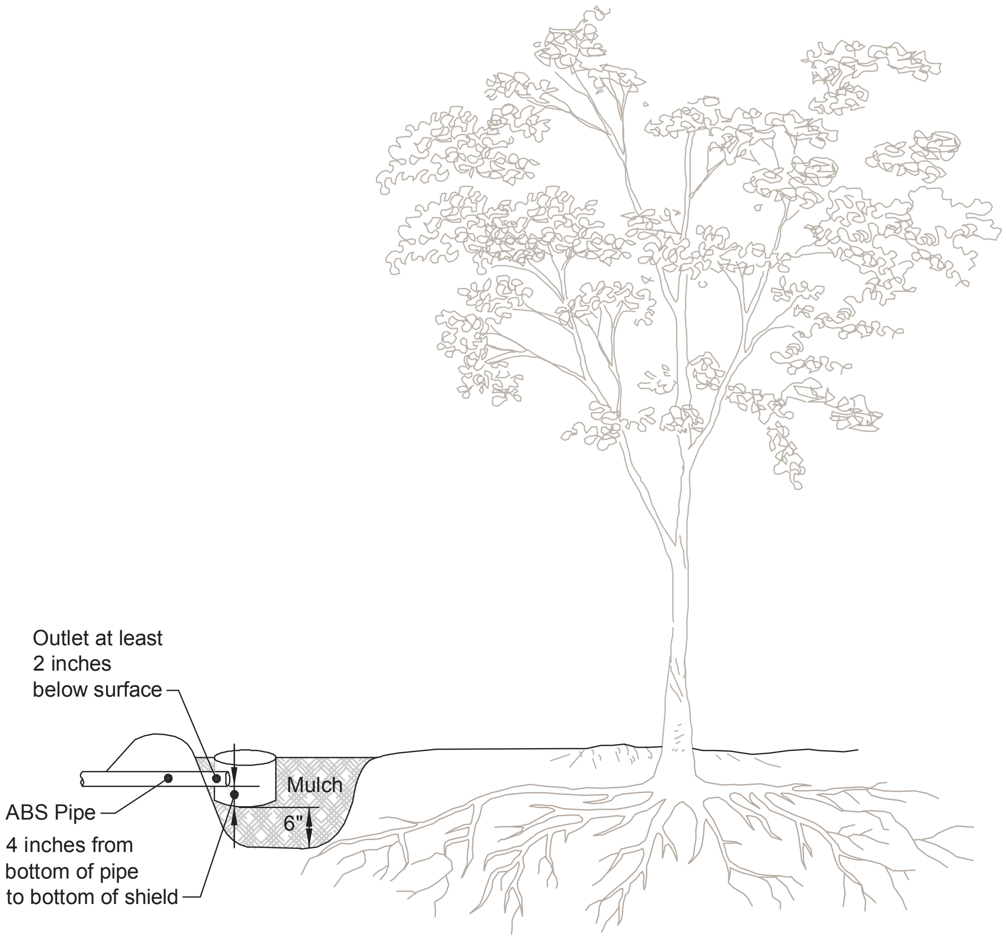


Figure 8. *Mulch shield inside of mulch basin. Note: Roots of a real tree would extend under basin and outside of drip line by many feet.*

plumbing requirements that must be followed when you install the system.

5. Prepare the landscape: dig mulch basins around the drip lines of the plants to be irrigated, trench the pipe to the plants, and construct mulch shields for subsurface irrigation (Figure 8). Make sure that the graywater is discharged at least 2 inches below ground surface and that it falls through the air onto 4 to 6 inches of mulch.

6. Pipe must slope at least 1/4 inch per foot, which is the standard slope for drainage plumbing. The burial depth of the pipe does not have to meet standard depths for sewer pipes, since this is an irrigation system. In flat yards, start with the pipe buried as shallowly as possible (approximately 2 inches), as it will get progressively deeper. If yard is downward sloping, bury the pipe deep enough to prevent it from becoming exposed over time. Consult with DBI about proper depths in this situation.

7. Test the system by turning on the fixture(s), making sure that the graywater flows properly.

For more information about how to install a branched-drain system, see the book references in Appendix F.

Pumped Systems

Electricity and Water in California

In California, almost 20 percent of all electricity and over 30 percent of natural gas is used to pump, heat, and treat water. Graywater systems sometimes need to incorporate a pump, but the homeowner should carefully examine non-pumping options first to minimize the use of electricity. Pumped systems are most often installed when irrigation is needed uphill of the graywater source. Pumped systems can also be installed to pressurize graywater for a drip irrigation system, in which case the water must be filtered.

Overview of Pumped Systems

In pumped systems, graywater is directed to a holding tank for temporary storage (less than 24 hours) before being pumped to the landscape. If the system is to be used for drip irrigation, the graywater must be filtered before it reaches the drip emitters (see description of Sand Filter-to-Drip Irrigation system in the next section). The pumped system described below does not include filtration and therefore can only be used for sending graywater uphill, not for drip irrigation.

Pumped System with No Filtration

As illustrated in Figure 9, in a pumped system with no filtration, also referred to as a "drum with effluent pump system," graywater is directed to a watertight tank (also called a surge tank), from which an effluent pump

Pumped Systems with No Filtration

Description: Graywater from showers, sinks, or laundry is directed to a temporary holding tank and then pumped to the landscape, which can be uphill of the graywater source(s). This system usually alters the existing plumbing and always requires a permit; an additional electrical permit might also be required for the outlet that the pump is plugged into. These systems are best suited for irrigating perennials of any size and larger annuals, for example, corn.

Installation: Installation difficulty varies greatly depending on the existing household plumbing. A solid understanding of plumbing is needed, as well as basic landscaping skills. If a new electrical outlet is required, electrical skills are also required.

Cost: Costs can range from $500-$700 (installed by homeowner) to a few thousand dollars (professional installation).

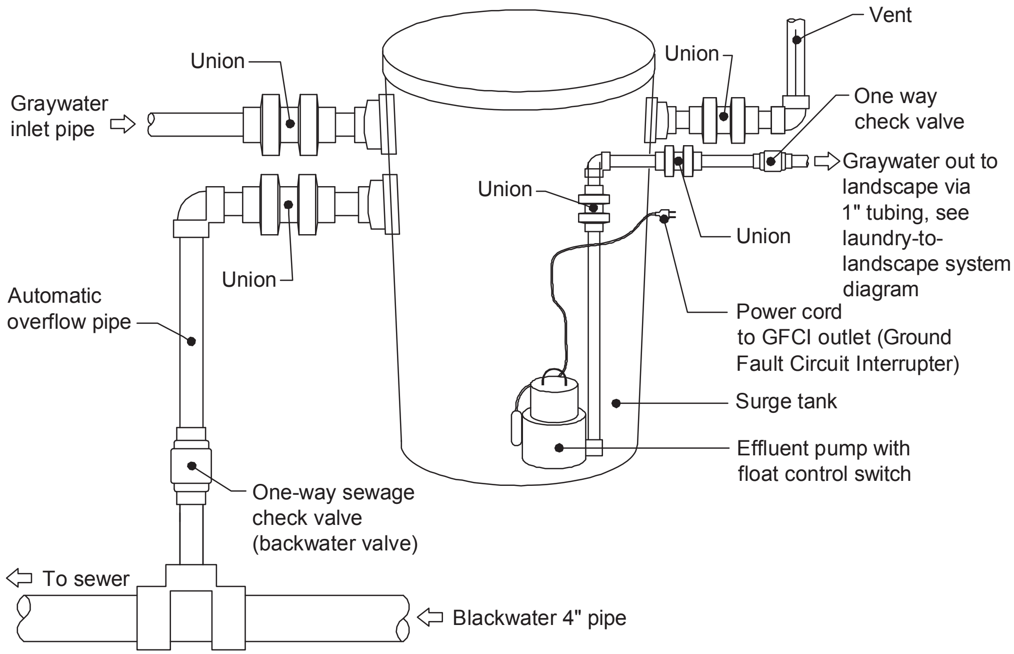


Figure 9. *Drum with effluent pump.*
Source: Robert Kourik, in Drip Irrigation for Every Landscape and All Climates.

discharges water through tubing to the landscape. This system is lower in cost and easier to install than a system that includes a filter for drip irrigation, but it is less water-efficient, since the outlets are larger.

It is possible to put in simple filters to capture hair and lint "upstream" of the surge tank, thus reducing the power required of the pump, but the filters need to be cleaned regularly. Cleaning a graywater filter is a smelly, slimy, and generally unpleasant task that is sometimes left undone, leading to clogged filters, possibly graywater overflows, and other undesired consequences. It is critical to understand the maintenance requirements of your system before installing it. See the Manufactured System section for information about other filtering options.

How to Build a Pumped System with No Filtration

Once you have determined that pumping the graywater is the only possible way to reach your landscape, the steps below provide a general overview for installing a simple pumped system with no filtration. Note that you will need to consult additional resources to build the system. Keep in mind that a pumped system is more complicated than the systems described previously.

1. Assess your site: Identify the graywater pipes (shower, sink, or laundry) and make sure you can access them. Identify a location for the surge tank and an outlet to plug in the pump. If there is an existing outlet nearby, you'll need to determine if the outlet can handle the additional electrical load of the pump. If you are unsure how to determine this, hire a professional. If you need to add an electrical outlet, an electrical permit will be required.

2. Apply to DBI for a graywater permit and for an electrical permit, if a new outlet or dedicated circuit is needed for the pump.

3. Install a 3-way diverter valve in the drain line of the desired graywater fixture, after the p-trap and vent but before the connection to a toilet or kitchen sink drain.

4. Install the surge tank and route the graywater to it. Check the California Plumbing Code for requirements for how to outfit the tank. Requirements include a union fitting, vent, overflow pipe with a backwater valve, and a swing-check valve on the

graywater pipe exiting the tank. Graywater may not be stored for longer than 24 hours, so size the tank so that it empties at least once a day.

5. Direct the irrigation line to the landscape using 1-inch tubing and reducing tee fittings at each plant. See Figure 3 for the laundry-to-landscape system for more details.

6. Prepare the landscape: dig mulch basins around the drip lines of the plants to be irrigated, trench the pipe to the plants, and construct mulch shields for subsurface irrigation.

7. Test the system by turning on the fixture(s), making sure that the graywater flows properly, the pump turns on when it should, and graywater is distributed evenly to the landscape.

Materials needed for a pumped system:

- 3-way valve
- ABS fittings
- Tank
- Effluent pump rated to pump ¾-inch solids
- Unions
- Backwater valve
- Swing-check valve
- 1-inch tubing
- Barbed fittings with ½-inch outlets
- Mulch

For more information about pumped systems, see the references in Appendix F.

Graywater sand filter at the Sunset San Francisco Idea House.
Photo: WaterSprout.

Sand Filter-to-Drip Irrigation

Description: Graywater flows by gravity to a temporary holding tank, is pumped through a sand filter to remove particles, and then is pumped to a drip irrigation system. An irrigation controller allows municipal water to supplement graywater as needed and also controls automatic cleaning of the filter. This system requires a permit for graywater and could require an electrical permit as well. In addition, a backflow prevention assembly must be installed on the municipal water supply line, and the assembly must be tested annually. This system is suitable for all plants, except for lawns.

Installation: Sand filter-to-drip irrigation systems should be installed by a professional.

Cost: System costs range from $7,000 to $15,000 (professional installation).

Other Graywater Systems

In addition to the systems described previously in this manual, there are other options for designing and installing more complex graywater systems. Some of these options are briefly discussed below. New construction or full plumbing remodels can give you access to more graywater sources than are typically available in a retrofit situation. With a larger volume of graywater available, more complex options might be appropriate for your situation. These systems are usually more expensive, can distribute water to more locations, and are a more water-efficient way to irrigate. Complex graywater systems are typically found in high-end residential new construction, especially houses seeking LEED (Leadership in Energy and Environmental Design). Such systems always require a permit.

Dual-Drainage Plumbing

If you are building a new house or doing a major plumbing remodel, you can ask the plumber to keep the graywater drains separate from the toilet and kitchen sink drains, enabling you to access all the household graywater in one pipe. This is dual-drainage plumbing. In this scenario, the graywater and black water (toilet and kitchen sink) pipes can combine either after they exit the house or "downstream" of a convenient location for installing a 3-way valve on the graywater pipe.

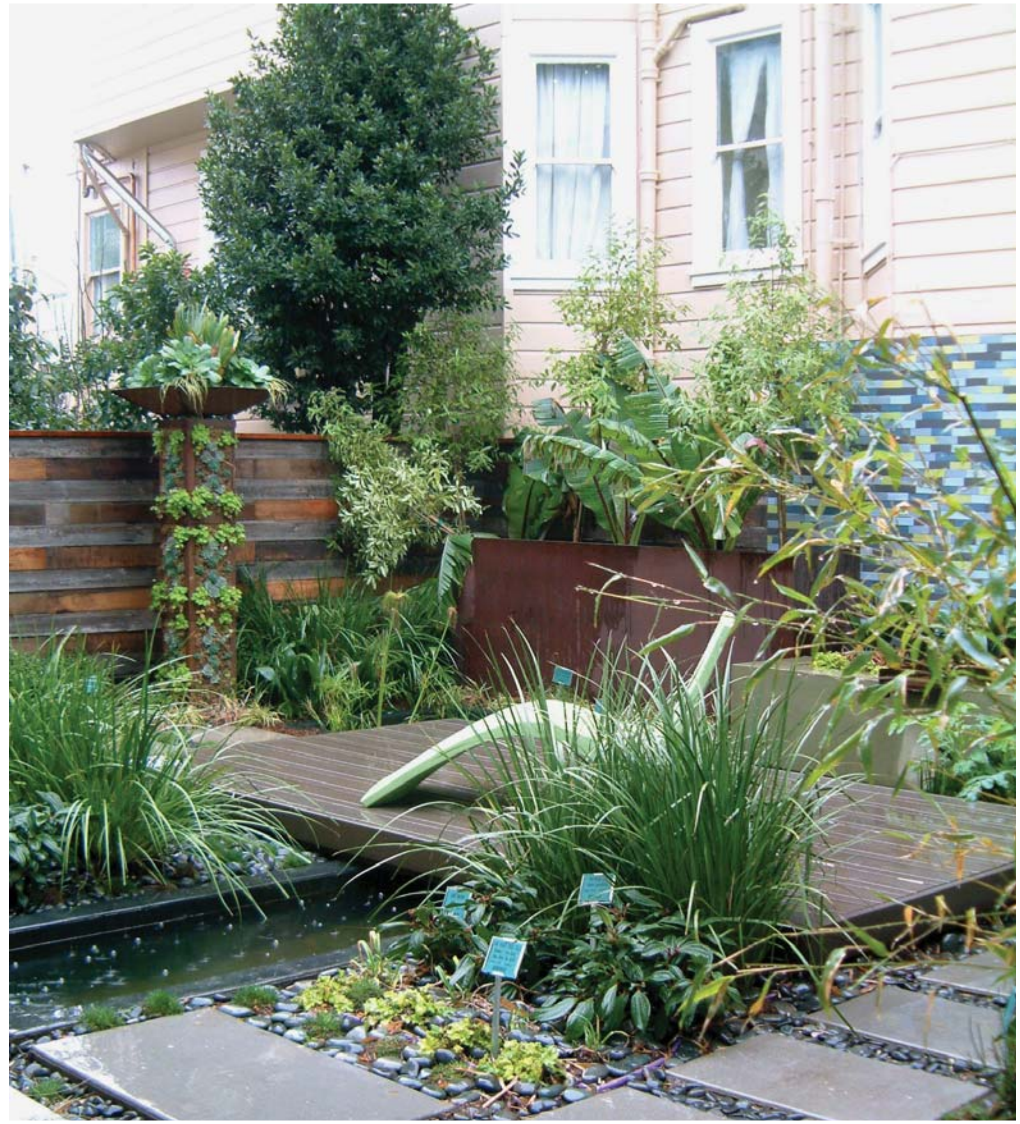
Sand Filter-to-Drip Irrigation

Drip irrigation is the most water-efficient form of landscape irrigation. For graywater to be used in a drip irrigation system, the dirt, hair, and lint must be filtered out so they won't clog the drip emitters. Graywater for drip irrigation is commonly filtered with a sand filter. Note that sand filters only remove solids, not salts or chemicals, so it is still important to use graywater-friendly cleaning products (Appendix C).

In a sand filter-to-drip irrigation system, all the graywater from the house is plumbed to a holding tank, where the graywater is temporarily stored. An irrigation controller turns on an effluent pump in the holding tank when irrigation is needed. The pump sends the graywater through a sand filter, where the dirt, hair, and lint particles are filtered out. The filtered graywater then goes to drip irrigation tubing in the landscape. If there is not enough graywater, the system is set up to include municipal water. This type of system is fully automated and thus more complex and higher in cost than simpler systems, but it allows for greater flexibility in irrigation and can irrigate plants of any size and elevation relative to the house. The sand filter is cleaned automatically on a timed schedule: pressurized municipal water is sent backwards through the filter to remove debris, with the effluent water directed to the sewer. A reduced pressure principle backflow prevention assembly must be installed at the point of connection to protect the municipal (potable) water supply from accidental contamination with graywater. This assembly must be tested by a licensed tester upon installation and subsequently on an annual basis. Results must be sent to the Water Quality Division of the SFPUC. This system requires a plumbing permit and could require an electrical permit as well. Design must be reviewed and approved by the City's DBI.

Manufactured Graywater Systems

Several types of manufactured graywater systems are available for purchase in California. These systems typically filter graywater for use in graywater-compatible drip



This landscape is irrigated with graywater that has passed through a sand filter before entering the subsurface drip irrigation system. Note: The pond is not supplied by graywater and is lined so that graywater doesn't enter it. Photo: WaterSprout.

irrigation tubing. This makes it possible to irrigate smaller plants and to spread the water out over a larger area than is possible with other simple graywater systems or unfiltered pumped systems. Manufactured graywater systems are typically lower in cost than automatized sand filter-to-drip irrigation systems, but higher in cost than the previously mentioned simple systems. The technology for these types of systems is relatively new and still being developed, so their longevity is unknown. If possible, it would be helpful to talk to a homeowner who has owned and operated the system (and not just a sales person) for at least a year to learn more about how it functions. Because these systems incorporate filters, pumps, and sometimes disinfectant (in higher-technology versions), they have more components to maintain and replace. It is also important to find out the system's maintenance needs and learn how you'll know if the system isn't working properly. Since these systems typically require manual filter cleaning one solution is a maintenance contract with the installer, or training an existing on-site landscaper/gardener in system maintenance. This could help prevent system failures from lack of maintenance. All of these systems require a permit.

Indoor Use

In theory, graywater can be filtered, disinfected, and pumped back inside residential buildings to be used for toilet flushing and other non-potable uses. In practice, doing so is not very easy. There are currently rigorous water quality standards that need to be met for interior graywater reuse (California Code of Regulations, Title 22, Section 60301.230). While technology has been developed to meet these standards, it can be expensive for individual homes. Many of these systems also have kinks that need to be worked out.

Currently, it may be easier for most households to use rainwater for toilet flushing and graywater for outdoor irrigation.

Glossary

3-way diverter valve A valve that directs water in one of two directions: the sewer or the landscape. Diverter valves come in different materials and sizes.

ABS Acrylonitrile butadiene styrene, a black plastic pipe used in drainage plumbing. ABS pipe is used in gravity-based graywater systems, such as branched-drain systems. ABS is cut with a saw or tubing cutters and glued together with ABS glue, also called ABS cement.

Actuator A motor that attaches to the face of a plastic 3-way valve and connects to a plug-in transformer and a toggle switch so that a graywater system can be turned on or off from another location (usually inside the house).

Auto vent (also called air admittance valve, AAV, Studor valve, in-line vent)
A device that allows air to enter a drainage plumbing system. In a graywater system, it prevents water being "sucked out" or siphoned out of the washing machine while it is filling. The auto vent must be located at the high point of the graywater system. This device must not be installed on the plumbing system of the house or unit, as this is not allowed under the San Francisco Plumbing Code.

Backflow preventer An assembly that prevents water from reversing its flow direction. Backflow preventers are used to protect the municipal water system from contamination, for example, by graywater from a sand filter-to-drip irrigation system. Backflow preventer assemblies must be tested annually by a licensed tester to ensure they're working properly. A reduced pressure principle backflow preventer (RP) is required for graywater systems that include municipal make-up water and do not have an air gap.

Backwater valve A type of swing-check valve used on the overflow pipe of a graywater tank. Its purpose is to prevent sewage from entering the tank in the event of a sewage clog.

Ball valve — A device that shuts off the flow through a tube or pipe when a "ball" is turned inside the valve.

Barbed fitting — Fitting used in the irrigation part of a laundry-to-landscape system. The tubing fits over the barbs and can be forcibly removed if needed. The connection may not be completely watertight; if a watertight connection is required, a hose clamp can be added. A Blu-Lock fitting, a special type of irrigation fitting, can be used as an alternative to barbed fittings. Blu-Lock fittings make a watertight seal and are easy to work with.

Branched-drain system — A simple graywater system that uses standard drainage plumbing parts to distribute graywater by gravity out to the landscape.

Double ell (also called twin 90, double ¼ bend) — A plumbing fitting that divides the flow in a branched-drain system. Typical sizes are 1½ and 2 inches.

Drainage test — A test to determine how well water drains on a site.

Drip line — The outer point of the leaves on a tree or shrub, where water would drip off onto the ground in a light rain. Trees should be irrigated at or beyond their drip lines; roots typically extend at least twice the distance from the trunk to the drip line.

Dual-drainage plumbing — Separate plumbing systems for separate wastewater flows. As applied to graywater systems, dual-drainage plumbing separates graywater flows (laundry, sinks, and shower/baths) from toilet and kitchen sink wastewater, enabling the entire graywater flow to be accessed in one pipe.

Effluent pump — A pump designed to pump wastewater, including graywater. A graywater effluent pump should be able to pass ¾-inch solids.

Emitter An outlet that discharges water into the landscape. Drip irrigation emitters have very small openings and thus must have adequate filtration if graywater is used. Unfiltered graywater requires emitters, or outlets, of at least 1/2 inch in diameter.

Evapotranspiration The combination of water transpired from plants and evaporated from soil and surfaces. The evapotranspiration rate, or ET, is one variable that determines how much irrigation plants require.

FHT (female hose thread) An adapter or fitting that has hose threads on the inside of the fitting. These hose threads are incompatible with pipe threads.

FPT (female pipe thread) An adapter or fitting that has standard pipe threads on the inside of the fitting.

Filter A device that captures lint, hair, and other particles in graywater to prevent clogging in the rest of the system.

HDPE/PE High density polyethylene or polyethylene, a type of plastic that is used in irrigation tubing. The manufacturing process for HDPE and PE produces fewer toxins than that for PVC, and they are also recyclable.

Loam Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Laundry-to-landscape system A type of graywater system that diverts laundry water directly to the landscape. This system does not require a permit in a one- or two-family dwelling so long as 12 guidelines are followed and the system does not alter the drainage plumbing.

MPT (male pipe thread) Pipes that have standard pipe threads on the outside of the adapter or fitting.

Manufactured system	A type of graywater system purchased from a company. These types of systems usually incorporate a surge tank, a filter, and a pump.
Mulch	A covering, usually of organic matter, placed on the soil surface. For graywater systems, the preferred mulch is large wood chips (not shredded wood or small chips), as the large chips take longer to decompose and thus require less frequent replacement.
Mulch basin	An area created by removing soil and filling the empty space with mulch. Mulch basins are typically located in the drip line of a plant and are sized according to the amount of graywater entering them. Mulch basins create a large space for graywater to spread out and sink into the ground without pooling or runoff.
Mulch shield	See valve box.
Overflow	A pipe exiting a surge tank to allow graywater to flow to the sewer in case of pump failure. The diameter of the overflow pipe must be at least the size of the total of all inlet pipes to the tank.
P-trap	A curved, U-section of drain pipe that holds a water seal to prevent sewer gasses from entering a building through a fixture's drain pipe.
Pathogens of concern	Disease agents and viruses that enter graywater through contact with fecal matter or other infectious agents. Such pathogens could harm health if ingested.
Phytophthora (crown rot)	A plant disease caused by water pooling at the base of the plant, or crown. Crown rot can be prevented by irrigating in the drip zone of the plant and locating the plant on a mound so its crown is above the elevation of the landscape.
Plot plan	A simple aerial view drawing of the site, including the footprint of the building, property lines, municipal supply lines, graywater lines, and areas to be irrigated.

Pooling Pools or puddles of water at the surface. Pooling of graywater is not allowed under the California Plumbing Code and is also unsightly. Pooled graywater provides a place for mosquitoes to breed and the potential for contact by people or pets.

PVC Polyvinyl chloride, a material commonly used for pipes. The manufacturing process is highly toxic, so PVC pipe use should be minimized. PVC is used to make rigid 1-inch pipe that is easy to work with.

Reclaimed water See recycled water.

Recycled water Treated wastewater produced by a wastewater treatment plant.

Sand filter (or rapid sand filter)
Sand filters remove particles from graywater so the water can be used in a drip irrigation system. These filters do not remove salts or chemicals. To function properly, sand filters must be automatically backflushed with fresh water to clean them out. Sand filters are commonly used in pool and spa systems.

Sand filter-to-drip irrigation system
A type of graywater system that uses a sand filter to remove particles from graywater and distributes the water through graywater-compatible drip irrigation tubing.

Slip connection A connection of plastic fittings made by slipping one piece of pipe inside the fitting. These fittings must be glued with the appropriate glue (depending on pipe material) to create a watertight seal.

Surge tank A tank that temporarily collects graywater before it is pumped or drained out to the landscape. Surge tanks should not store graywater for longer than 24 hours.

Surfactants (anionic and nonionic)
Substances used in detergents and cleaning products to loosen dirt from fabric and prevent it from re-adhering. Surfactants can be made from plants or petro-chemicals.

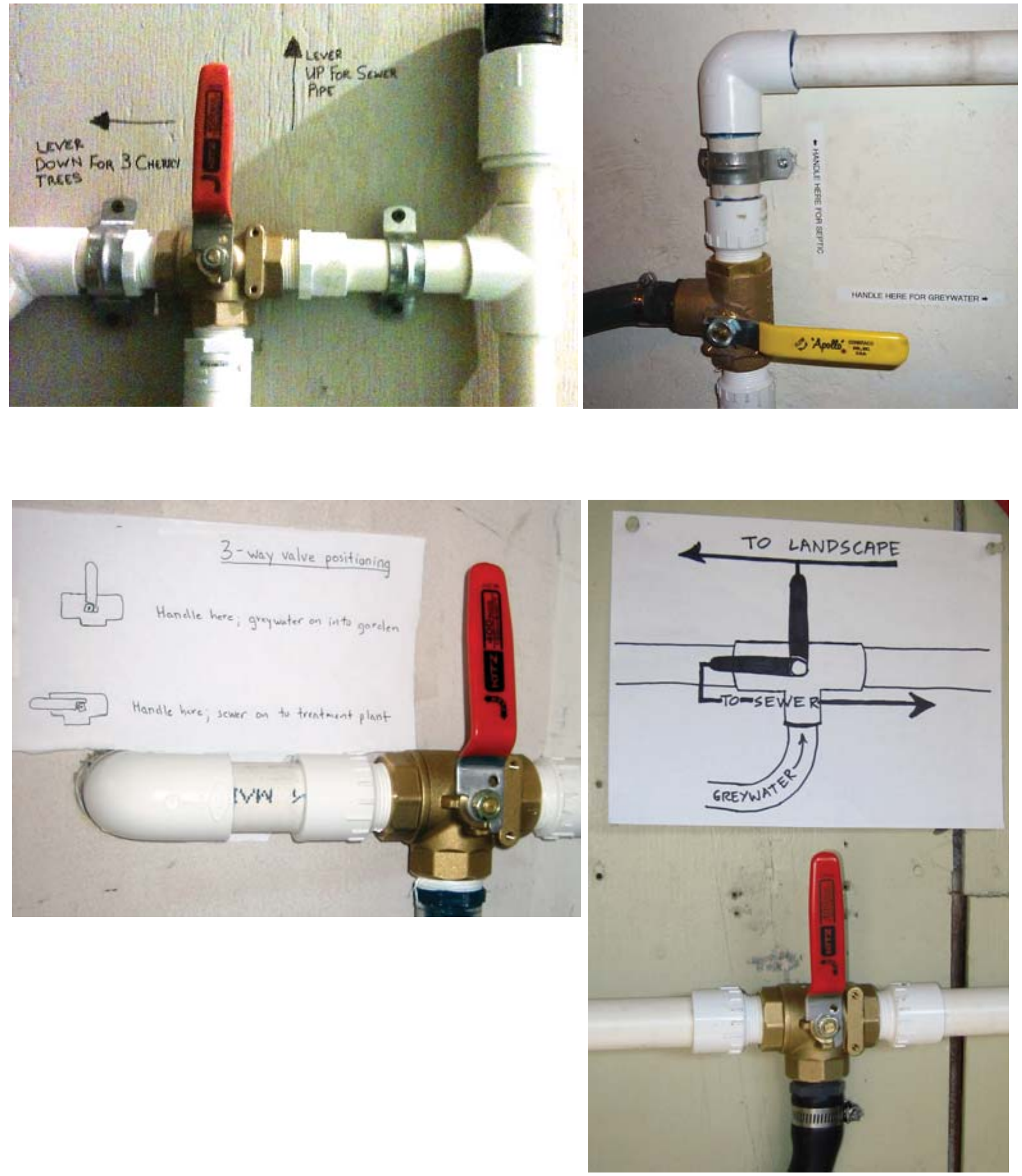
Swing-check valve (one-way valve)
A valve that allows water to flow in one direction only. Inside the valve is a flap that swings open in one direction; if water begins to flow backward, the valve closes and prevents water from passing. These valves are used in pumped systems when the irrigated area is higher in elevation than the pump. Note: do not confuse a "swing" check valve with a "spring" check valve, as they are not the same thing.

Valve box
Also called a mulch shield, a valve box is a subsurface cavity into which graywater is discharged. Graywater flows from the valve box into mulch. Air space between the outlet and the mulch prevents roots from growing back into the graywater pipe and clogging the system. Valve boxes can be purchased or made at home out of 1- to 5-gallon plastic pots, the size depending on the quantity of graywater to be discharged.

Water table
The upper surface of the saturated zone, where water fills the pore spaces of soil or rock.

Appendix A: Signs for Your Graywater System

- Your graywater system must be labeled so that all users (current and future) know how to turn it on and off. Sample signs are shown in the images to the right.
- You must label all above-ground graywater pipes as follows: "Caution: Non-potable water, do not drink" at intervals of 5 feet or less.
- Consider putting a reminder of what soaps to use on or near your machine, particularly if you share it with other people.



Examples of labeling the 3-way valve.

Appendix B: Operation and Maintenance Manual Templates

See *http://www.sfwater.org/landscape* for links to Microsoft Word versions of these templates. Graph paper is provided at the end of each template for use in drawing a plan of your graywater system.

Sample Operation and Maintenance Manual for Laundry-to-Landscape Graywater System

Congratulations on your new graywater system! This manual will help you maintain a well-functioning, water-saving graywater irrigation system. This manual is to remain with the building throughout the life of the system. Upon change of ownership or occupancy, the new owner or tenant must be notified that the structure contains a graywater system. A map showing the location of all graywater system components should be attached to this manual.

Insert the calculations you used to design your system here:

My washing machine uses ___________ gallons per load.

My household does ___________ loads of laundry per day on a typical laundry day.

My household does ___________ loads of laundry per week.

Soil type ____________________

This system was designed to accommodate _____________ gallons per day.

1. How do I turn my graywater system off?

To turn your graywater system off, turn the handle of the 3-way valve to direct the water towards the sewer or septic system. The first few times you do this, check to make sure the system is turning off and that your 3-way valve is labeled correctly.

These are common times you'll need to turn off your system:

- During the rainy season. Graywater may be used if there are extended dry periods during the typical rainy season, but the system must be turned off as soon as the rain resumes.
- When washing dirty diapers.

- When washing anything with chemicals, such as oily rags.
- Anytime you notice that the water isn't draining well and you see pooling or runoff.
- If you think your plants are receiving too much water.
- Anytime you use products that are harmful to plants (like bleach or harsh cleaners).

2. What products can I use in my graywater system?

It is important to use plant-friendly products when reusing your graywater. All products should be biodegradable and non-toxic. In addition, they should be free of salt (sodium) and boron (borax), two common ingredients that are non-toxic to people but are harmful to plants and/or the soil.

Chlorine bleach is harmful to plants and should be diverted, along with any other harmful products, to the sewer or septic system (by switching the 3-way valve). Hydrogen peroxide bleaches are less harmful and can be used instead of chlorine.

Another consideration with cleaning and personal care products, such as shampoos and conditioners, is their effect on the pH of the water. While many soaps do not change the water's pH, some do. In general, liquid soaps do not affect the pH, while bar soaps make the water alkaline (opposite of acidic). Certain acid-loving plants might not be happy with alkaline water. If you're uncertain if the pH is being affected, use the graywater to irrigate plants that are not acid-loving. Acid-loving plants include ferns, azaleas, camellias, rhododendrons, and blueberries.

For information about products that independent groups have found to be free of ingredients that may harm plants, see websites such as *http://greywateraction.org/content/greywater-friendly-products* and *http://www.harvestingrainwater.com/greywater-harvesting/greywater-compatible-soaps-and-detergents/*.

3. How do I maintain my graywater system?

The main thing you'll need to do to maintain your graywater system is periodically check on the mulch basins (the mulch layer the graywater flows into) and make sure the graywater is draining properly. If you notice any pooling or runoff, dig out the mulch basin and put in new mulch (wood chips or bark). Mulch usually needs to be replaced every one or two years.

At the beginning of the irrigation season, check to ensure that graywater is flowing out of the outlets evenly. If you notice uneven distribution, check the outlets for clogs, and manually remove any debris. If you notice that many of the outlets are clogged, you need to flush the system.

To flush the system, open any partially closed ball valves, making sure the end of each line is open. Pull the tubing off the PVC connection point and insert the barbed 1-inch female hose thread adapter. Attach a garden hose to the hose connection and turn the hose on high to flush particles out of the system. ***Any time you attach a garden hose to temporarily flush the system, you are required to have an anti-siphon valve or vacuum breaker on the hose bibb!*** When you are finished, be sure to readjust the ball valves for an even flow of graywater.

A basic operation and maintenance checklist for laundry-to-landscape systems is provided in Table B-1.

Table B-1. *Laundry-to-Landscape System: Operation and Maintenance Checklist*

Component	Inspection Schedule	O&M Activity	Action Needed
3-way valve	Annual	Check for leaks at washer hose and that label is in place	☐ Condition good ☐ Action needed • If leaking, tighten hose clamp. • Replace label if needed.
Auto vent	Annual	Check for leaks from auto vent	☐ Condition good ☐ Action needed • If leaking, replace the auto vent.
Piping and tubing	If you notice water in an unusual place	Check for leaks	☐ Condition good ☐ Action needed • If piping or tubing is damaged, cut out damaged section and reconnect with a 1-inch barbed coupling.
	Annual	Check for even distribution from outlets	☐ Condition good ☐ Action needed • Unclog hair or lint built up in the outlets. Open ball valves, check for clogs. If needed, flush the system with a hose: temporarily disconnect the tubing from the PVC fitting, attach the garden hose by barb fitting, and connect the hose to the system.
Mulch basins	Annual	Check to see if mulch has decomposed and water is pooling under graywater outlets	☐ Condition good ☐ Action needed • Remove decomposed mulch and add new mulch.

4. What are the 12 guidelines I must follow to comply with the law?

Under the 2010 California Plumbing Code (California Code of Regulations, Title 24, Part 5, Chapter 16A), washing machine systems in one- or two-unit residential buildings do not require a permit as long as the installer follows the 12 minimum requirements outlined in the code:

1. If required, notification has been provided to the Enforcing Agency regarding the proposed location and installation of a graywater irrigation or disposal system. *Note: A city, county, or other local government may, after a public hearing and enactment of an ordinance or resolution, further restrict or prohibit the use of graywater systems.*

2. The design shall allow the user to direct the flow to the irrigation or disposal field or the building sewer. The direction control of the graywater shall be clearly labeled and readily accessible to the user.

3. The installation, change, alteration or repair of the system does not include a potable water connection or a pump and does not affect other building, plumbing, electrical or mechanical components including structural features, egress, fire-life safety, sanitation, potable water supply piping or accessibility.

4. The graywater shall be contained on the site where it is generated.

5. Graywater shall be directed to and contained within an irrigation or disposal field.

6. Ponding or runoff is prohibited and shall be considered a nuisance.

7. Graywater may be released above the ground surface provided at least two (2) inches (51 mm) of mulch, rock, or soil, or a solid shield covers the release point. Other methods which provide equivalent separation are also acceptable.

8. Graywater systems shall be designed to minimize contact with humans and domestic pets.

9. Water used to wash diapers or similarly soiled or infectious garments shall not be used and shall be diverted to the building sewer.

10. Graywater shall not contain hazardous chemicals derived from activities such as cleaning car parts, washing greasy or oily rags, or disposing of waste solutions from home photo labs or similar hobbyist or home occupational activities.

11. Exemption from construction permit requirements of this code shall not be deemed to grant authorization for any graywater system to be installed in a manner that violates other provisions of this code or any other laws or ordinances of the Enforcing Agency.

12. An operation and maintenance manual shall be provided. Directions shall indicate the manual is to remain with the building throughout the life of the system and indicate that upon change of ownership or occupancy, the new owner or tenant shall be notified the structure contains a graywater system.

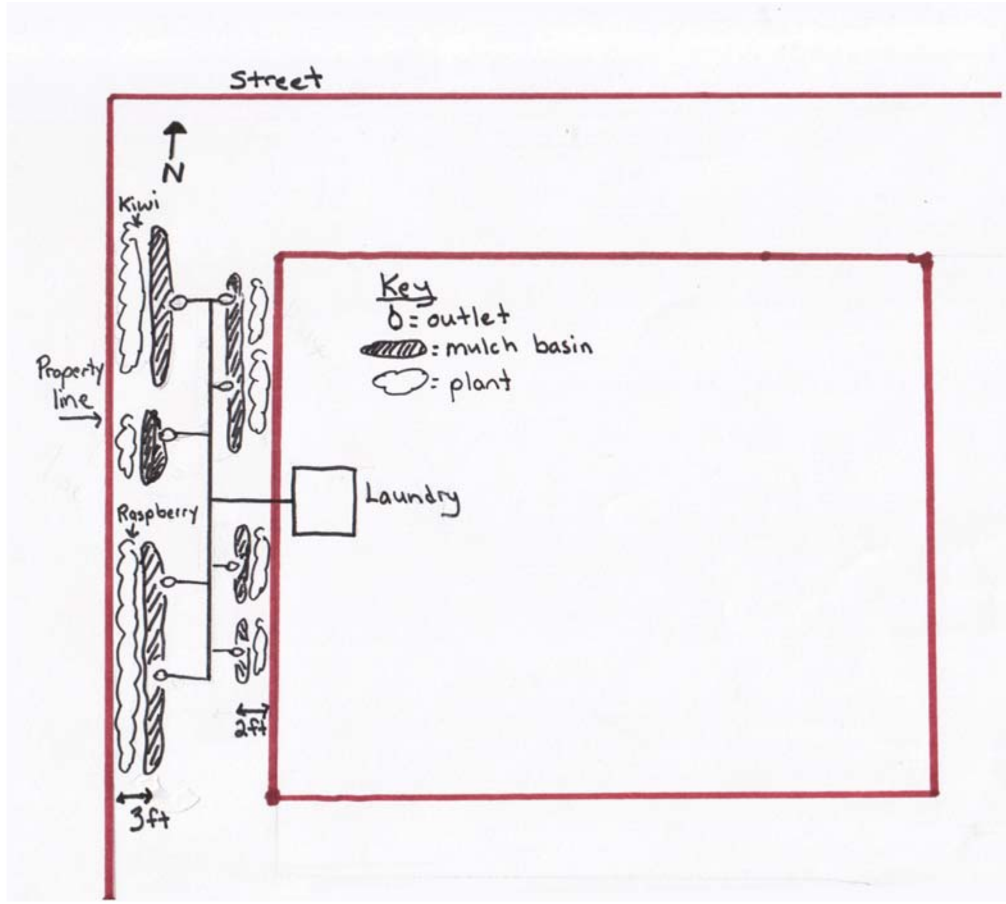
Creating a Simple Plot Plan

It is recommended that you sketch the layout of your laundry to landscape graywater system and attach it to your O&M manual. Guidelines for the sketch are listed below, and grid paper is provided on the next page. Attach photos of irrigation tubing taken after installation but before the tubing is covered with soil. Together, the sketch and photos will provide a good record of your system for future reference.

Guidelines for your sketch:

- Put in landmarks for reference, for example, the side of your home, sidewalk, fences, and street.
- Indicate where the pipe exits your home.
- Show the pipe, tubing, and mulch shields.
- Add setbacks between the system and your home, property lines, and other structures.
- Add a rough scale, for example, 1 inch = 10 feet.
- Add a north (or other direction) arrow.

This sketch is for your own use, so it can be as simple or detailed as you like. An example is shown at right.



Sketch: Laura Allen.

Graywater System Plot Plan

Address: ______________________________ Date: ______________________

Sample Operation and Maintenance Manual for Branched-Drain Graywater System

Congratulations on your new graywater system! This manual will help you maintain a well-functioning, water-saving graywater irrigation system.

This manual is to remain with the building throughout the life of the system. Upon change of ownership or occupancy, the new owner or tenant must be notified that the structure contains a graywater system. A map showing the location of all graywater system components is attached to this O&M manual.

Insert the information you used to design your system here:

Estimated graywater flow (permitted systems calculation) ___________

Soil type ____________________

Minimum size of irrigation or infiltration area required _________________

Actual size of irrigation or infiltration area _____________

Estimated graywater flow (irrigation supply calculations) ___________

1. How do I turn my graywater system off?

To turn your graywater system off, turn the handle of the 3-way valve to direct the water towards the sewer or septic system. The first few times you do this, check to make sure the system is turning off and that your 3-way valve is labeled correctly.

These are common times you'll need to turn off your system.

- During the rainy season. Graywater may be used if there are extended dry periods during the typical rainy season, but the system must be turned off as soon as the rain resumes.
- When washing dirty diapers.

- When washing anything with chemicals, such as oily rags.
- Anytime you notice that the water isn't draining well and you see pooling or runoff.
- If you think your plants are receiving too much water.
- Anytime you use products that are harmful to plants (like bleach or harsh cleaners).

2. What products can I use in my graywater system?

It is important to use plant-friendly products when reusing your graywater. All products should be biodegradable and non-toxic. In addition, they should be free of salt (sodium) and boron (borax), two common ingredients that are non-toxic to people but are harmful to plants and/or the soil.

Chlorine bleach is harmful to plants and should be diverted, along with any other harmful products, to the sewer or septic (by switching the 3-way valve). Hydrogen peroxide bleaches are less harmful and can be used instead of chlorine.

Another consideration with cleaning and personal care products, such as shampoos and conditioners, is their effect on the pH of the water. While many soaps do not change the water's pH, some do. In general, liquid soaps do not affect the pH, while bar soaps make the water alkaline (opposite of acidic). Certain acid-loving plants might not be happy with alkaline water. If you're uncertain if the pH is being affected, use the graywater to irrigate plants that are not acid-loving. Acid-loving plants include ferns, azaleas, camellias, rhododendrons, and blueberries.

For information about products that independent groups have found to be free of ingredients that may harm plants, see websites such as *http://greywateraction.org/content/greywater-friendly-products* and *http://www.harvestingrainwater.com/greywater-harvesting/greywater-compatible-soaps-and-detergents/*. You can also find out what's in your products at *http://cosmeticdatabase.org*. In a shower, shampoo is fairly diluted so it is not as important as detergents in the washing machine.

3. How do I maintain my graywater system?

The main thing you'll need to do to maintain your graywater system is periodically check on the mulch basins (the mulch layer the graywater flows into) and make sure the graywater is draining properly. If you notice any pooling or runoff, dig out the mulch basin and put in new mulch (wood chips or bark). Mulch usually needs to be replaced every one or two years.

At the beginning of the irrigation season, check to ensure that graywater is flowing out of the outlets evenly. If you notice uneven distribution of graywater, check the outlets for clogs, and manually remove any debris you find. If you notice that many of the outlets are clogged, you need to flush the system. There could be some settling of the system over time, which could result in uneven distribution out of the outlets. You can readjust the slope of the double-ell (twin 90) flow splitters to even out the flow.

To "flush" the system, insert a garden hose into a clean-out and force water through the system. If there is a blockage, you can insert a "snake" to push out a clog.

4. What is required to keep my system legal and in compliance with the graywater code?

Under the 2010 California Plumbing Code (California Code of Regulations, Title 24, Part 5, Chapter 16A), the requirements below must be followed:

- The graywater system shall not be connected to any potable water system without an air gap or other physical device which prevents backflow and shall not cause the ponding or runoff of graywater.
- No graywater system or part thereof shall be located on any lot other than the lot that is the site of the building or structure that discharges the graywater, nor shall any graywater system or part thereof be located at any point having less than the minimum distances indicated in Table 16A-1.
- Water used to wash diapers or similarly soiled or infectious garments or other prohibited contents shall be diverted by the user to the building sewer.

- Graywater shall not be used in spray irrigation, allowed to pond or runoff and shall not be discharged directly into or reach any storm sewer system or any surface body of water.
- Human contact with graywater or the soil irrigated by graywater shall be minimized and avoided, except as required to maintain the graywater system. The discharge point of any graywater irrigation or disposal field shall be covered by at least (2) inches of mulch, rock, or soil, or a solid shield to minimize the possibility of human contact.
- Graywater shall not be used to irrigate root crops or edible parts of food crops that touch the soil.

Creating a Plot Plan

Permitted System

If your system requires a permit because you altered the existing plumbing to access sink or shower water, you will be required to submit a plan of your graywater system to DBI. Contact DBI for plot plan requirements. For an example of the level of detail that might be required, refer to the example plans in Appendix E of the Graywater Design Manual. Keep this plot plan with your O&M manual. Attach photos of irrigation tubing taken after installation but before the tubing is covered with soil. Together, the plan and photos will provide a good record of your system for future reference.

Unpermitted System

If you have a second-standpipe system for laundry graywater and have not altered the existing plumbing, it is recommended (but not required) that you sketch the layout of your graywater system and attach it to your O&M manual. Guidelines for the sketch are listed below, and grid paper is provided on the next page. Attach photos of irrigation tubing taken after installation but before the tubing is covered with soil. Together, the sketch and photos will provide a good record of your system for future reference.

Guidelines for your sketch:

Put in landmarks for reference, for example, the side of your home, sidewalk, fences, and street.

- Indicate where the pipe exits your home.
- Show the pipe, tubing, and mulch shields.
- Add setbacks between the system and your home, property lines, and other structures.
- Add a rough scale, for example, 1 inch = 10 feet.
- Add a north (or other direction) arrow.

Graywater System Plot Plan

Address: ______________________________ Date: ______________________________

Sample Operation and Maintenance Manual for Pumped Graywater System

Congratulations on your new graywater system! This manual will help you maintain a well-functioning, water-saving graywater system.

This manual is to remain with the building throughout the life of the system. Upon change of ownership or occupancy, the new owner or tenant must be notified that the structure contains a graywater system. A map showing the location of all graywater system components is attached to this O&M manual.

1. How do I turn my graywater system off?

To turn your graywater system off, turn the handle of the 3-way valve to direct the water towards the sewer or septic system. The first few times you do this, check to make sure the system is turning off when you want and that your 3-way valve is labeled correctly.

These are common times you'll need to turn off your system:

- During the rainy season. Graywater may be used if there are extended dry periods during the typical rainy season, but the system must be turned off as soon as the rain resumes.
- When washing dirty diapers.
- When washing anything with chemicals, such as oily rags.
- Anytime you notice that the water isn't draining well and you see pooling or runoff.
- If you think your plants are receiving too much water.
- Anytime you use products that are harmful to plants (like bleach or harsh cleaners).

2. What products can I use in my graywater system?

It is important to use plant-friendly products when reusing your graywater. All products should be biodegradable and non-toxic. In addition, they should be free of salt (sodium) and boron (borax), two common ingredients that are non-toxic to people but are harmful to plants and/or the soil.

Chlorine bleach is harmful to plants and should be diverted, along with any other harmful products, to the sewer or septic system (by switching the 3-way valve). Hydrogen peroxide bleaches are less harmful and can be used instead of chlorine.

Another consideration with cleaning and personal care products, such as shampoos and conditioners, is their effect on the pH of the water. While many soaps do not change the water's pH, some do. In general, liquid soaps do not affect the pH, while bar soaps make the water alkaline (opposite of acidic). Certain acid-loving plants might not be happy with alkaline water. If you're uncertain if the pH is being affected, use the graywater to irrigate plants that are not acid-loving. Acid-loving plants include ferns, azaleas, camellias, rhododendrons, and blueberries.

For information about products that independent groups have found to be free of ingredients that may harm plants, see websites such as *http://greywateraction.org/content/greywater-friendly-products* and *http://www.harvestingrainwater.com/greywater-harvesting/greywater-compatible-soaps-and-detergents/*. You can also find out what's in your products at *http://cosmeticdatabase.org*. In a shower, shampoo is fairly diluted so it is not as important as detergents in the washing machine.

3. How do I maintain my system?

You will be required to submit a plan of your graywater system with your permit application. Contact DBI for requirements. For an example of the level of detail that might be required, refer to the example plans in Appendix E of the Graywater Design Manual. Attach photos of irrigation tubing taken after installation but before the tubing is covered with soil. Together, the plan and photos will provide a good record of your system for future reference.

4. What is required to keep my system legal and in compliance with the graywater code?

Under the 2010 California Plumbing Code (California Code of Regulations, Title 24, Part 5, Chapter 16A), the requirements below must be followed:

- The graywater system shall not be connected to any potable water system without an air gap or other physical device which prevents backflow and shall not cause the ponding or runoff of graywater.
- No graywater system or part thereof shall be located on any lot other than the lot that is the site of the building or structure that discharges the graywater, nor shall any graywater system or part thereof be located at any point having less than the minimum distances indicated in Table 16A-1.
- Water used to wash diapers or similarly soiled or infectious garments or other prohibited contents shall be diverted by the user to the building sewer.
- Graywater shall not be used in spray irrigation, allowed to pond or runoff and shall not be discharged directly into or reach any storm sewer system or any surface body of water.
- Human contact with graywater or the soil irrigated by graywater shall be minimized and avoided, except as required to maintain the graywater system. The discharge point of any graywater irrigation or disposal field shall be covered by at least (2) inches of mulch, rock, or soil, or a solid shield to minimize the possibility of human contact.
- Graywater shall not be used to irrigate root crops or edible parts of food crops that touch the soil.

Creating a Plot Plan

You will be required to submit a plot plan of your graywater system with your permit application. For an example of the level of detail that might be required for simpler systems, refer to the example plans in Appendix E of the Graywater Design Manual. However, depending on system complexity, you may be required to provide additional details to DBI. Contact DBI for requirements. You may need to consult with a professional to assist you with your plans. Keep this plot plan with your O&M manual. Attach photos of irrigation tubing taken after installation but before the tubing is covered with soil. Together, the plan and photos will provide a good record of your system for future reference.

Graywater System Plot Plan

Address: ______________________________ Date: ______________________

Appendix C: Products

Product Ingredients to Avoid

Salt and sodium compounds**:** Salts can build up in the soil and prevent plants from taking up water. Over time, salt build-up can kill plants.

Boron or borax**:** Boron is a plant micronutrient, but once plants have their boron needs met, it quickly becomes a microtoxin that damages plants. Since boron is non-toxic to people, it is a common element in ecological detergents. To avoid boron poisoning of your plants, do not use any soap or detergent that contains boron or borax.

Chlorine bleach**:** Chlorine bleach kills soil microorganisms and can damage your plants. Do not use it in a graywater system! Hydrogen peroxide bleach can be used as an alternative.

Recommended Soaps and Products

Look for products that are free of the ingredients above. For information about products that independent groups have found to be free of ingredients that may harm plants, see websites such as *http://greywateraction.org/content/greywater-friendly-products* and http://*www.harvesingrainwater.com/greywater-harvesting/greywater-compatible-soaps-and-detergents/*. You can also read the back of detergent bottles. If a company doesn't list all its ingredients, you'll have no way of knowing if the product is safe for your plants or not. There are also soap alternatives for laundry machines, such as soap nuts, magnets, and balls that deionize the water.

Cleaners: Many cleaners have high levels of salts, contain harmful chemicals, and can be very basic (alkaline). In general, cleaning products made from vinegar are better for plants. Use cleaners sparingly.

Personal care products: If you are interested in learning more about the ingredients in your shampoos, conditioners, and deodorants, visit *http://cosmeticdatabase.org*, an on-line information site that allows you to investigate what is in your products.

Appendix D: What to Irrigate with Graywater and How Much Water to Use

Irrigation

The key to proper irrigation with low-tech graywater systems is to get an accurate estimate of how much graywater is produced and then match the available amount of graywater with the proper plants. Typically, plants with larger root zones, like trees and shrubs, can withstand times without irrigation, although they do better with regular watering.

"Hydrozoning" is keeping plants with similar water needs on the same irrigation cycle. This practice is important for conserving water in a landscape. In a landscape irrigated with graywater, it is important to put your water-loving plants in locations accessible to graywater while putting drought-tolerant plants in other areas. This way you can avoid the need for irrigation with potable water. Low-tech graywater systems typically supply only one hydrozone at a time, whereas more complex systems can supply multiple hydrozones.

The information below will help you estimate how much of your landscape can be irrigated using a graywater system.

A typical medium-sized fruit tree in San Francisco needs approximately 10 to 20 gallons of water per week during the dry season. Using this rough estimate, graywater from one load of laundry from a front-loading machine (approximately 20 gallons) could irrigate one to two trees per week; graywater from a top loader (approximately 40 gallons) could irrigate three to four trees per week.

Another easy rule of thumb for estimating plant water needs is to find the square footage of the plant's canopy and divide it by 4. This approximates the gallons per week the plant needs. For example, an apple tree with a canopy area of 80 square feet might need 80/4, or about 20 gallons per week. Note that drought-tolerant plants require much less water than estimated by this method!

This graywater system is used to irrigate plants with similar water needs. The fruit trees and larger perennials are irrigated from the laundry machine in one "hydrozone." Photo: Leigh Jerrard.

Table D-1. *Water Needs of Some Common Plants*

Low (Species Factor 0.2)	Moderate (Species Factor 0.5)	High (Species Factor 0.8)
California poppy	Tulip tree	Birch
Pineapple guava	Apple tree	Willow
European grape	Fig tree	Coast redwood
Bougainvillea	(Most other fruit trees)	Kiwi
Lemon verbena	Shasta daisy	White Alder

Source: Water Use Classification of Landscape Species, California Department of Water Resources.

Source: California Irrigation Management Information System (CIMIS)

REFERENCE EVAPOTRANSPIRATION

Legend

1 COASTAL PLAINS HEAVY FOG BELT
Lowest ETo in California, characterized by dense fog

2 COASTAL MIXED FOG AREA
Less fog and higher ETo than zone 1

Monthly Average Reference Evapotranspiration by ETo Zone (inches/month)

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	0.93	1.40	2.48	3.30	4.03	4.50	4.65	4.03	3.30	2.48	1.20	0.62	33.0
2	1.24	1.68	3.10	3.90	4.65	5.10	4.96	4.65	3.90	2.79	1.80	1.24	39.0

Figure D-1. *Reference evapotranspiration zones in San Francisco.*

You can also use an equation to estimate how much water your specific plants need. However, note that there are many variables that affect plant water needs, so any technique you use will be an approximation. The most important thing is to observe your plants and note how they are doing.

The equation for plant water requirements on the following page provides a method for calculating how many gallons per week a specific plant or planted area requires. To use this equation, you need the following information:

- **The area of the plants:** Estimate the planted area using the area of a circle for trees (the distance from the trunk to the drip line is the radius of the circle) or the area of a rectangle for rectangular-shaped planted areas.
- **The species factor of the plant(s):** Available at *http://www.water.ca.gov/wateruseefficiency/docs/wucols00.pdf* or in the *Sunset Western Garden Book*. The species factor is a number used to differentiate between the water needs of plants (high, moderate, and low). Table D-1 lists the species factors of some common plants in San Francisco.
- **The evapotranspiration, or ET, rate:** Available at *http://wwwcimis.water.ca.gov/cimis/infoEtoOverview.jsp#*. Evapotranspiration is a combination of water transpired from plants and evaporated from soil and plant surfaces.

Example: Estimating How Much Water Your Plants Need

A western San Francisco household has a yard with eight small fruit trees and native plants. The homeowners currently irrigate the trees using tap water, but they would like to use graywater from their washing machine instead. The homeowners estimate that they produce 60 gallons of graywater from their washing machine per week. The drip lines of the trees are 3 feet from their trunks.

The homeowners start by making a rough estimate of how much water the trees need. Since a medium-sized fruit tree requires between 10 and 20 gallons per week, they assume that their small fruit trees will need less than 10 gallons per week, or less than a total of 80 gallons for all eight trees.

For a more accurate estimate, they use the plant water requirements formula on page D-3. Three variables are needed for this calculation: area of the trees, species factor, and evapotranspiration (ET) rate.

Area of each tree: πr^2 = 3 x 3 feet x 3 feet = 27 square feet (note that π = 3.14, but 3 is close enough for this estimate)

Species factor: 0.5 (from *http://www.water.ca.gov/wateruseefficiency/docs/wucols00.pdf* or the *Sunset Western Garden Book*)

July weekly ET = 1.16 and April weekly ET = 0.82. For weekly ET divide monthly ET by four (July ET 4.65/4 = 1.16)

Using the plant water requirements formula:

Weekly plant water needs in July (in gallons) = 0.62 x 1.16 (July ET weekly) x 0.5 (species factor) x 27 square feet (area of each tree) = 9.7 gallons per week in July

Using the April ET weekly rate of 0.82, the homeowners calculate that each tree requires 6.9 gallons per week in April.

The homeowners estimate that if they split the 60 gallons equally between eight trees, each will get approximately 7 gallons a week. This is less than the peak irrigation need in July but enough for most of the year. They decide to install a laundry-to-landscape system, with graywater distributed equally to all eight trees. They plan to observe the trees in the summer. If the trees exhibit signs of water stress, they will supplement the graywater irrigation with tap water.

Evapotranspiration is given in inches per month or inches per day. You can convert this to inches per week. Figure D-1 includes a map of ET zones in San Francisco and ET rates for each month of the year.

Plant water requirements (in gallons per week) = 0.62 (conversion factor for the ET rate, converting inches to gallons) x planted area (square feet) x species factor (high, moderate, or low) x evapotranspiration (ET) rate (inches per week).

For simplicity, it is assumed that all the water goes to the roots of the plants, i.e., that the irrigation is 100 percent efficient.

Note that although July has the highest ET and thus the highest irrigation needs of the year, you don't need to irrigate at the July rate all year long. You could decide to irrigate your plants with graywater at less than their July requirement for most of the year, knowing that your plants might need additional water in July. Alternatively, if you have more graywater than your plants need, you could irrigate your plants according to their peak need all year round, even though they don't need that much water most of the year. If your drainage is good, slight over-watering with graywater will not harm your plants, although it is unnecessary.

To learn more about plant water requirements and evapotranspiration rates, visit the California Irrigation Management Information Systems (CIMIS) at *http://wwwcimis.water.ca.gov/*.

Graywater irrigates this row of fruit trees. Thick mulch from a local tree company has been placed over the pathway, as well as inside the mulch basins. Photo: Leigh Jerrard.

Edibles

You can safely irrigate edible crops with graywater, as long as the graywater does not touch the edible part of the plant. For example, the California graywater code prohibits watering root crops like carrots with graywater. It is possible that the graywater could contact the carrots, and someone who ate a carrot without washing it first could ingest graywater. It is generally easier to irrigate perennial plants and trees with graywater; good edibles to water can be fruit trees, fruiting vines, berries, and large perennials.

Any system that uses drip irrigation tubing can water all types of vegetables with the edible portion above the ground. Vegetable beds with larger annuals and food above the ground, like corn, beans, tomatoes, etc. can be watered with laundry and pumped systems, since it is easier to spread out the water to reach these types of plants with these pumped systems. In contrast, it is not as easy to irrigate vegetables with gravity-fed, branched-drain systems.

Easy Plants to Water

- Fruit trees adapted to your local microclimate
- Berries
- Riparian plants that like irrigation (willow, maple, birch, water-loving plants)
- Any plant that likes to be irrigated.

What Not to Water

- Root crops. Reason: Health risk. Someone ingesting a root crop without washing it could ingest graywater. The graywater code prohibits irrigation of root crops.
- Drought-established plants. Reason: Risk to plant. Plants that have never been watered before, like an oak tree, or an old citrus that was never irrigated, are used to extended dry periods and could be damaged by sudden frequent irrigation.
- Possibly acid-loving plants (depending on the pH of graywater). Reason: Risk to plant. Graywater tends to be basic (alkaline), and acid-loving plants might not do well with basic irrigation water. You can use pH-neutral liquid laundry detergents and put acidic bark in mulch basins to create acidic soil conditions. Common

acid-loving plants include ferns, azaleas, rhododendrons, camellias, and blueberries. You can look up the pH needs of your plants in a plant or gardening book. If the book doesn't mention pH or acidic conditions, it is generally safe to assume the plant doesn't need acidic conditions, as garden plants commonly prefer neutral or slightly alkaline conditions.

- Very sensitive plants. Reason: Risk to plant. Plants that are generally hard to grow, like some ferns and avocados, might not be a good choice for graywater irrigation.

Soil Health

To have healthy plants, you need healthy soils! Soils are alive with billions of beneficial organisms. These are some easy steps you can take to promote healthy soils in your yard:

- A few times a year, irrigate with rainwater or freshwater. A rainy day counts!
- Add compost to your soil.
- Use mulch.
- Don't use chemical pesticides or fertilizers.
- Only use plant-friendly products; salts and chlorine bleach can harm soil and soil microbes.

References

California Irrigation Management Information Systems (CIMIS) at: http://wwwcimis.water.ca.gov/f

Sunset Western Garden Book 8th Edition, 2007

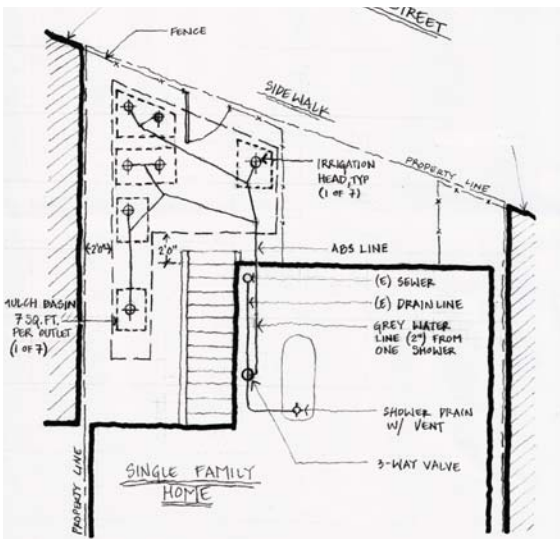
California Department of Water Resources Water Use Classification of Landscape Species at: http://www.water.ca.gov/wateruseefficiency/docs/wucols00.pdf

SFPUC Low Water Use and Climate Appropriate Plant List at: sfwater.org/landscape

DATE OF REPORT: 08/13/10 SOIL PHYSICAL CHARACTERISTICS

Sample ID	Lab Number	% Sand	% Silt	% Clay	Soil Texture
FRYRD	55218	66	20	13	SANDY LOAM

Sample laboratory results from a soil texture analysis.



Sample plot plan showing the street, building, setbacks, location of irrigation area, and size of mulch basins.

Appendix E: Worked Example with Sample Plot Plans and Permits

The following is a simplified example of the design and permitting steps followed by two San Francisco homeowners when they installed a branched-drain graywater system. Samples of the documentation submitted with their permit application are included. Elements of this worked example have been fictionalized for simplicity and clarity.

Note that if you are installing your own system, you will need to consult the applicable sections of this manual for an overview of installing your system, as well as consult additional resources for further guidance on branched-drain system installation details.

Step 1: Estimated the gallons of graywater generated by the shower fixture in a one-bedroom home using the permitted systems estimation method on page 9 of this manual.

- One-bedroom home = 2 occupants
- System uses graywater from a shower only: 25 gpd x 2 people = 50 gpd

Step 2: Identified the soil type.

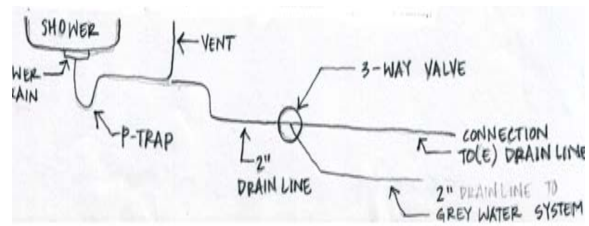
Soil ribbon test indicated soil to be sandy loam. Soil was also sent to a laboratory for soil texture analysis, which confirmed the soil to be sandy loam.

Step 3: Calculated minimum irrigation, or infiltration, area based on soil type and gallons of graywater generated per day. This process is described on page 13 of this manual.

- As shown in Table 2 of this manual, "sandy loam soil" needs 0.4 square feet of infiltration area per gallon per day.
- 0.4 square feet per gallon per day x 50 gpd = 20 square feet

Step 4: Drew a plot plan (previous page) and plumbing detail (at right).

- In the plot plan, the flow was divided into seven outlets, with basins of 7 square feet each, totaling 49 square feet of infiltration area. This number is significantly higher than the minimum 20 square feet calculated using Table 2 of this manual, as the homeowners designed their system to spread the graywater out to many plants across their yard.
- The plumbing diagram on the right shows the 3-way valve located after the p-trap and vent, as well as the size of pipe used. The graywater pipe is 2-inch ABS (plastic), since it is for irrigation, while the rest of the plumbing is of cast iron.
- House had up-to-code plumbing, so it did not need to be upgraded.



Sample plumbing detail showing the 3-way valve connection after the p-trap and vent; pipe size shown as 2-inch, which is required for a shower drain.

Step 5: Applied for a permit.

Step 6: Constructed the system.

- Installed the system. This system started with the pipe shallowly buried (approximately 2 inches) and got deeper as the system progressed.
- Tested system.
- Buried straight runs of pipe. Runs with bends were left exposed for inspection.
- Labeled above-ground pipe.
- Labeled 3-way valve.
- Attached O&M manual under the 3-way valve.

Step 7: Called DBI to schedule an inspection.

PLUMBING PERMIT
CITY AND COUNTY OF SAN FRANCISCO
DEPARTMENT OF BUILDING INSPECTION

PERMIT # PP20100803886
DATE AND TIME ISSUED: 08/03/2010 12:12:23
PLUMBING DIVISION (558-6570)
Call between 8:00 am and 3:00 pm to schedule an inspecti

RENEWAL AMENDMENT PID PERMIT #
Job Location ST Unit BLK/LOT 5667 / 002
Unit BLK/LOT District 4

OWNER: BLDG APPL# EID PMT#
Owner Name Owner/Contact
Owner Address ST SAN FRANCISCO CA

CONTRACTOR: HOMEOWNER PERMIT: X Approving Inspector: Panelli Steven
Company Name License # Class Expiration BTRC #
HOMEOWNER'S PERMIT
Address CA Zip
Phone

DESCRIPTION OF WORK COVERED BY THIS PERMIT:
Grey water system from bathroom shower/tub to yard.

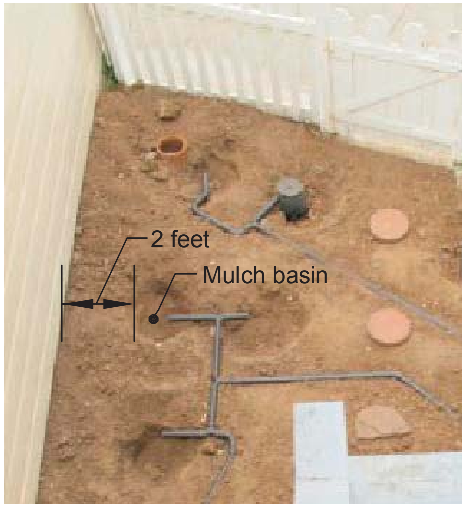
FEES:	MAX INSPECTIONS AVAILABLE	2		VALUATION	300.00	BLDG STDS ADMIN FUND
NUMBER OF ADDITIONAL INSPECTIONS	0 @	0.00 / 1 EA.	0.00	SURVEY:		
NUMBER OF PLAN REVIEW HOURS:	0 @	0.00 / 1 EA.	0.00	MISCELLANEOUS:		
NUMBER OF ADMIN HOURS:	0 @	0.00 / 1 EA.	0.00	FIRE SPRINKLER:		
SINGLE RESIDENTIAL UNIT:			160.00	FIRE SPRINKLER (NEW/REMODEL):	0 @	0.00/ 1 EA.
PLUMBING INSTALLATION (WITHOUT)	0	UNITS	0.00	RESTAURANT (NEW/REMODEL):	0	OUTLETS
PLUMBING INSTALLATION (WITH):	0	UNITS	0.00	Web fee: 0.00 Penalty	0.00	Tech surcharge (2%)
NEW BOILER INSTALLATION:	0 @	0.00 / 1 EA.	0.00			
OFFICE, MERC AND RETAIL BUILDING:	0 @	0.00 / 1 EA.	0.00		TOTAL PERMIT FEE:	

* NOT VALID FOR PERMIT IF ANY EMPLOYEE DESCENDS INTO EXCAVATION DEEPER THAN 5'
Effective 8/7/2009 - Permit shall expire 1 year from date of issuance.
DO NOT WRITE BELOW THIS LINE - FOR OFFICIAL USE ONLY

Date	Initials	Remarks
9/3/10	DZ	Grey water system Appd

Plumbing Inspector's signatures:
Rough In: Date:
Final: Date: 9/3/10

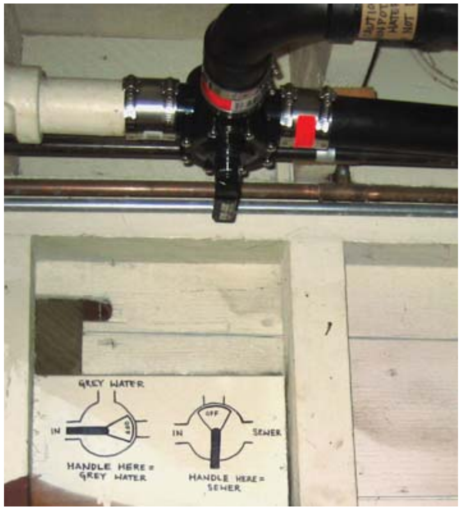
Sample graywater permit.



Sample image of a graywater system pre-burial. Photo: Josh Lowe.

Sample image of a completed graywater system after installation and planting. Photo: Josh Lowe.

Sample image of a completed graywater system after one year of operation and plant growth. Photo: Josh Lowe.



Sample image of a 3-way valve clearly labeled. Photo: Josh Lowe.

Step 8: Operated the system.

Notes from the homeowers one year after installing the graywater system: *"The graywater system is going great. We have not watered the yard with anything but the graywater since the weekend after we planted the plants. They are doing great and the ground cover is really taking off too."*

Appendix F: Information and Resources

San Francisco Information

San Francisco Public Utilities Commission: *http://sfwater.org/landscape*
Water Conservation and Urban Watershed Management Program
525 Golden Gate Avenue, San Francisco, CA 94102
Email: landscape@sfwater.org

San Francisco Department of Building Inspection: *http://www.sfdbi.org*
1660 Mission Street, San Francisco, CA 94103
Tel: (415) 558-6088
Fax: (415) 558-6401

San Francisco Department of Public Health: *http://www.sfdph.org/*
101 Grove Street, San Francisco, CA 94102-4505
Tel: (415) 554-2625

California Residential Graywater Code:
http://www.hcd.ca.gov/codes/shl/2007CPC_Graywater_Complete_2-2-10.pdf

Additional Resources

Note that the following lists are not comprehensive and contain only a few of the resources available to homeowners designing and installing graywater systems. The inclusion of these organizations and resources is intended to assist homeowners and designers in their process and does not imply any endorsement by the SFPUC.

Websites

Oasis Design Graywater Information Site: *http://www.oasisdesign.net/greywater*

Greywater Action: For a Sustainable Water Culture: *http://www.greywateraction.org*

California's Integrated Water Reuse Management Center: *http://www.whollyh2o.org/*

Books

Create an Oasis with Greywater, by Art Ludwig. 19th Revision, Oasis Design. 2009.

Golden Gate Gardening: Year-Round Food Gardening in the San Francisco Bay Area and Coastal California, by Pam Pierce. 1998.

Classes

Greywater Action: *http://www.greywateraction.org/*

The Ecology Center: *http://www.ecologycenter.org/*

The Garden for the Environment: *http://www.gardenfortheenvironment.org/*

Plants

California Irrigation Management Information System: *http://wwwcimis.water.ca.gov*

Laboratories for Soil Analyses

A&L Western Agricultural Laboratories
1311 Woodland Ave #1
Modesto, CA 95351
Telephone: (209) 529-4080
http://www.al-labs-west.com/

Control Laboratories Inc.
42 Hangar Way
Watsonville, CA 95076
Telephone: (831) 724-5422
http://compostlab.com/

Materials

Urban Farmer Store (kits for laundry-to-landscape systems): *http://urbanfarmerstore.com/*

Clean Water Components (kits for graywater systems): *http://cleanwatercomponents.com*

Bayview Greenwaste (for mulch): *http://bayviewgreenwaste.com/*

Local tree trimmers (for wood chips)

SAN FRANCISCO

graywater design manual

FOR OUTDOOR IRRIGATION

San Francisco
Water
Power
Sewer

Services of the San Francisco Public Utilities Commission

Printed on post-consumer recycled paper.