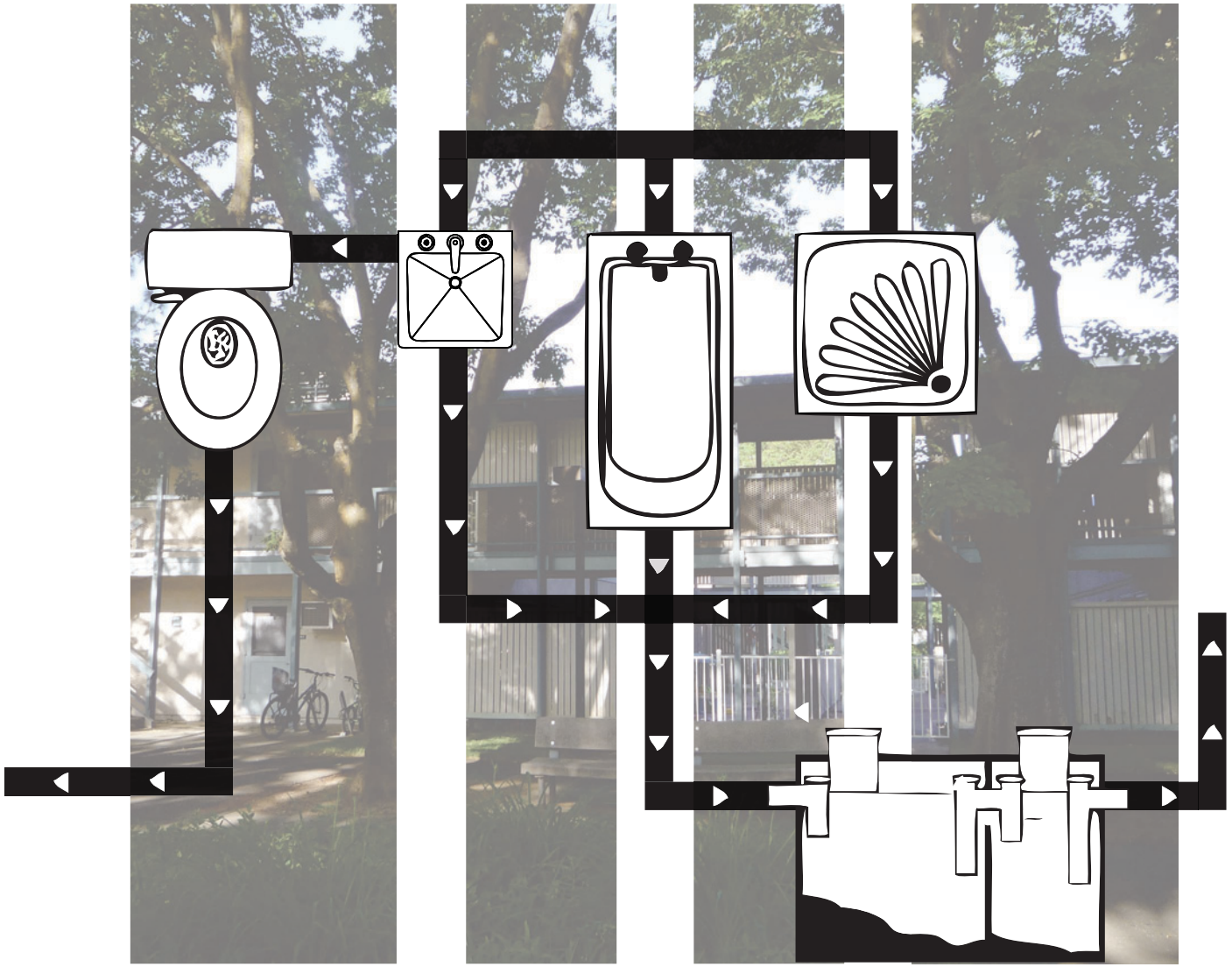
REASSESS & REUSE:

REASSESSING WASTEWATER MANAGEMENT THROUGH GREYWATER REUSE IN AN APARTMENT COMPLEX



HOANGLAN NGUYEN | SENIOR PROJECT 2013 | UNIVERSITY OF CALIFORNIA, DAVIS

REASSESS & REUSE:

REASSESSING WASTEWATER MANAGEMENT THROUGH GREYWATER REUSE IN AN APARTMENT COMPLEX

Presented to the faculty of the Landscape Architecture program at the University of California, Davis in partial fulfillment of the requirements for the degree of Bachelor of Sciences in Landscape Architecture.

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June 14, 2013

ABSTRACT

This project reassesses the way household wastewater is currently managed and how greywater in the home can be reused for irrigation. Greywater systems are a local on-site method in dealing with wastewater management in the home. Greywater systems implemented in the urban environment will conserve local water supplies and reduce the pollution of our streams and waterways. Reducing the amount of potable water used for irrigation through the practice of using greywater for irrigation will help in this conservation of water. This project uses an apartment complex as a model for possible greywater reuse in the urban environment through an analysis of home based greywater systems.

The study site is the Orchard Park Apartment complex which is located on Russell Boulevard in Davis, California. This particular apartment complex is managed by the University of California, Davis; Student Housing. Currently there are plans for future redevelopment of this particular apartment complex. Unfortunately, there has not been any finalization of the design for the new redevelopment, as they are still undergoing the bidding process for the new design. The design and implementation of a greywater system is based on the existing conditions of the Orchard Park Apartment complex. Greywater will be reused for flushing of the toilets and for landscape irrigation using two main methods which include subsurface irrigation and a subsurface flow constructed wetland. The soil and the wetland plants do a fairly good job at "cleaning" the greywater.

ACKNOWLEDGMENTS

I would like to thank my committee members; Loren Oki, Steve Greco, and Kevin Perry for guiding me through my senior project. My senior project would not be what it is, without the help and knowledge that each one of you have provided me. I would like to especially thank Loren Oki and Jennifer Tso for providing me with so many resources and a large greywater tolerate plant palette. I would also like to thank my family . I would not be the person I am without the love and support that you have provided me. Finally, I would like to thank my graduating class of 2013 for being with me through all the late nights in studio. I know I have made long-lasting friends with many of you and you guys have made my years in the Landscape Architecture program an enjoyable one for sure! Now we definitely have time for everything!

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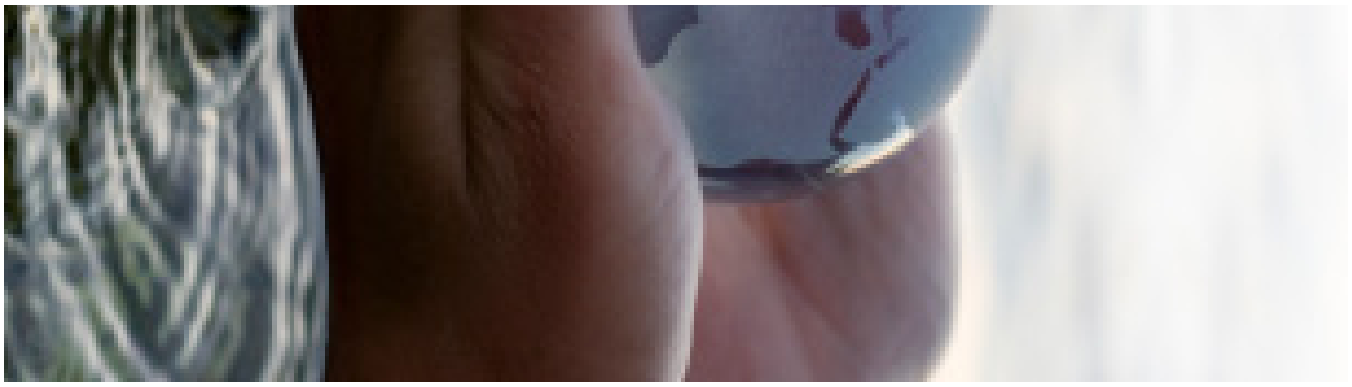


INTRODUCTION

THE PROBLEM

Water is a vital component for human survival. Unfortunately, many undeveloped countries do not have access to safe drinking water or water in general. On the contrary, in many developing countries water is taken for granted. In the United States, roughly half of the water supply is used for thermoelectric power and a third for irrigation (Greywater Systems, 2011). A significant portion of freshwater is also used for industry, recreational usage, and human consumption. With the expansion of cities and an increase in population growth, the vast demand for water is ever-increasing (Greywater Systems, 2011).

Fresh water is being used for everyday uses in homes across the United States. Unfortunately, some of these uses are both unsustainable and wasteful, and further drains the available drinking/ portable water that many people and wildlife desperately depend. Some of these uses include using portable water to flush toilets and wastefully irrigating lawns with potable. Furthermore, the treatment of household wastewater involves physical, chemical, and biological processes that remove the contaminants and pollutants found in the wastewater. This treatment degrades the environment and pollutes the streams. The amount of energy and chemicals that goes into treating household wastewater is of a huge concern. If the treatment of household wastewater can be done at a local scale, then less impact will result from the treatment of wastewater.

In general, water scarcity is present throughout the world. As the future of the world's water supply remains uncertain, the practice of using greywater to irrigate landscapes and for a number of other uses has become an acceptable practice. Reusing greywater is not only beneficial on an individual scale, but also to the ecosystem as a whole.

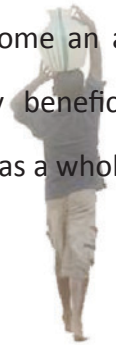


Fig 1.1

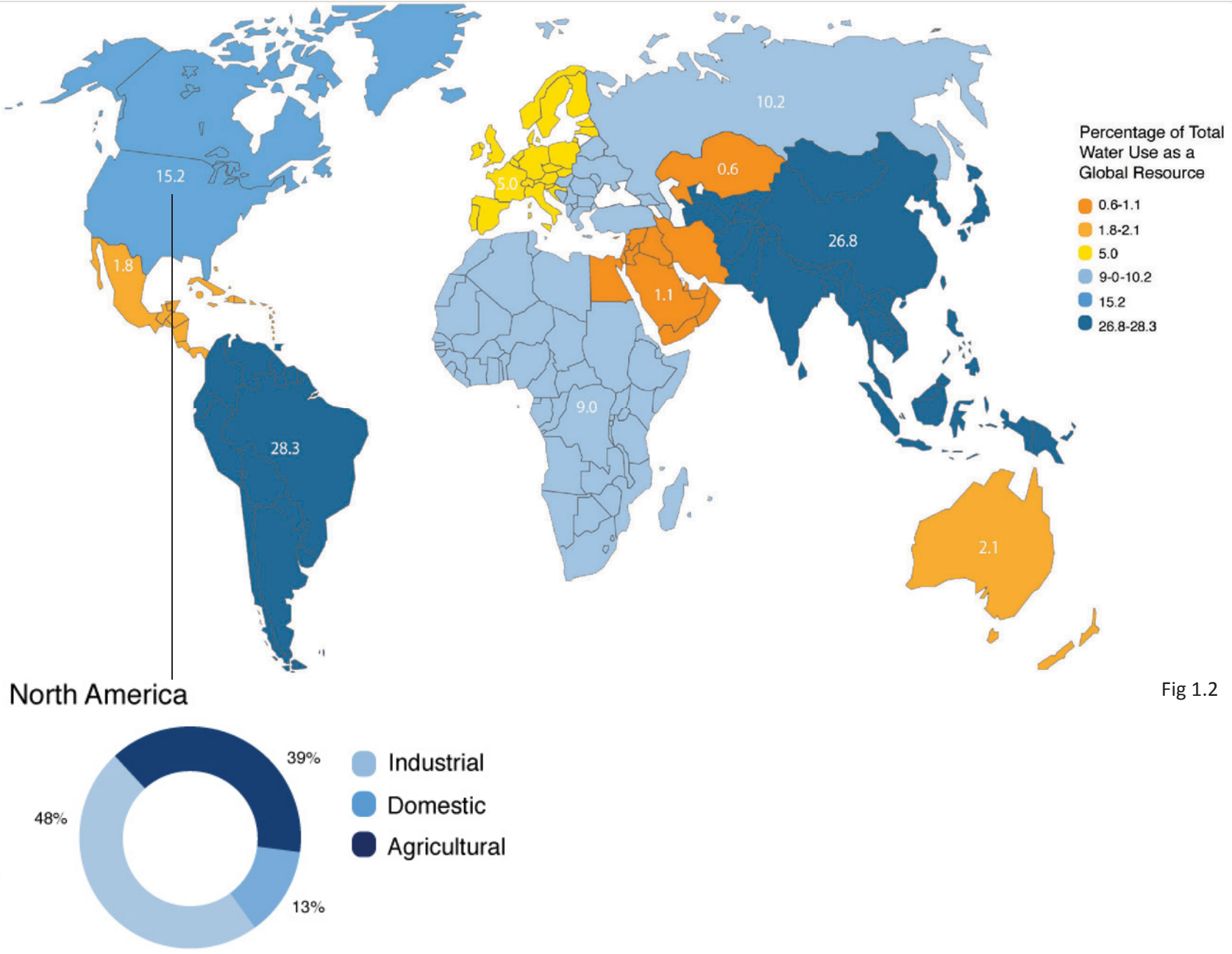

Percentage of Total Water Use as a Global Resource
0.6-1.1
1.8-2.1
5.0
9-0-10.2
15.2
26.8-28.3
15.2
1.8
28.3
5.0
10.2
0.6
26.8
1.1
9.0
2.1
North America
39%
48%
13%
Industrial
Domestic
Agricultural

Fig 1.2

PROJECT GOALS

(01) Rethink the way household wastewater is currently manage in the urban environment

(02) Use greywater in an apartment complex

(03) Examine how greywater systems work and the different methods of treating/ cleaning of the greywater for landscape irrigation

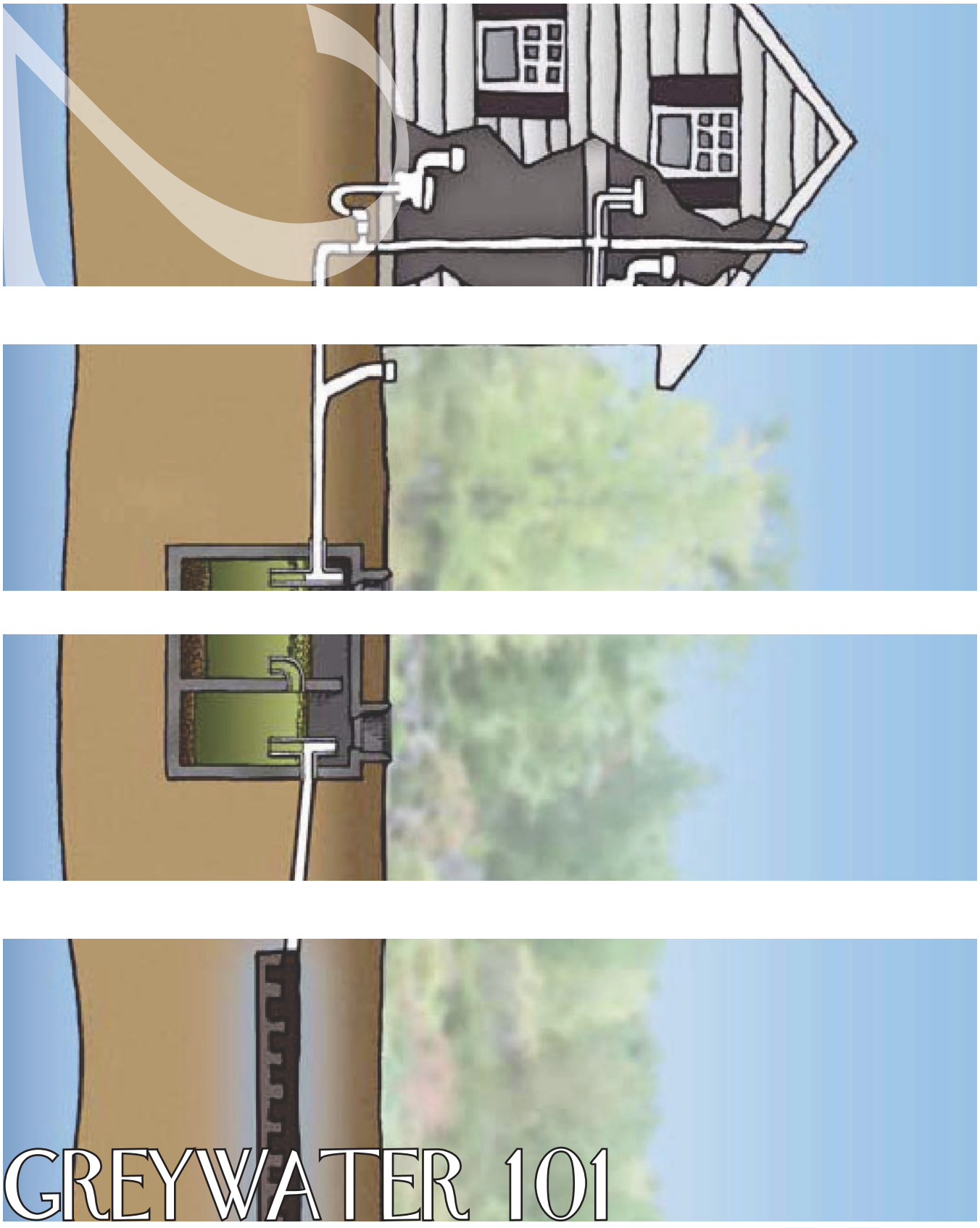
RESEARCH QUESTIONS

(01) How can we conserve the world's fresh water Supply for the next generation?

(02) How can household wastewater be treated at a Local scale in the urban environment?

(03) How can we decrease the amount of household wastewater from being diverted to the wastewater treatment plants

Fig 1.3



GREYWATER 101

GREYWATER

Greywater is untreated household wastewater that is generated from bathroom sinks, showers, and laundry machines (that does not contain any human and/ or chemical contaminants). Greywater cannot contain water that is contaminated with soiled diapers, human waste, or food waste which include water from toilets, and kitchen sinks. Kitchen sinks and dishwashers contain food particles and other residues, and as a result are often not considered to be greywater (The County of Santa Barbara 1990).

GREYWATER VS. BLACKWATER

Fig 2.1

Household wastewater is divided into two main categories: Greywater and Blackwater. Household wastewater that is flushed down the toilet is referred to as blackwater because it contains fecal matter and other pathogens (The county of Santa Barbara, 1990). Greywater by all means is cleaner than blackwater and therefore should not be mixed. Drinkable/ potable water has been used to transport wastewater (blackwater) from toilets for over a hundred years. In the past, blackwater is mixed with greywater and then dumped into rivers and lakes without any prior treatment, thus polluting and contaminating the environment (Winneberger, 1974).

Today, household wastewater, both greywater and blackwater are diverted to the underground sewer where the two household wastewater are then transported to the treatment plants nearby, where treatment takes place.

It is unsustainable to use drinkable water to move body waste down the drain. Since greywater and blackwater are biologically different, they should undergo different treatments.

GREYWATER SYSTEM

A typical greywater reuse system includes sources, such as the washing machine, pipes that transport greywater out of the house, and a surge tank that temporary stores greywater. Furthermore, a greywater system also consists of a distribution system that transports greywater from the surge tank to the receiving landscape. The receiving landscape includes the soil, and plants. Lastly the system include people who install and maintain the greywater system (Greywater Recycling Basics).

The greywater system consists of a system of pipes that bring greywater from the home into a capture/ control tank that temporary stores the greywater. The surge tank "should have a lid, be sunlight and rust resistant, have threaded fittings and be sturdy" (The County of Santa Barbara, 1990). The surge tank will have one or two incoming lines that will connect it to washing machines or bathroom sinks and another outgoing line that will connect it to an irrigation line that will then distribute the water to the surrounding plants. Usually greywater from bathroom sinks and laundry water are separate from each other. Through multiple valves, individuals can alter which greywater source to distribute to areas of the garden/ landscape. Greywater should be used immediately after it is brought into the surge tank. If greywater is left for long periods of time, it will most likely get contaminated.

Although washing machines contain laundry detergents, in general, laundry detergents are safe to irrigate the landscape. However, laundry detergents that contain a large amount of sodium, boron, and chlorine can damage the health of some plants and, it is not recommended to irrigate the landscape with greywater that contains these products. Likewise, "[m]ost hand and dish soaps and shampoos will not damage plants at low residential concentrations and the phosphates may act as a mild fertilizer" (The County of Santa Barbara, 1990). Greywater pipes extend underground allowing the soil to kill the bacteria. The use of greywater is fairly safe.

Maintaining a greywater system is equally important as properly installing it. According to the County of Santa Barbara, greywater systems should be checked on a regular basis to avoid any contamination. Letting greywater sit for long periods

of time expose it to various bacteria in the air/ environment. Furthermore greywater should not be allowed to “pool on the surface of the ground, used for sprinkling lawns, used on vegetable gardens, or used to wash off driveways or sidewalks” (The County of Santa Barbara, 1990). Using greywater to wash off driveways or for sprinklers will expose people, plants, and pets (animals) to the bacteria or viruses that may be in greywater. Direct contact with greywater should be avoided at all times. In other words, greywater should not be exposed on the surface of the ground. The “safest greywater irrigation systems keep the water underground…insures that no people or animals will be exposed to possible bacteria, keeps the water from pooling on the ground (and perhaps smelling), and is resistant to clogging” (The County of Santa Barbara, 1990). When greywater is underground it allows the active topsoil layer of the soil to break down the bacteria thus, making it safe for irrigation.

BENEFITS OF GREYWATER REUSE

There are many benefits in Greywater reuse. Reusing greywater can help to reduce the use of fresh water. During the summer/ warm weathers, about half of the water consumption in Americans' homes occur outdoors (Lets go green, 2011). Therefore reusing greywater for the outdoors can reduce a significant amount of water consumption. Another benefit includes maintaining soil fertility. The soil breaks down the bacteria/ nutrients in the greywater thus maintaining soil fertility.

Perhaps the most significant benefit of reusing greywater is that it recharges underground aquifers. Underground recharge are "one of the most generally accepted forms of water reuse. The water disappears from sight and is usually diluted by other sources of water. Furthermore, a long time ordinarily elapses before recharged water is extracted, so any microbial contaminants will have died a natural death" (Dean, 1981). This process involves the passage of water through the soil and its treatment by organisms in the soil. This is very beneficial to the ecosystem. Recharging an aquifer

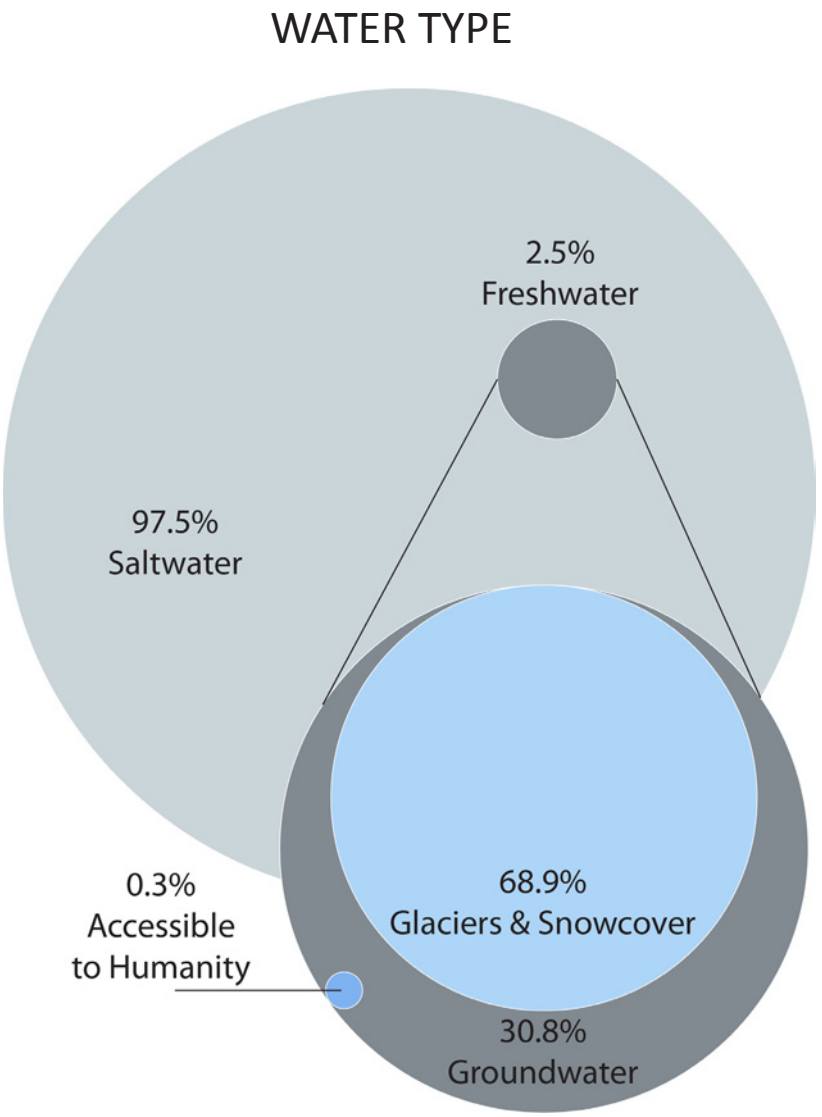


Fig 2.2

can happen in two ways: “Water may be allowed to enter from the surface through spreading beds or spray irrigation. Alternatively, it may be pumped under pressure down wells which penetrate a deep aquifer” (Dean, 1981). Human exposure should be minimize. In short, reusing greywater for irrigation or other uses will put less pressure in extracting water from aquifers. If less fresh water is extracted from aquifers then it will also be beneficial to the environment.

Greywater systems are a local way of reducing the consumption and impact on the fresh water supply. Reusing greywater conserves water, reduces the overall water usage, and preserves the cleanest water for drinking (water-use efficiency in the U.S.). On a household scale, it reduces monthly water bills, and less water is being sent to the wastewater treatment plant. The energy and resources that go into the wastewater treatment process is also saved.

CONSTRAINTS OF GREYWATER REUSE

The main constraint surrounding greywater systems is that the use of greywater is strictly regulated in most states. For instance, in 2009, the State of California passed a law allowing greywater systems. Furthermore, within each individual city there are different code requirements. The reason for this is the primary health concern that greywater may be contaminated and pose a threat to human health. According to U.S. Department of Housing, “Regulations invariably prohibit gray water systems from being connected to potable water systems: cross-connections are typically avoided with air-gaps” (U.S. Department of Housing and Urban Development). There are also maintenance requirements that have to be addressed. In short there are different laws, regulations, and plumbing codes. The more complex a greywater system is, more regulations, and code restrictions may apply.

The majority of the general public has a negative perception of greywater. The main reason is health issues. There is a fear of potential spread of disease and contamination of water if the greywater system isn’t installed or used correctly. Research on these various challenges has to be conducted before any greywater system can be incorporated into a building.

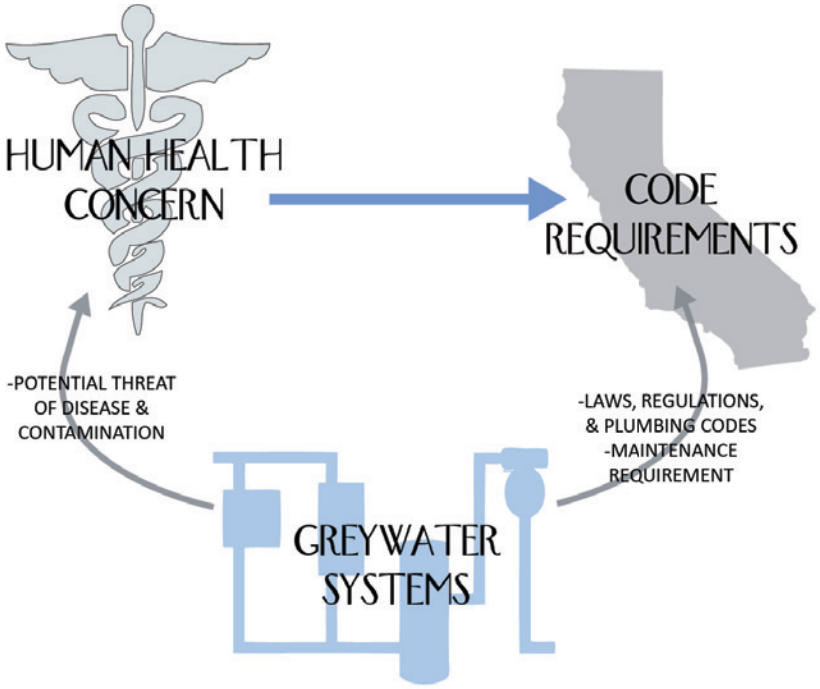


Fig 2.3

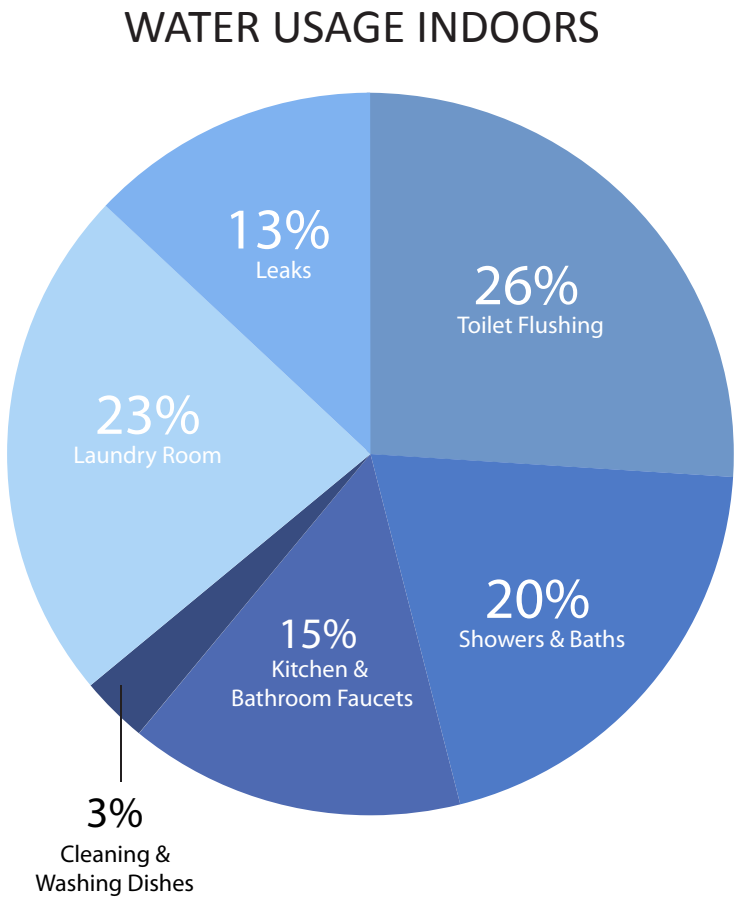


Fig 2.4

There are various methods and techniques in dealing with the "cleaning" of greywater so that it can be used for irrigation or for other purposes. One of these methods is directing all the greywater collected from the apartment/ home to a surge tank that will then be diverted directly into the ground (the soil will do the job of cleaning the greywater) for landscape irrigation. Another technique is to discharge the greywater into a constructed wetland and letting the wetland plants do their job in cleaning the greywater, then reusing that water for irrigation.

Greywater can be used for the flushing of toilets in the home/ apartment. 26% of water usage in the home is used to flush toilets which is the largest water usage in the home. Greywater can also be used to irrigate the gardens and/ or surrounding landscapes. 50% of the water that is diverted to the wastewater treatment plant is greywater which could have been reused (Reschke).

Incorporating a greywater system into an apartment complex is a local on-site method in dealing with the treatment

of wastewater in homes/ apartments. Greywater systems can be classified into three main systems which include laundry-to-landscape systems, simple systems, and complex systems.

A laundry-to-landscape system involves diverting the greywater from washing machines to the landscape without having to retrofit any existing piping.

Simple systems are ones that involve less than 250 gallons of water a day. This type of system requires a permit because it involves altering the plumbing and installing a surge tank. Water from the bathroom sink and showers get reused in this type of system.

A complex system is one that involves greater than 250 gallons of water a day. This type of system is complex in that it is very expensive to install and requires on-going maintenance. It relies on pumps, surge tanks, and filtration systems (Office of Energy and Sustainable Development). The complex system also requires a permit.

There are various ways to treat greywater. One method is to direct the water to a surge tank that can be delivered

LAUNDRY-TO-LANDSCAPE SYSTEM

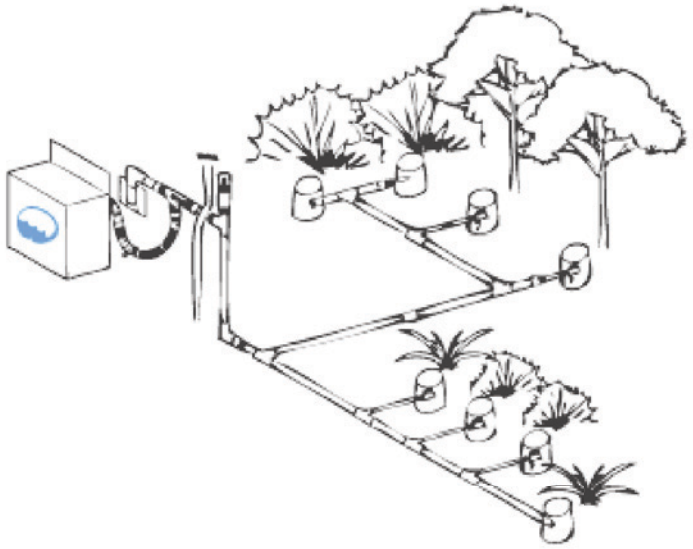


Fig 2.5

SIMPLE SYSTEM

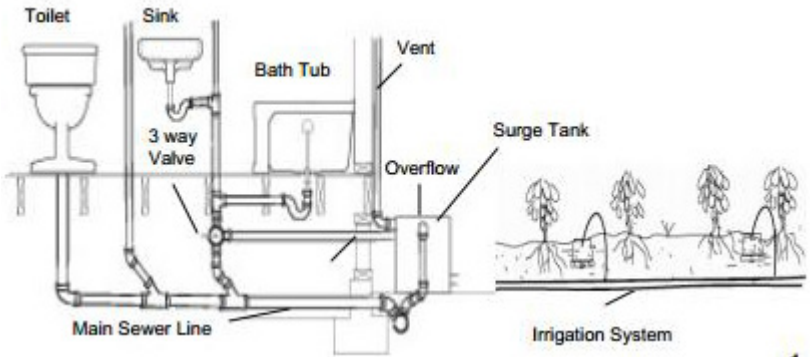


Fig 2.6

COMPLEX SYSTEM

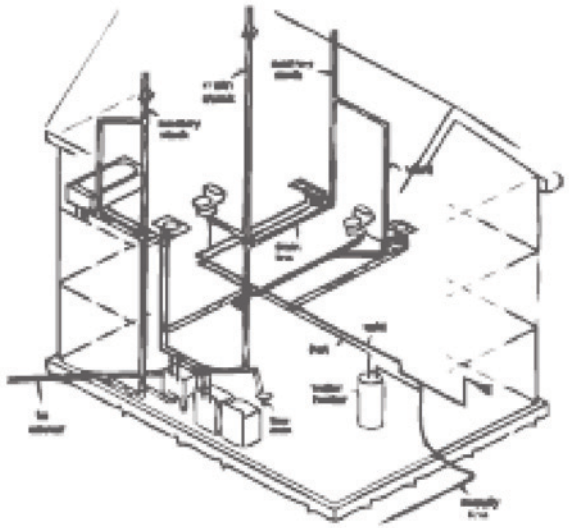


Fig 2.7

TYPES OF SOIL

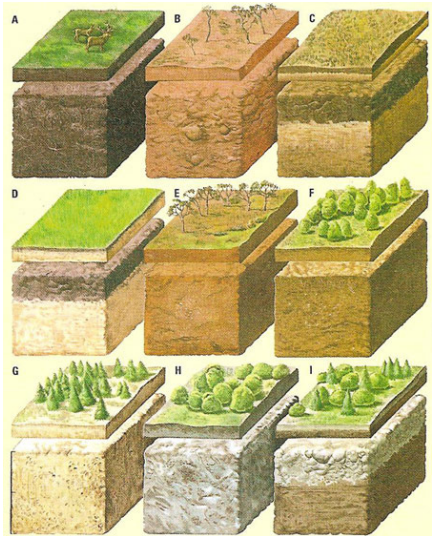


Fig 2.8

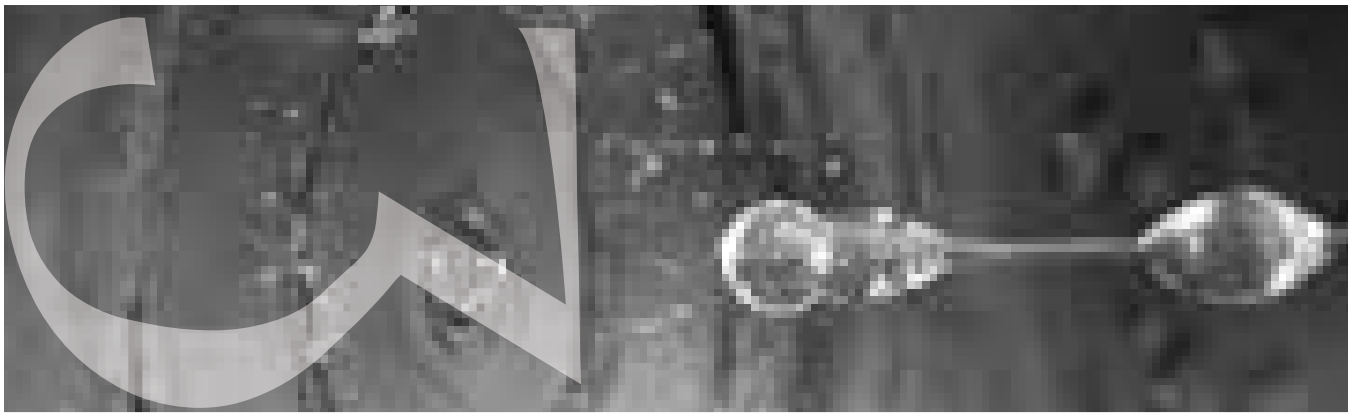
to certain plants through pipes. The house can be altered through plumping where the laundry water can be directed into certain areas of the garden. Soil and plants are a very powerful and effective tool for treating greywater. According to Greywater Recycling Basics, the best way to handle greywater is “to introduce it directly to the biologically active topsoil layer, where soil bacteria can quickly break it down…This biological water purification is much more effective than any engineered treatment” (Greywater Recycling Basics 2011).

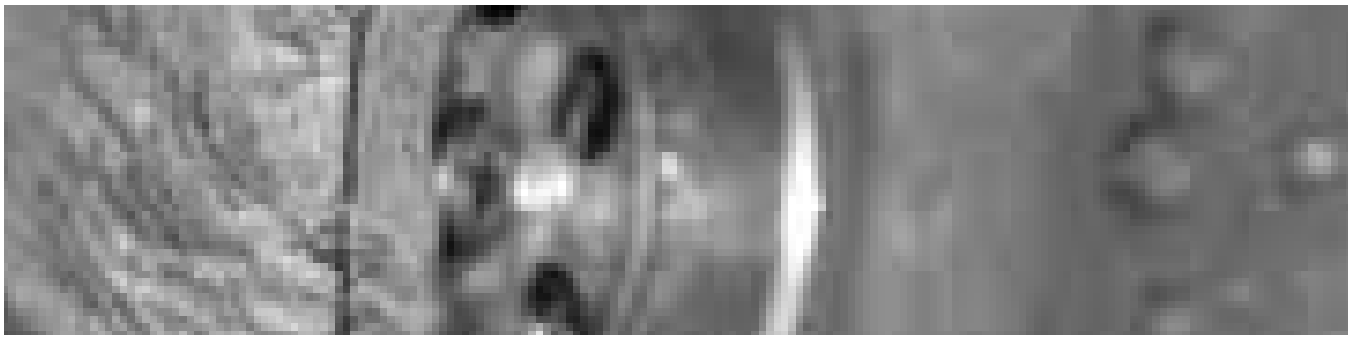
Although generally soil is very effective at filtration, not all soil will be suitable for the treatment of greywater. According to Winneberger “soil must have an acceptable percolation rate” to be suitable for the treatment of greywater (Winneberger, 1974). In other words, examining the percolation rates and soil characteristics will help determine whether or not the soil is suitable for treating greywater. Winneberger also mentions that “soil in which the percolation rate is slower than 1 inch in 30 minutes is unsuitable for disposal pits, and that slower than 1 inch in 60 minutes is unsuitable for other

conventional disposal fields" (Winneberger 1974). Knowing how much area of the soil is suitable is also important.

Education is very important in the greywater system process. People who use greywater systems need to be aware of what they can and cannot put into the water that would be collected as greywater (Ecology Center). When designing wetlands greywater systems, many different things , including how much water is needed in the garden, how much water will be produced from the graywater system, type of water plants need, and which distribution system to use.

Some things to keep in mind are to use plant friendly materials. Suggested products include biodegradable and non-toxic materials that do not harm plants. They should be free of sodium (salts) and boron (borax). For instance chlorine bleach is harmful to plants while hydrogen peroxide bleaches are less harmful. One should also know the effect on pH of water.





CASE STUDIES

CASE STUDY 01

HOME IN NORTH OAKLAND

Javier Amaro, an Oakland resident has a landscape-to-laundry system installed into his home in North Oakland. The water from his washing machine gets redirected to his backyard and is used for subsurface irrigation. This type of system is the most common greywater reuse method. According to Kerr a landscape-to-laundry system can save “5, 000 to 10, 000 gallons of water a year, depending on the size of the machine and how often laundry is washed” (Kerr 2010). Water gets emptied out of his washing machine and makes its way to various parts (“terminals”) of his garden through subsurface irrigation. The shut-off (Diverter) valve of his laundry-to-landscape system allows Amaro to decide where to direct the greywater from his washing machine. For instance, if Amaro were doing laundry and there were clothes that contain human waste, Amaro can just turn off his greywater system and direct the water to the sewer. As mentioned before, this type of greywater system does not require a permit because it does not cut into existing piping. My project will look into using water from laundry machines for subsurface irrigation.

Fig 3.1

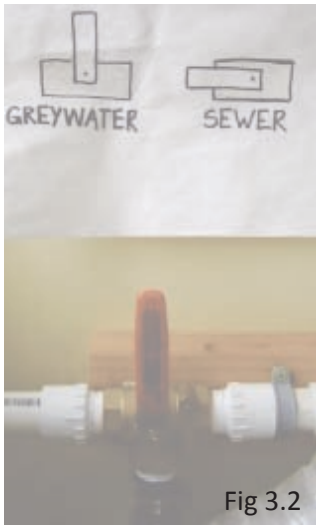


Fig 3.2

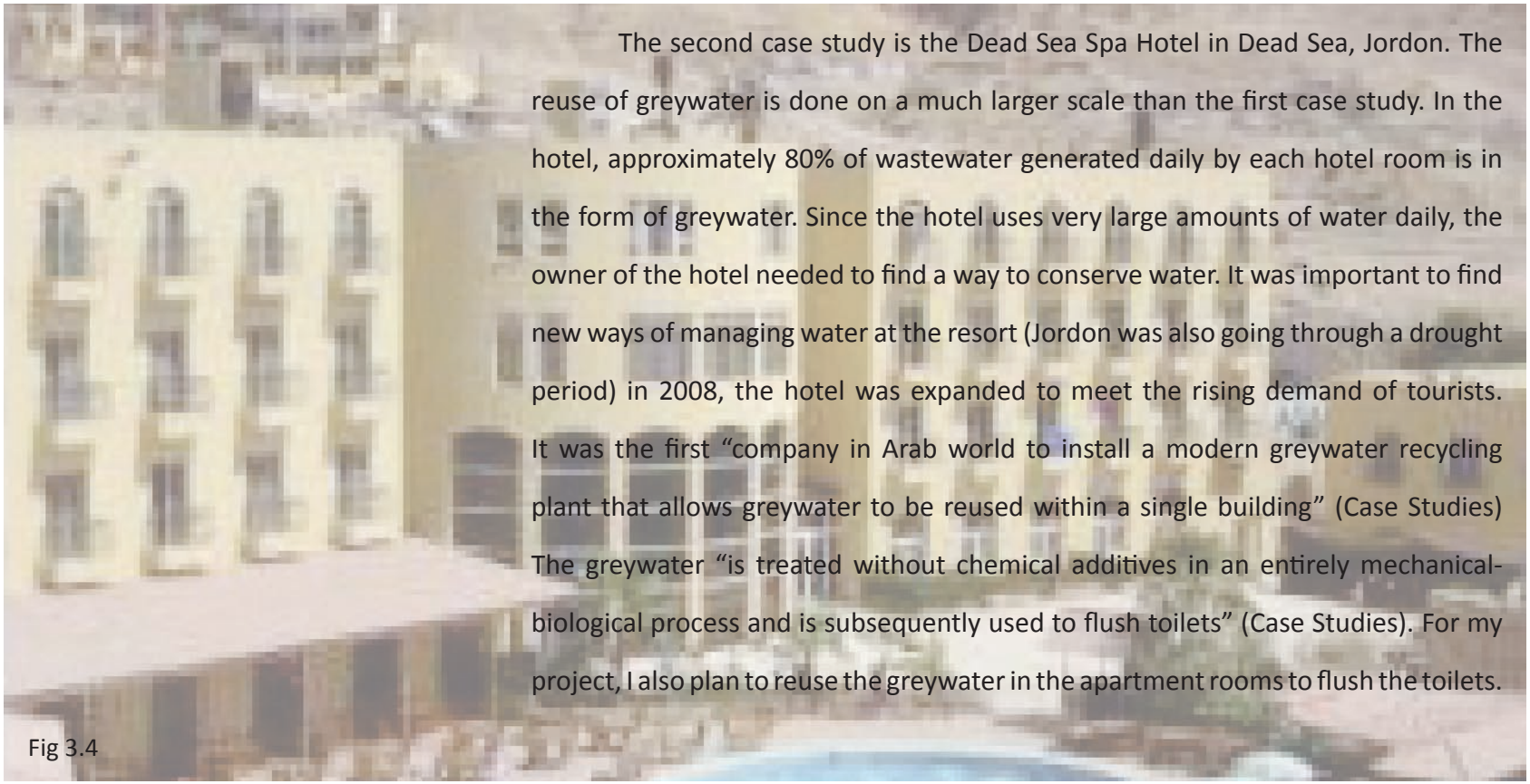
Above: Shut-off Valve & strip of paper illustrating greywater redirection

Below: Various terminals around his backyard for greywater subsurface irrigation

Fig 3.3

CASE STUDY 02

DEAD SEA SPA HOTEL IN DEAD SEA, JORDON



The second case study is the Dead Sea Spa Hotel in Dead Sea, Jordon. The reuse of greywater is done on a much larger scale than the first case study. In the hotel, approximately 80% of wastewater generated daily by each hotel room is in the form of greywater. Since the hotel uses very large amounts of water daily, the owner of the hotel needed to find a way to conserve water. It was important to find new ways of managing water at the resort (Jordon was also going through a drought period) in 2008, the hotel was expanded to meet the rising demand of tourists. It was the first "company in Arab world to install a modern greywater recycling plant that allows greywater to be reused within a single building" (Case Studies) The greywater "is treated without chemical additives in an entirely mechanical-biological process and is subsequently used to flush toilets" (Case Studies). For my project, I also plan to reuse the greywater in the apartment rooms to flush the toilets.

Fig 3.4

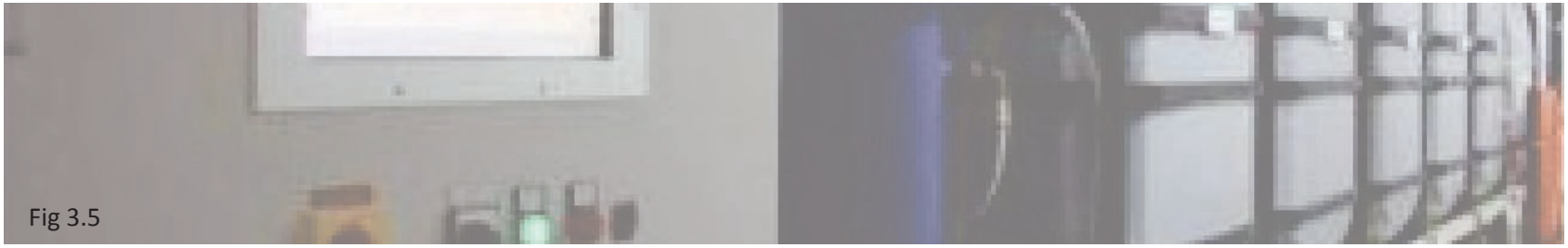


Fig 3.5

CASE STUDY 03

EcoHouse IN BERKELEY, CALIFORNIA

The EcoHouse in Berkeley, California is a demonstration home and garden that is located in North Berkeley residential neighborhood. Classes,and tours help educate people on how to live a more sustainable life. There is a greywater and wetland system that is incorporated into the house where greywater gets re-use in the garden.

On October of 2007, a “constructed wetland and greywater hybrid design” (ecologycenter.org/ecohouse/) was built into the home. This type of greywater system was the first to be approved by the City of Berkeley. This particular site also uses a Simple Laundry-to-Landscape system. The constructed wetland on this site has been used as a model for the construction a subsurface wetland for this senior project. A wetland offers better treatment of the greywater as the wetland plants help to get rid of the pollutants that reside in greywater.

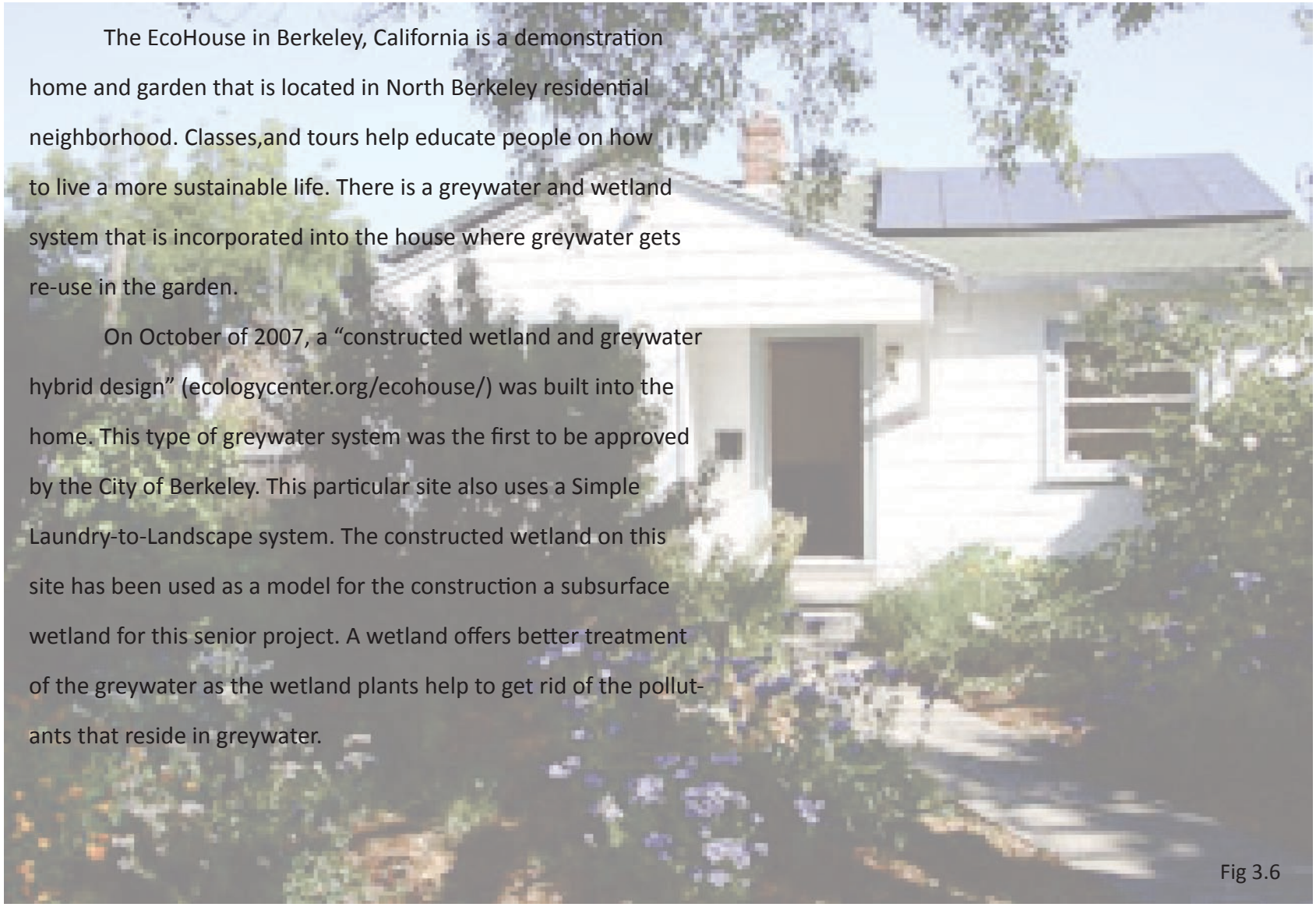


Fig 3.6

CASE STUDY 04

NE SISKIYOU GREEN STREET, KEVIN ROBERT PERRY

Fig 3.7

Although stormwater management is not the main focus of this senior project, but it is a relevant water topic that is increasingly being implemented in the urban environment to manage stormwater. The Orchard Park Apartment, has many potential for stormwater management.

This particular case study is a green street. Stormwater management is apart of the framework for the integrated site design. It is a “framework for increasing the quality of the built environment, and involves maximizing existing natural systems to minimize water use” (Sustainable Residential Design). Stormwater management technologies include bioswale, bio-retention ponds.

4 THE SITE

ORCHARD PARK APARTMENTS


ORCHARD PARK

SITE CONTEXT

EXISTING CONDITIONS

CIRCULATION LEGEND:

Pedestrian

Bicyclist

Road

Fig 4.1

ORCHARD PARK APARTMENT MAP

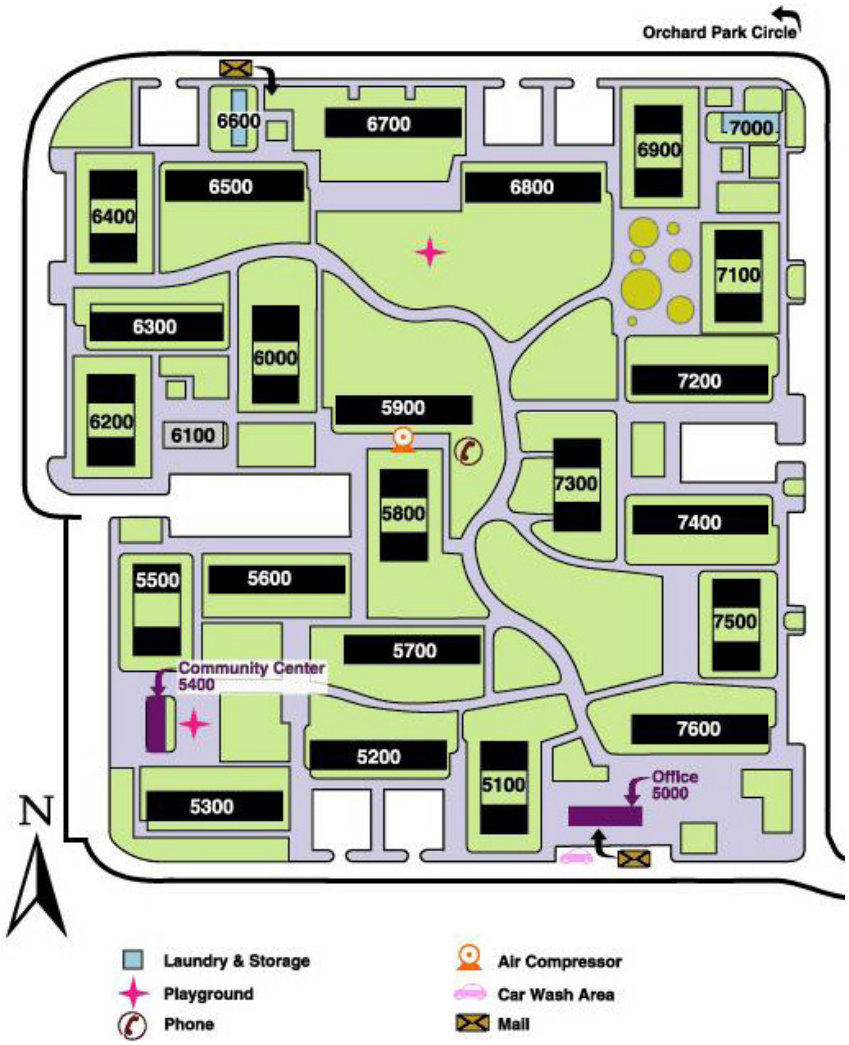


Fig 4.2

Orchard Park Apartment consists of 22-two story buildings with a total of 200 two-bedroom apartments and two laundry facilities. There is not a whole lot of landscaping on the site. The complex is covered in mostly turf. The main tree canopy on and around the site consists of Cork Oaks, Redwoods, Eucalyptus, Pines, Acacias. Highway 113 is in close proximity to the site. The site is also surrounded by other apartment complexes.

This particular apartment complex is for married student and students with family, hence the two playgrounds on the site. There are also various large planters on the site that are not put to good use. On the west end of the complex is an open unused area that currently appears to serve no purpose as it is vacant. There are six parking lots and parking surrounding the site. Within the site are green spaces that are of various grasses from tall fescue to bermunda grass.

SITE ANALYSIS

Fig 4.3

OPPORTUNITY

A. GREYWATER IRRIGATION: Currently, this whole area is covered in turf. This area has potential for subsurface irrigation. The current turfgrass are not salt tolerant, and as a result, these turfgrasses will be replaced by ones that can survive in salt conditions. Furthermore, this area is an opportunity for a greywater learning experience/ demonstration.

B. CONSTRUCTED WETLAND: Currently, this area is not in use. This area can be used for more effective greywater treatment. Since human exposure must be limited, a subsurface flow constructed wetland will be constructed and the wetland plants will clean the greywater prior to irrigation use.

C. STORMWATER MANAGEMENT: The site has 7 parking lots, all of which have great potential for stormwater management.

D. PICNIC AREA: This area has potential for more greywater tolerant plants. Since the subsurface constructed wetland will be somewhat close to this area, this can be an opportunity for people to have picnics and learn more about the process of treating greywater and its many benefits.

CONSTRAINT

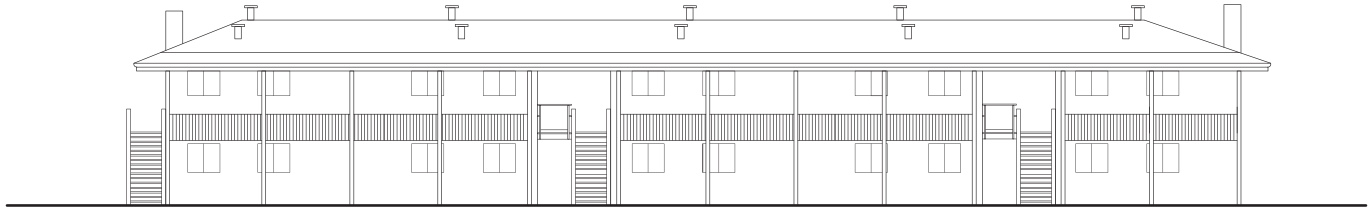
The only main constraint is the fact that this site is right next to a major highway (highway 113). Due to the elevation change, the construction of the wetland since greywater will be diverted underground. Furthermore, noise will be a huge concern.

Fig 4.4- 4.7

BUILDING FOOTPRINT

TYPICAL APARTMENT LAYOUT

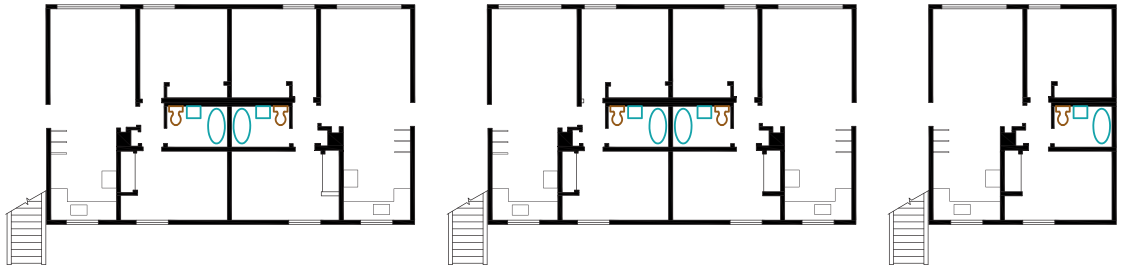
SCALE 1/8”= 1’-0”



ELEVATION

Fig 4.8

Each apartment buildings consists of 10 units, and within each unit there is one bathroom.

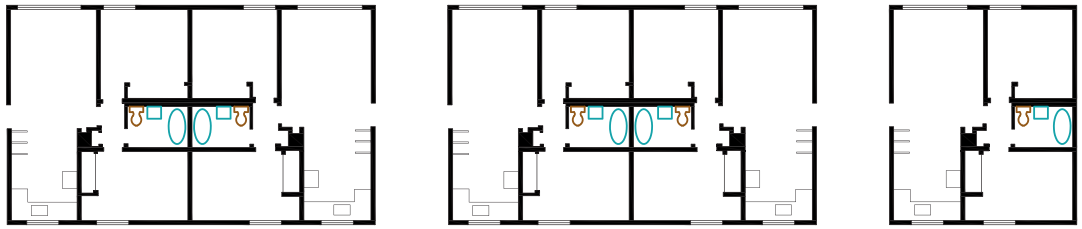


FIRST FLOOR PLAN

LEGEND:

Greywater

Blackwater



SECOND FLOOR PLAN

Fig 4.9

LAUNDRY FACILITY

SCALE 3/16”= 1’-0”

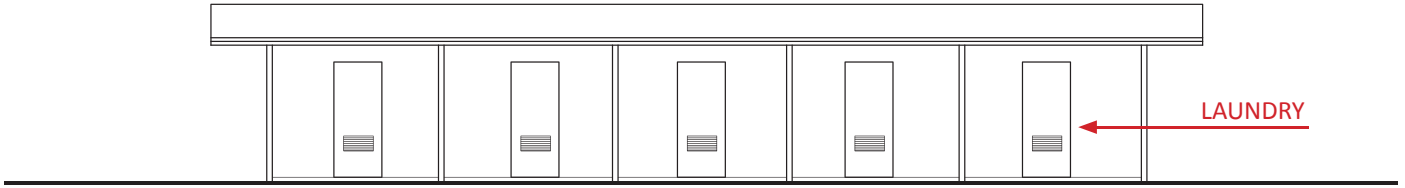


Fig 4.10

ELEVATION

There are two laundry facilities on site.

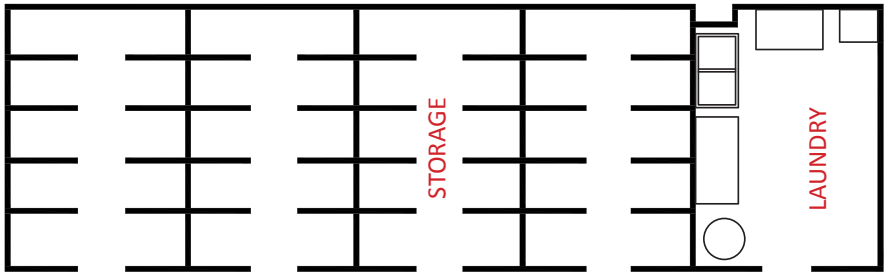


Fig 4.11

PLAN

5 DESIGN

THE PURPOSE

REUSE GREYWATER TO FLUSH TOILETS (01)

IRRIGATE THE LANDSCAPES (02)

MASTER PLAN

SCALE: 1” = 60’-o”

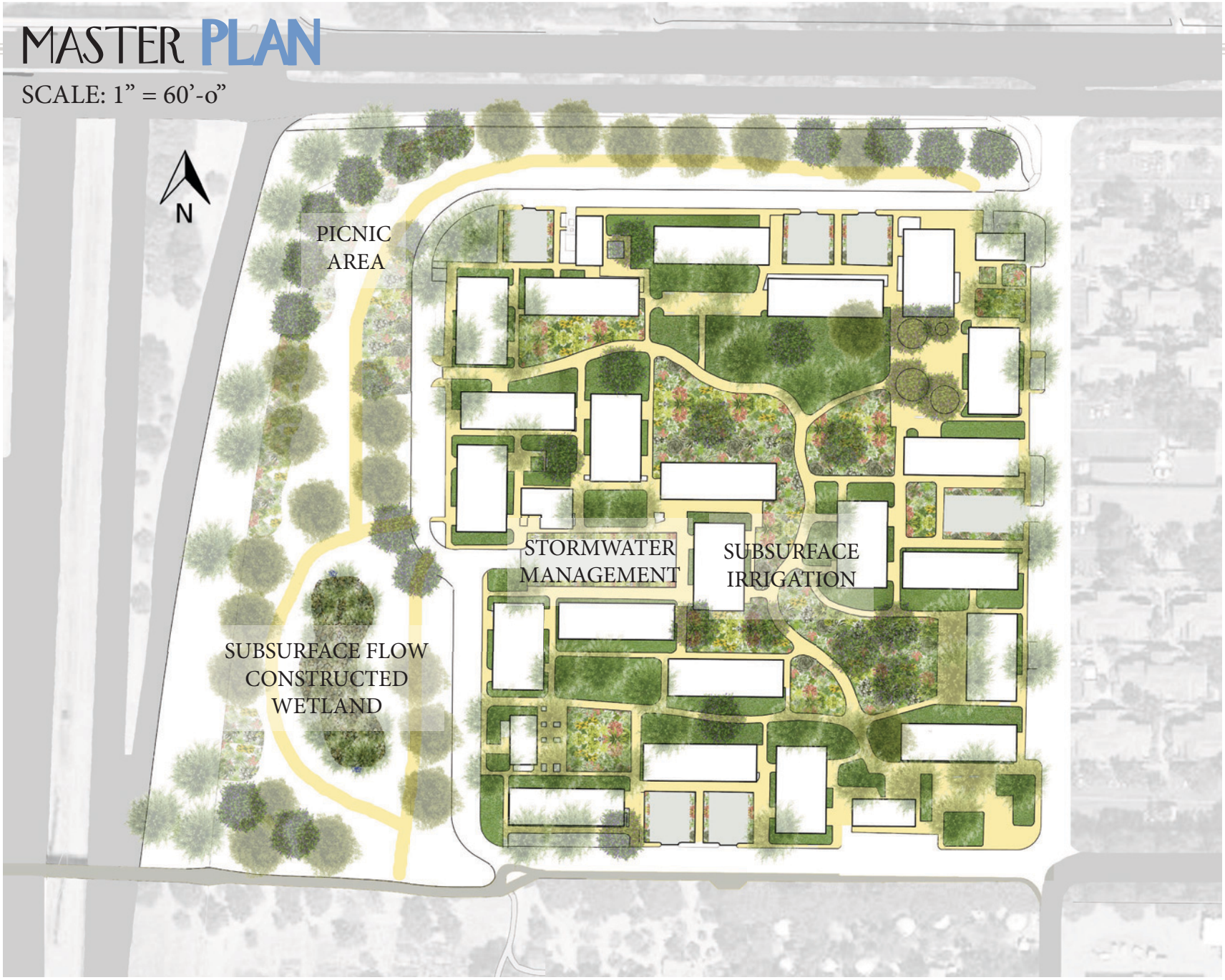


Fig 5.1

DESIGN ELEMENTS:

1. Subsurface Irrigation
2. Subsurface Flow Constructed Wetland
3. Stormwater Management
4. Picnic Area

WATER FLOW DIAGRAM

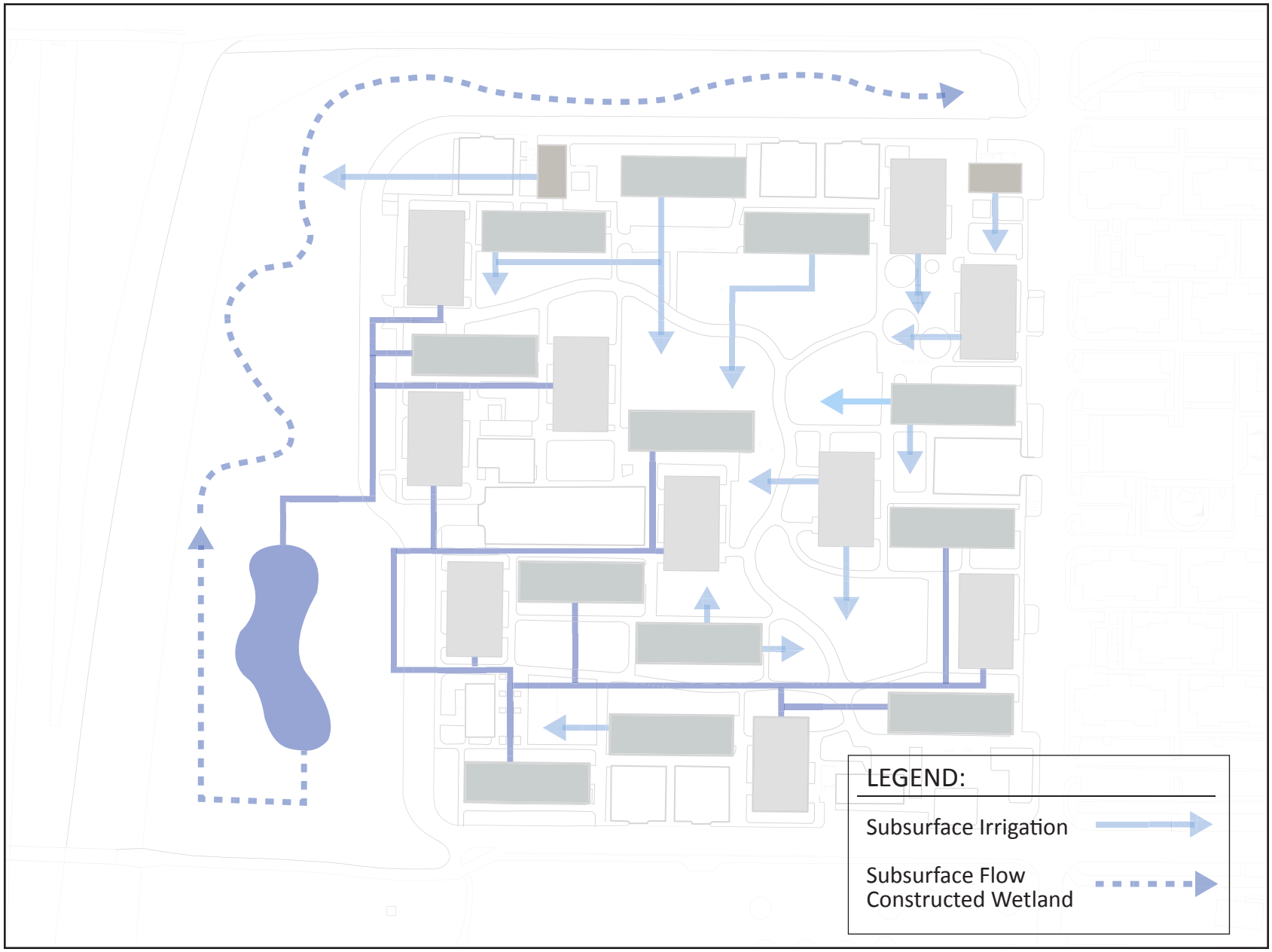


Fig 5.2

SUBSURFACE IRRIGATION

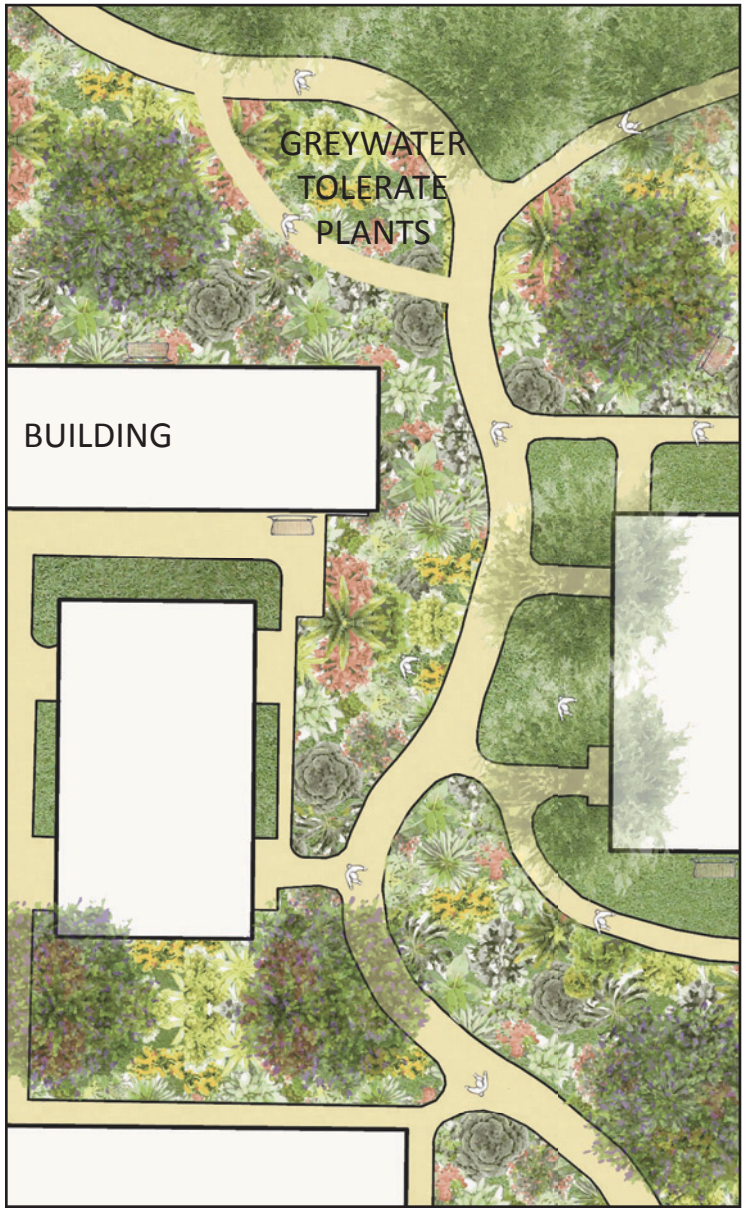


Fig 5.3

PLAN

The use of greywater in the buildings will be for the flushing of toilets and for subsurface irrigation. Greywater generated from bathroom sinks will be used in the flushing of toilets. The overflow, will then be diverted along with greywater from showers and washing machines underground for subsurface irrigation.

Household greywater will be diverted out of the building for subsurface irrigation. The turfgrasses will be replaced with plants that can tolerate greywater. In this case, plant choice is very important because only plants that do well in salt-tolerate conditions will be able to survive with greywater irrigation. Plants that are both salt-tolerate and attractive will be used throughout the site. These colorful and attractive plants will stand out when combined with turf (that is also salt-tolerate). Previously mentioned, greywater cannot be pooled on the surface nor be in direct contact with people, and so a subsurface irrigation is

GREYWATER SYSTEM

TYPICAL APARTMENT BUILDING

1. INDOOR: Water that is generated from the bathroom sink will be used to flush the toilets. There will be an overflow of greywater from the bathroom, which will be diverted to the capture tank, along with water from showers.

2. OUTDOOR: Greywater generated from the showers and bathroom sinks will be re-diverted underground to the capture tank, where it would then be pumped and filtered. Once greywater is filtered it will then go through distribution areas where it will get in contact with the soil (process of subsurface irrigation). When the capture tank is full, it will automatically divert the excessive greywater to the normal sewer system.

SECTION
of *TYPICAL APARTMENT BUILDING*

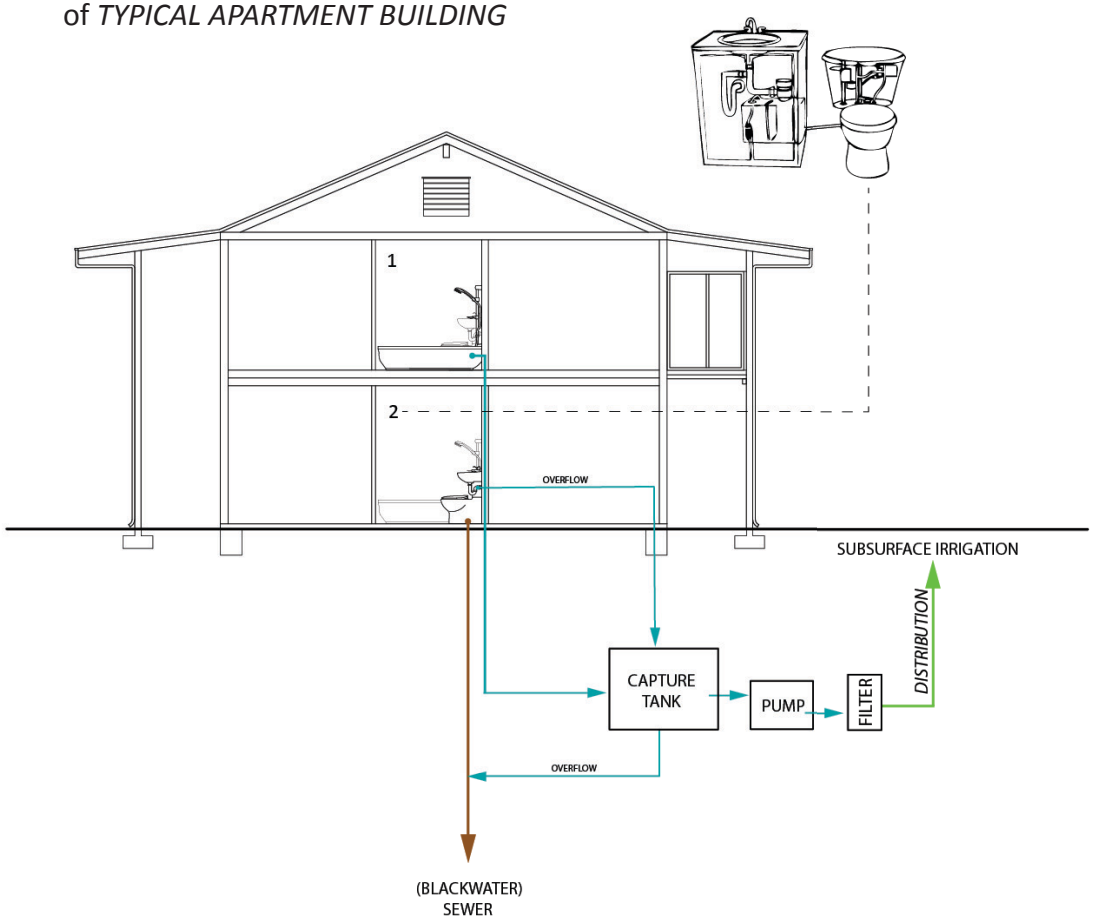


Fig 5.5

LAUNDRY FACILITY

Using a laundry-to-landscape system, water generated from the washing machines (in the laundry facilities) will be diverted to the surrounding landscape where it will be used for subsurface irrigation. Residents will be able to divert the greywater from the washing machines to either the sewer or the landscape depending on if their washes contain contaminants such as human waste.

SECTION
of LAUNDRY FACILITY

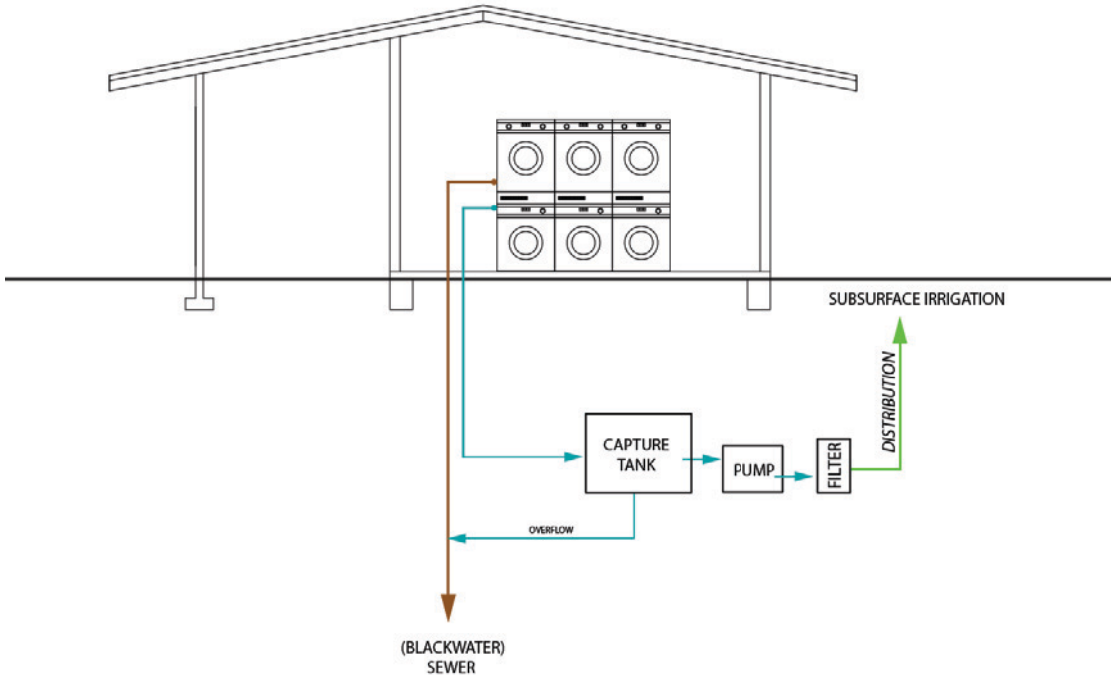


Fig 5.6

Fig 5.4 Perspective of Subsurface irrgiation area

Plant palette

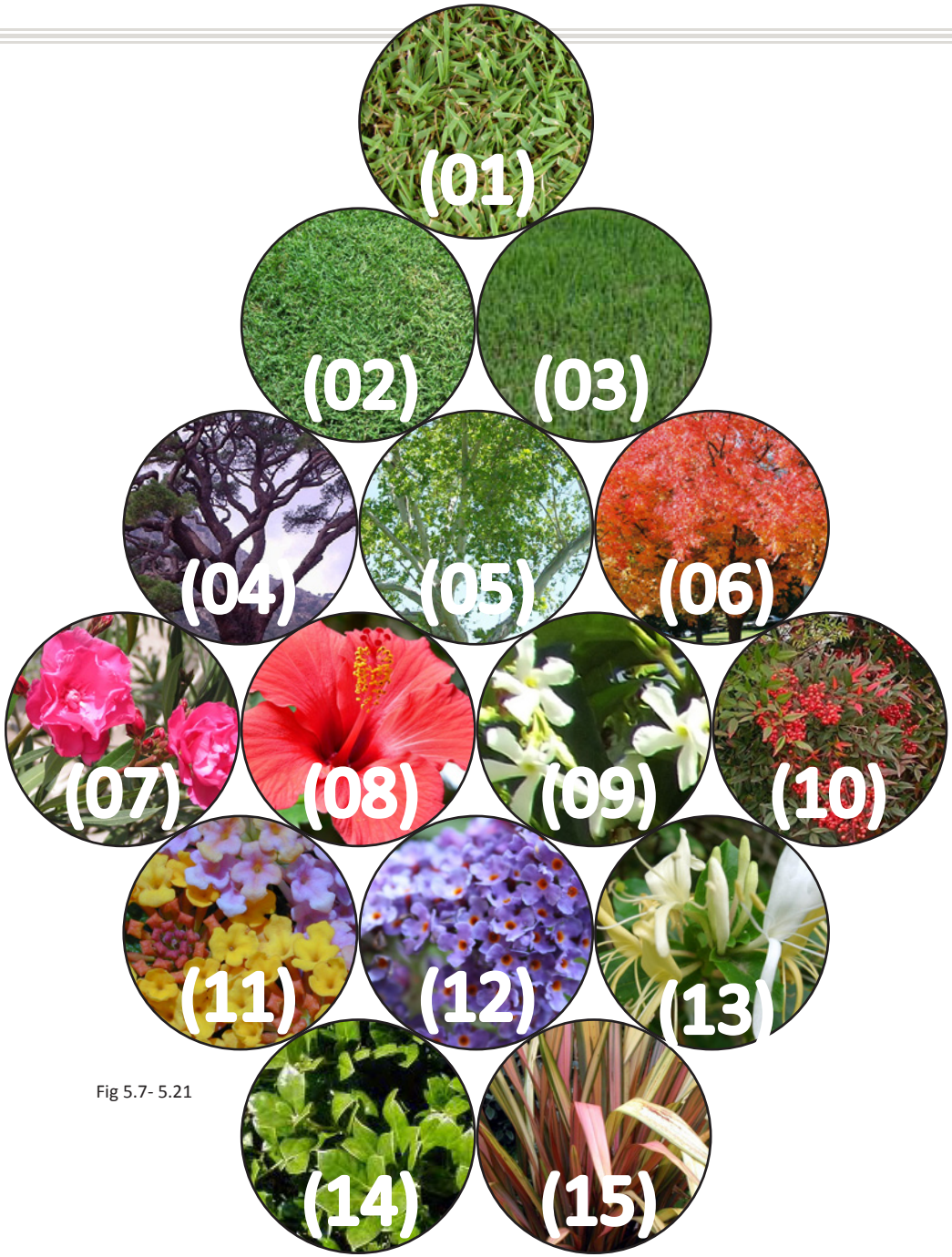


Fig 5.7- 5.21

(01) Seashore Paspalum
(Paspalum vaginatum)

(02) Bermuda Grass
(Cynodon dactylon)

(03) Zoysia Grass
(Zoysia sp.)

(04) Italian Stone Pine
(Pinus pinea)

(05) American sycamore
(Platanus occidentalis)

(06) Chinese pistache
(Pistacia chinensis)

(07) Oleander
(Nerium oleander)

(08) Hibiscus
(Hibscus Rosa-sinenglis cv. brilliante)

(09) Star Jasmine
(Trachelospermum jasminoides)

(10) Heavenly Bamboo
(Nandina domestica)

(11) Lantana
(Lantana camara)

(12) Butterfly Bush
(Buddleia davidii)

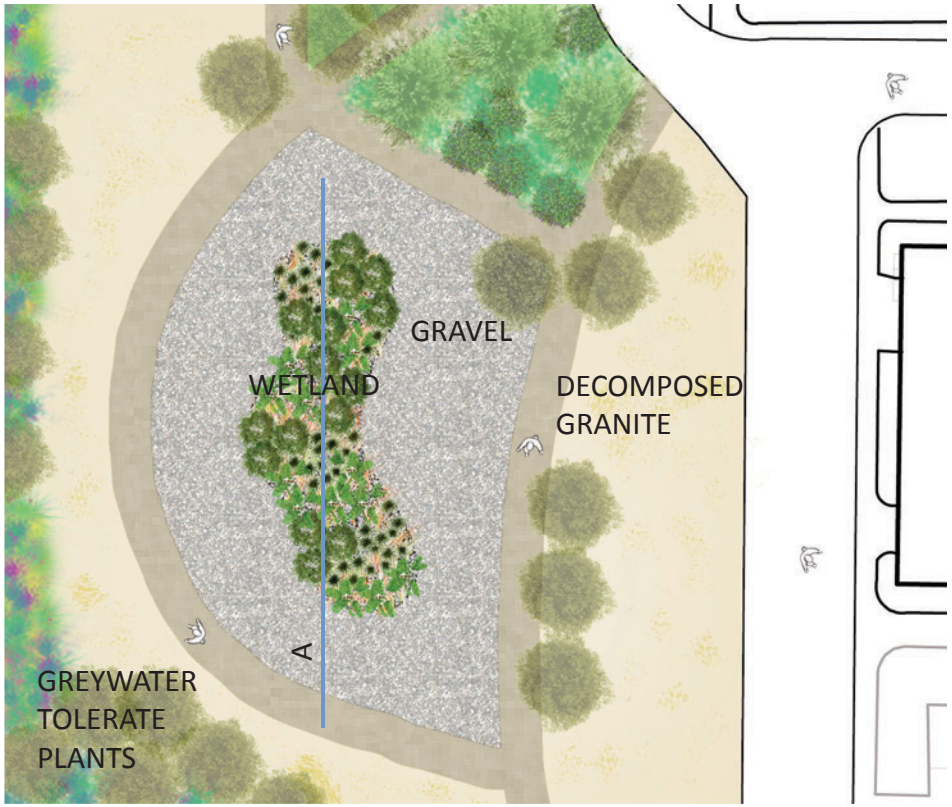
(13) Japanese Honeysuckle
(Lonicera japonica)

(14) Burford Holly
(Llex cornuta cv. burfordii)

(15) New Zealand Flax
(Phorium tentax)

SUBSURFACE FLOW CONSTRUCTED WETLAND

Greywater treatment can happen in a number of ways either through the soil or through (wetland) plants. Wetlands have long been used to treat wastewater/ stormwater. A subsurface flow constructed wetland will provide an alternative to the treatment/ cleaning of greywater. Wetland plants play a huge part in this cleaning. And so, various wetland plants have been chosen for this cleaning process. The subsurface flow constructed wetland and from plan view/ bird's eye, individuals will only be able to see the wetland plants.



PLAN

Fig 5.22

Fig 5.23 Perspective of SFCW

Wetland plant palette

Sedges
(Carex sp.)

Foxtail barley
(Hordeum jubatum)

Rushes
(Juncus sp.)

Water Mint
(Mentha aquatica)

Hardy water canna
(Thalia dealbata)

Arrow arum
(Peltandra virginia)

Bulrushes
(Schoenoplectus sp.)

Cattail
(Typha sp.)

Calla lily
(Zantedeschia aethiopica)

Taro
(Colocasia esculenta)

Fig 5.24- 5.33

SUBSURFACE FLOW CONSTRUCTED WETLAND

TREATMENT PROCESS

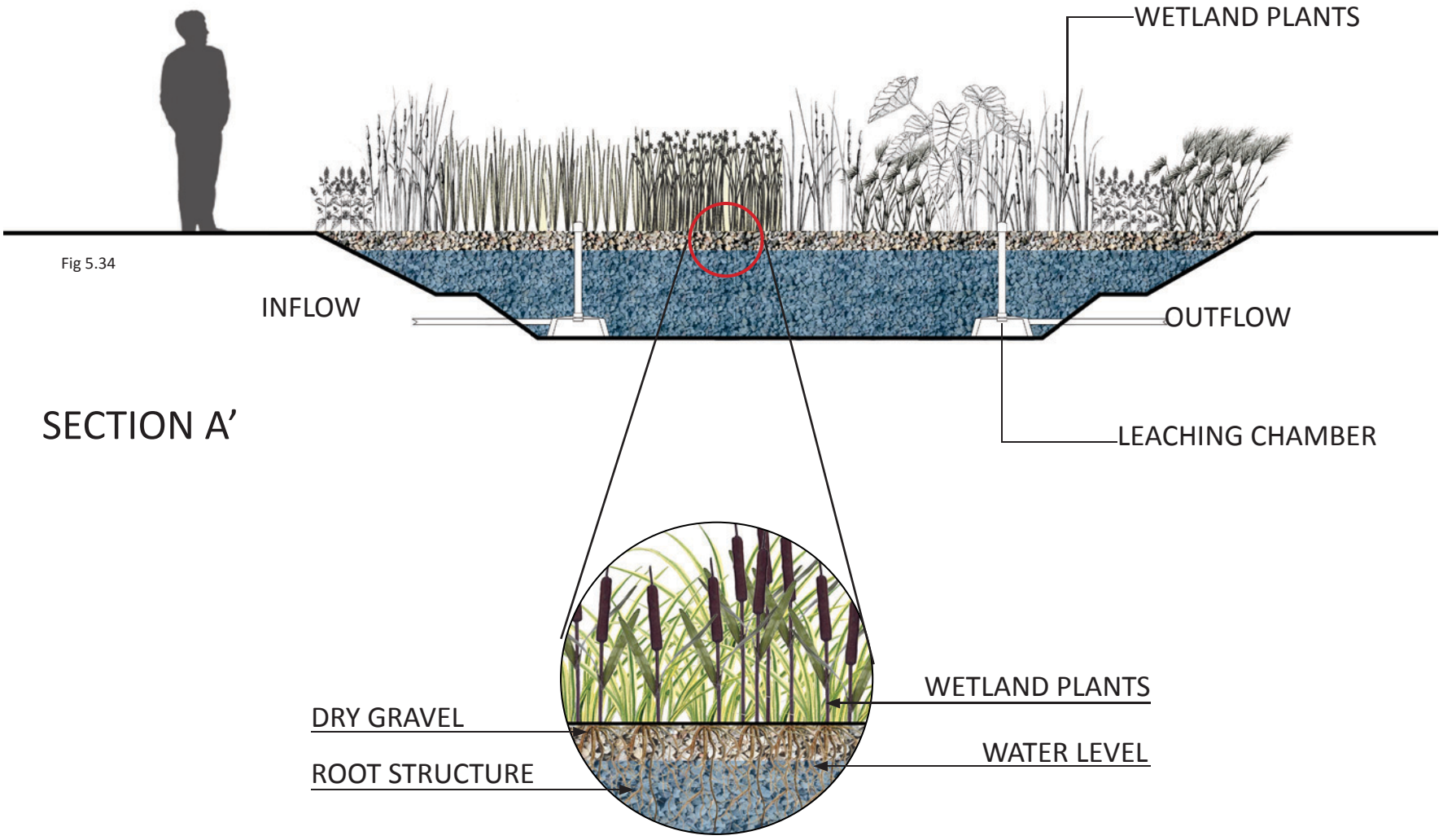


Fig 5.34

SECTION A’

TREATMENT PROCESS

A subsurface flow constructed wetland treats water by moving it through a sand or gravel medium. It consists of “a lined or impermeable basin filed with a 2-foot-deep layer of coarse medium pea gravel with a high hydraulic conductivity and wetland plants” (Nursery Management). Wastewater moves through the wetland and out. This type of wetland does not require large area of land and do not attract mosquitoes because there are no standing surface water. After greywater passes through the wetland, the water is then pumped for irrigation. Another benefit of this type of constructed wetland is water flows under the gravel surface and therefore, odors are trapped (Wetland Wastewater Treatment).

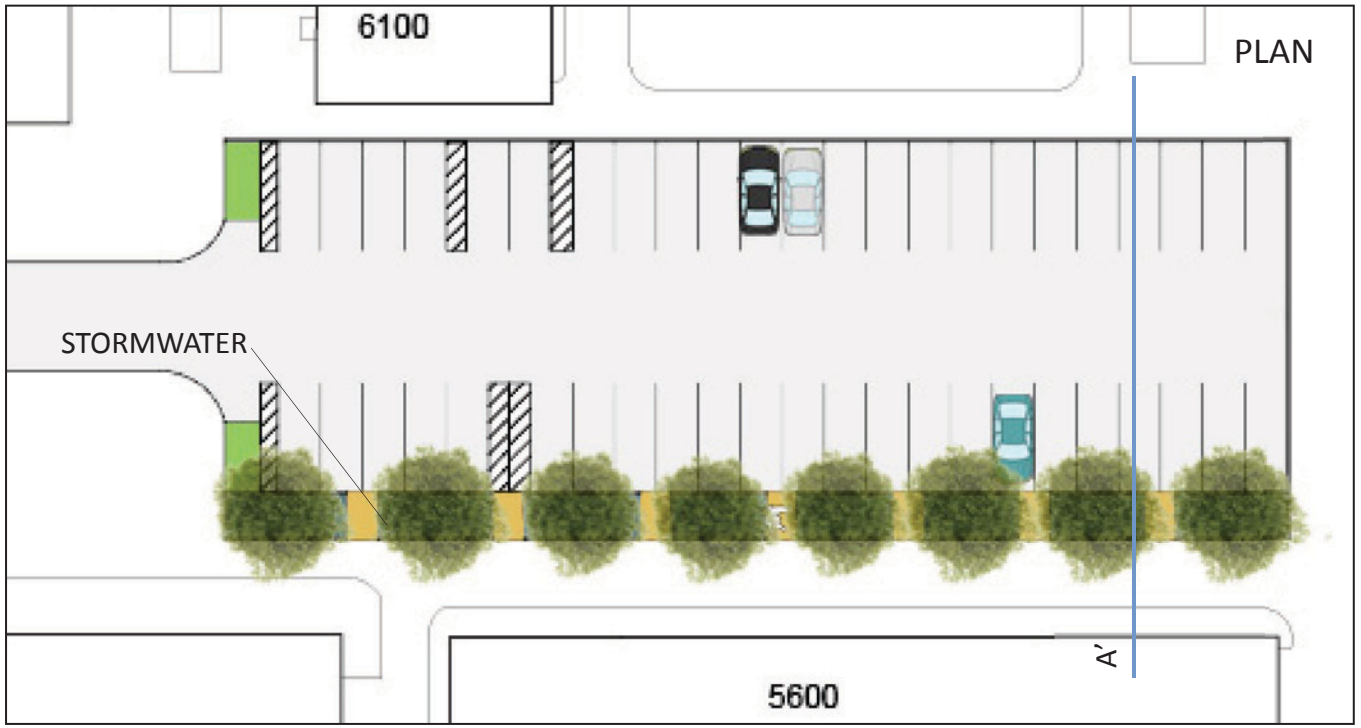


Fig 5.35

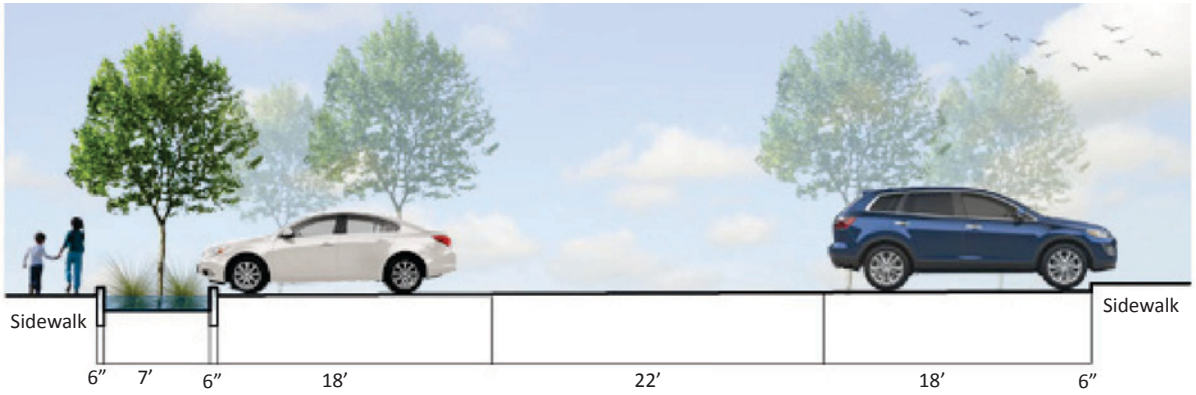


Fig 5.36

SECTION A'

STORMWATER MANAGEMENT

The seven parking lots on the site will be retrofitted to allow for stormwater management. The design will intercept the stormwater and treat it before it reaches the underground sewer system. Similar to the greywater subsurface irrigation and the subsurface constructed wetland, plants will play a huge part in the cleaning of the water, and once clean of pollutants will be used for irrigation of the various plants on the site.

RECREATIONAL/ PICNIC AREA

PLAN

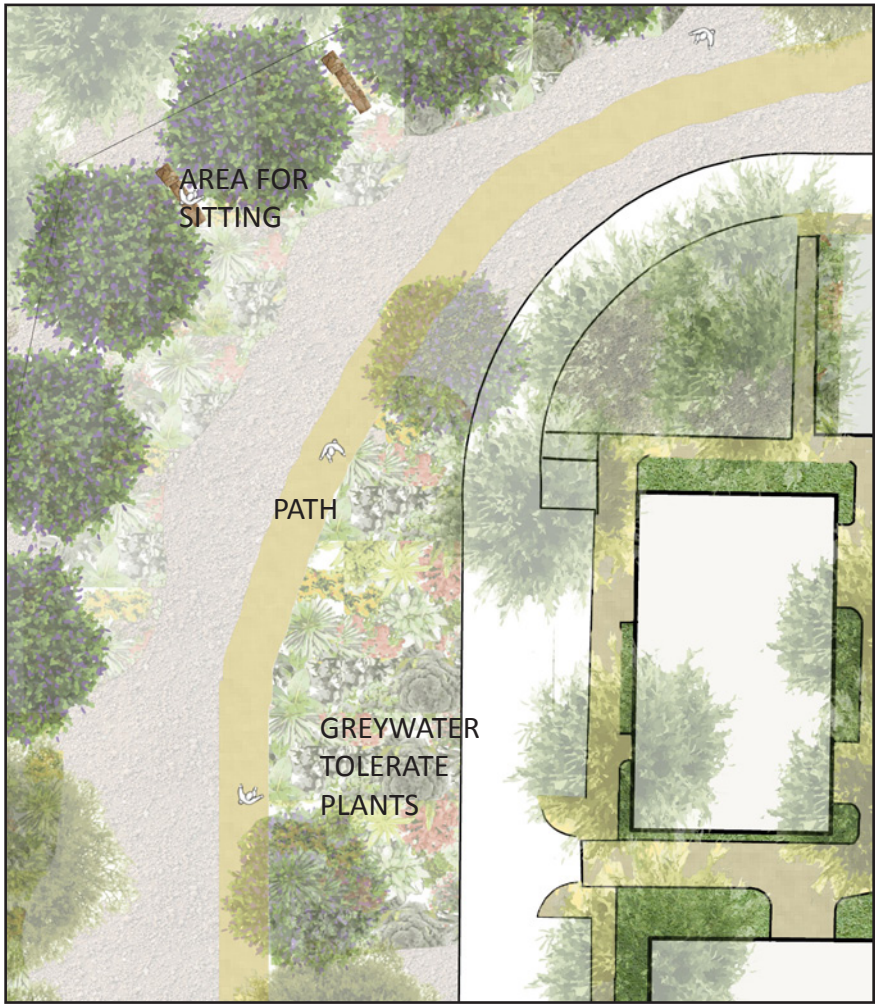


Fig 5.37

The whole site will be relandscape with salt-tolerate plants. A recreational/ picnic area will contain plants that have gone through the wetland treatment process . To reduce noise from the highway, various tall trees such as the Italian Stone Pine will be used as noise cancelation. These various plants and trees will create a space for the residents at Orchard Park (and any for that matter), to enjoy the peacefulness of being outdoors while at the same time being exposed to the reuse of greywater.

Fig 5.38 Perspective of recreational/ picnic area

CONCLUSION

People are beginning to realize how unsustainable it is to use potable water for irrigation. Portable water should be saved for human comsumption rather than for irrigation. Using greywater for irrigation not only saves potable water for human consumption but it also helps to put less strain on the underground sewer system.

The treatment of household wastewater (greywater) can occur at a local scale which will ultimately put less strain on the sewer system and wastewater treatment plants. This type of technology is still fairly new and is still being looked at because of the threat to human health. Greywater systems are the key to managing water a in sustainable way.

THANK YOU

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