

***Environmental Sustainability of
Landscaping:
An Analysis of the Means of Water
Conservation as Pertains to Irrigation and
Landscaping at Occidental College:
The Implementation of Centralized
Irrigation, or a Graywater, Storm Water or
Recycled Water Reuse System***

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Introduction

With a grassy quad, multiple rose beds, and four manicured playing fields, Occidental College uses between 65% and 75% of the water consumed on campus for irrigating the landscape. It is Myron Hunt's original master plan combined with this water usage that allows Occidental to take pride in being a beautiful campus in a dry climate. Recently, however, Occidental also seeks to be an environmentally sustainable campus. In April 2001, former president Mitchell signed Occidental's name to The Talloires Declaration. The Talloires Declaration, written and first signed by an international group of university leaders in 1990, is a ten-point action plan detailing how universities should promote environmental sustainability. One of the ten-points is to

“Practice Institution Ecology: Set an example of environmental responsibility by establishing institutional ecology policies and practices of resource conservation, recycling, waste reduction, and environmentally sound operations.”¹

Although water is not specifically mentioned in this point, water is an ecological resource. Occidental needs to look to conserve water, especially as the City of Los Angeles works to do so. In order for Occidental to maintain the appeal of its landscape, and practice institutional ecology, water conservation and water recycling practices as pertain to landscaping must be seriously considered.

With the goal to benefit the college and the environment, possible water conservation and recycling projects that Occidental could undertake include:

- placing the entire campus on centralized irrigation,
- implementing drip irrigation for certain areas of campus,
- reusing graywater from the new residence hall for its landscaping,
- bringing reclaimed city water to campus to be used for the entire landscape,
- treating and reusing wastewater from the new residence hall for a portion of the landscaping,
- and using the recycled water from the CMP sand filter system for partial irrigation of the soccer fields

In the following report, the cost effectiveness or payback period and applicability under the City of Los Angeles' water legislation is considered for each action listed above. The water conservation and water recycling practices at comparable colleges and universities are surveyed (Appendix B) to understand the problems and benefits of using different means for conserving water on a campus. Ultimately, the water conservation actions undertaken by other campuses and environmental sustainable organizations, such as TREE People, provide the best means to understand the feasibility of undertaking a particular water conservation practice at Occidental.

¹ “The Talloires Declaration.” *Association of University Leaders for a Sustainable Future*. (1990). http://www.ulsf.org/programs_talloires_td.html (1 June 2005).

Part I: Water In Los Angeles

Sources of Water for Southern California, Los Angeles and Occidental College

Approximately 16.5 million people live in Southern California², yet this part of the state uses water primarily from sources outside the region. Without these outside water sources, only three million people could live in Southern California.³ They would rely on groundwater basins found throughout the southern half of the state. Groundwater is the only source of water for Los Angeles found in Los Angeles. However, much of Los Angeles is concrete and asphalt, so storm water, which replenished groundwater aquifers, does not percolate into the ground. This significantly depletes Los Angeles' groundwater supply. Surface water, the source of water for the greater percent of Los Angeles' water supply, is found primarily in the northern half of the state.

Los Angeles receives its surface water from the California Aqueduct, the Los Angeles Aqueduct and the Colorado River Aqueduct (See Appendix A for a map of California's water distribution).

According to the Los Angeles Department of Water and Power (LADWP), Occidental College's water supplier, water sources for Central and Eastern areas of Los Angeles, including Eagle Rock, are:

- Los Angeles Aqueduct Filtration Plant (LAAFP): The LAAFP is supplied water from the Los Angeles Aqueduct and the State Water Project (SWP). Water from the Los Angeles Aqueduct originates in the Eastern Sierras, specifically Mono Basin. The SWP operates the California Aqueduct.
- Colorado River Aqueduct: The Metropolitan Water District (MWD) controls the water flowing into Los Angeles from the Colorado River Aqueduct.
- San Fernando and Central Basins

Approximately sixty percent of Los Angeles' water comes from the LAAFP, twenty-five percent from the Colorado River and the remaining fifteen percent from groundwater basins.⁴ (These numbers are subject to change from year-to-year based on rainfall.) 215 billion gallons of water are supplied annually to Los Angeles by the LADWP.

Reasons for Water Conservation and Recycling in Los Angeles and at Occidental

Population growth is an issue pertinent to the need for water conservation in Los Angeles. At present, approximately 660,000 acrefeet (1 acrefoot = 326000 gals) of water is consumed annually in the City of Los Angeles. By 2020, water usage is estimated to

²“Census Data.” *Southern California Association of Governments*. 2005. <http://www.scag.ca.gov/census/> (24 July 2005).

³Carle, David. *Introduction to Water in California*. Los Angeles: University of California Press, 2004.

⁴“Water Quality Annual Report, City of Los Angeles, Central and Eastern Los Angeles.” (2003). City of Los Angeles Department of Water and Power. (8 June 2005), p. 5.

increase to 800,000 acre-feet as the population grows to greater than 4.8 million people.⁵ Additionally, legislation, such as Decision 1631 and the Colorado River Use Plan, has already been issued that reduces Los Angeles' use of excess water from outside sources. Decision 1631, made by the State of California's Water Resources Control Board, states that the LADWP has to limit their water diversions from Mono Basin until the surface of Mono Lake reaches the elevation of 6392 feet above sea level. This surface elevation then must be maintained. The Colorado River Use Plan, also known as the "4.4 Plan," states that California will decrease its 800,000 acrefeet surplus use of the Colorado River. This is being achieved by instate water transfers between the MWD, the Imperial Irrigation District (IID) and other instate water authorities.

Therefore, the question remains from where is the additional 200,000 acre-feet of water going to come. Water recycling along with conservation practices may be the answer. In fact the City of Los Angeles used the same amount of water in 1999 as in 1972 despite the addition of one million people.⁶ Los Angeles managed this feat by recycling water for irrigation more frequently and reducing wastewater discharge.

⁵ *Los Angeles Department of Water and Power Website*. <http://www.ladwp.com/ladwp/homepage.jsp> (20 June 2005)

⁶ McClurg, Sue. *Water and the shaping of California*. California: Water Education Foundation and Heyday Books, 2000.

Part II: Water Conservation: Irrigation Systems

Water conservation is the practice of efficient water use, and has been undertaken by the City of Los Angeles at large. As a member of the California Urban Water Conservation Council (CUWCC), the LADWP is constantly working to implement “Best Management Practices” (BMPs) for proven water conservation. BMPs, defined in the Memorandum of Understanding Regarding Urban Water Conservation in California (MOU), include the use of low flow showerheads and toilets, and high-efficiency washers, as well as the use of efficient landscape irrigation devices such as centralized irrigation systems and drip irrigation infrastructure.⁷ LADWP’s water conservation programs “result in a demand reduction of more than 15% annually.”⁸

The Use of Centralized, Satellite Controlled Irrigation

Schools in Southern California that use or are implementing centralized irrigation for their entire campus include Pomona College, Pepperdine University, Loyola Marymount University, and the University of Southern California. Types of centralized irrigation systems used by these schools include Calsense, Rainmaster Evolution DX, and Rainbird MaxiCom. (See Appendix B for a summary of each school’s water practices.)

At Occidental, a centralized, satellite controlled Rainbird MaxiCom irrigation system was partially implemented in 1995/96. At present, the quad, Bell Field, the main entrance to the campus, the chiller plant, the president’s house and the area around Patterson Field are on the centralized system. The greater percent of campus, however, remains on manual and automatic, stand-alone irrigation. See Appendix C for a layout of Occidental’s irrigation system.

The greatest amount of water is conserved by the use of centralized, satellite controlled irrigation systems. This is due to the automatic calculation of the reference evapotranspiration (ET) rate on a daily basis. For manual and automatic, stand-alone irrigation systems, the reference ET rate must be calculated by hand, usually on a monthly basis.

Evapotranspiration (ET) Rate Defined:

“Evapotranspiration is the loss of water to the atmosphere by the combined processes of evaporation (from soil and plant surfaces) and transpiration (from plant tissues).”⁹ Thus, the ET rate represents the average daily water use of a type of plant, shrub, tree or grass, which indicates the amount of water that the plant, shrub, tree or grass must receive from irrigation or precipitation. Weather, soil and plant factors, such as relative humidity, soil

⁷ “Urban Water Management Plan, 2000.” (Ch. 4). *City of Los Angeles Department of Water and Power Online*. <http://ladwp.com> (7 June 2005).

⁸ “Urban Water Management Plan, Fiscal Year 2003-2004 Annual Update.” *City of Los Angeles Department of Water and Power Online*. <http://ladwp.com> (7 June 2005), p. 10.

⁹ “ET Overview.” *California Irrigation Management Information System, Department of Water Resources, Office of Water Use Efficiency*. <http://www.cimis.water.ca.gov/cimis/infoEtoOverview.jsp;jsessionid=B5CFD2FC0C778B466D531271B848B2CE> (11 July 2005).

chemistry and plant root depth, affect the ET rate. ET rate also depends on sprinklers precipitation rates, distribution uniformity, soil texture, soil structure, compaction, and infiltration rate. The ET rate is a complex calculation (See Appendix D); it cannot be calculated for every type of plant, tree, shrub and grass in a landscape. A reference ET rate, calculated from a reference crop, usually a type of grass, is used for irrigating a landscape. The calculation of a reference ET rate depends mostly on weather, and thus varies significantly with region and season. **Ultimately, the calculation of the ET rate “gives a far more accurate estimate of watering needs than rule-of-thumb or trial-and-error methods.”**¹⁰ Intuitively knowing when a plant needs water or has been over watered is still beneficial especially after the plant has been irrigated based on the reference ET rate.

Benefits of the Use of a Satellite Controlled, Centralized Irrigation System

- **Daily Weather Update:** Daily weather data from a weather satellite is sent to a main computer, which in turn calculates the reference ET rate for the day. For Occidental, the weather satellite is located at Cal Tech. Weather data is fed to a cluster control unit (CCU) located atop Keck. The CCU sends the information to a main computer at facilities.
- **Daily Irrigation Schedule:** Based on the day’s reference ET rate and initial parameters entered into the system, such as cycle time, the system creates an irrigation schedule specific to the day’s weather. This schedule includes the amount of water to be use as well as the time of day to irrigate. At Occidental, the schedule is sent to the CCU, which in turn sends signals to the Com boxes. A Com box turns on and off the irrigation for the portion of the landscape that it controls. Com boxes are placed strategically around campus.
- **Amount of Water Used to Irrigate Can Be Monitored on a Daily Basis:** As the system is constantly collecting and storing data, the number of gallons of water used to irrigate a certain area can be monitored on a daily basis. For Occidental, this area is the landscaping on one Com box. At the end of each month, or the end of the year, the data can easily be compiled to determine which area of landscaping used the most water or in which month the most water is used.
- **Flow Sensors/SEEF Program:** Flow sensors allow the actual amount of water running through irrigation pipeline to be measured. The sensors show if the amount of water indicated to be used is actually the amount of water being used. At Occidental, flow sensors are used in some parts of the centralized irrigation. A SEEF program compares expected flow rates to actual flow rates, and based on these figures can detect the possible source of a problem, for example, excess flow due to a broken valve. At present, a SEEF program is not used on campus.

¹⁰ Thompson, J. William & Sorvig, Kim. *Sustainable Landscape Construction, A Guide to Green Building Outdoors*. California: Island Press, 2000. p. 161.

Drawbacks to the Use of a Satellite Controlled, Centralized Irrigation System

- **Initial Calculations:** Before landscape can be placed on centralized irrigation, certain initial data, such as cycle time, must be calculated and entered into the system. This takes personnel and time. Once the calculations are complete, however, the systems itself creates an irrigation schedule.
- **Daily Manual Alterations of the System:** As the weather satellite is not located on campus and the weather on campus can vary slightly with that of Cal Tech, sometimes the amount of water needed to irrigate must be altered slightly. This takes personnel and time. The ability to alter the system can be beneficial, however, if, for example, the landscape should not be watered on Friday morning due to the cleaning of campus.
- **Additional Grounds Care Still Needed:** Personnel still need to walk the grounds to check that the landscape is not being over or under watered because, for example, a sprinkler head has become clogged. However, the use of flow sensors with the system makes identifying the source of a problem easier.
- **Training:** Although a centralized, satellite controlled irrigation system automatically calculates how much water needs to be used for irrigation on a daily basis, the system is not on autopilot. It constantly needs to be monitored both on the computer and out in the field. Ultimately, as with most things, the system is only as good as its user. In order to use the system efficiently, personnel must have the expertise to utilize the system. Rainbird offers MaxiCom certification classes to teach personnel how to use a MaxiCom system. Those with the expertise must also be willing to impart their knowledge to others. This may involve teaching hard working personnel with minimum education elementary math, including percents and fractions.¹¹ Ultimately, one or two personnel working on a full time basis can operate the main computer. At LMU, a university with half its landscaping on a centralized system, the landscape director operates the system. At present at Occidental, John Frederick operates the central system.

Overall, the use of a centralized, satellite controlled irrigation system is more water, time and labor efficient than the use of multiple automatic, stand-alone and manual systems. Pix Verendia at USC, a university in the process of implementing a centralized system for the entire campus, says, “How do I know we are more efficient? We are doing a lot of projects and less on maintenance.”¹² The use of centralized, satellite controlled irrigation allows for consistency which benefits plants as well as personnel. To determine water efficiency, a comparison between historical water use irrigation figures and current, ET adjusted irrigation figures for portions of campus now on central irrigation would show the amount of water conserved by the use of central irrigation. The numbers generated by this comparison could in turn be used to predict the amount of water that could be conserved if the entire campus was converted to a centrally operated irrigation system.

¹¹ Verendia, Pix. “Research – Irrigation at Occidental College.” 6 July 2005. Personal email. (7 July 2005).

¹² Verendia, Pix. “Research – Irrigation at Occidental College.” 6 July 2005. Personal email. (7 July 2005).

Areas of Highest Priority to Place on Centralized Irrigation:

- Area surrounding **Thorne Hall**: Both Ron Seymour and John Frederick agree that the area with the highest priority for being placed on centralized irrigation is that surrounding Thorne Hall. Ron Seymour estimated that this would cost about \$30,000.
- Area surrounding **Newcomb and Admissions**: As this is an area consistently viewed by those seeing Occidental for the first time, it is important that the landscaping is maintained to the highest degree. Approximately 2148 Hundred Cubic Feet (HCF, 1 HCF = 748 gals) of water was used to irrigate the grounds around Admissions from June 2004 to May 2005.
- **Upper and Lower Soccer Fields**: This area uses the greatest amount of water on campus. Approximately 6166 HCF of water was used to irrigate these fields from June 2004 to May 2005.
- Area surrounding **Stewie/Pauly/Bell-Young**: This area has a high percent of manual irrigation; much more water than necessary is used for maintaining it and the amount of water the landscape receives is inconsistent. The **New Residence Hall** should be placed directly on centralized irrigation, and perhaps the landscaping surrounding Stewie, Pauly and Bell-Young could be placed on the same Com box.
- Area surrounding **E. Norris**: This is a problematic area; consult John Frederick for more information.

The Use of Drip Irrigation

Drip irrigation is the application of water to just the area where plants, trees and shrubs need it, the root zone, using “drippers,” or “emitters.” Basic spray systems, on the other hand, water landscaping from overhead, and thus water is wasted on non-growth areas of plants, trees and shrubs. Whereas the flow rate for basic spray systems is 60 to 300 gallons per hour, the flow rate for drip systems is 1 to 4 gallons per hour. Consequently, drip irrigation systems must be run for longer periods of time, but they still use less water than spray systems.

The water efficiency of a drip irrigation system is the main benefit to the use of a drip system. Drip systems lose very little water to runoff and evaporation. Evaporation is the main cause of water loss with a spray system, and thus the need for the calculation of the evapotranspiration rate with a spray system. Additionally, fertilizer costs and nitrate losses can be reduced with the use of drip irrigation. Smaller amounts of fertilizers can be applied much more specifically with a drip system than a spray system; water from a spray system tends to wash away fertilizers.¹³ Drip systems can also be run at 15-30 PSI, which is very low PSI by irrigation standards.

¹³ Schock, Clinton C. (10 April 2005). *An Introduction to Drip Irrigation*. From the Malheur Experiment

The main drawback to the use of drip irrigation is the maintenance of the drip system. Drip systems are very fragile; they can be easily damaged during regular landscape maintenance, planting and replanting. Their valves and lines become easily clogged with landscape debris and plant roots. Drip systems susceptibility to clogging also means that they do not work well with the use of reclaimed water; the additional chemicals in reclaimed water block drip lines easily. Ultimately, large amounts of time and sufficient personnel are needed to maintain a drip system.¹⁴ Additionally, the cost of implementing a drip system ranges from approximately \$500 to \$1200 per acre.¹⁵

At Occidental, the greatest area irrigated with drip irrigation is a small area between Johnson Student Center and Thorne Hall. The drip irrigation was placed here to make this area an example of xeriscaping. This drip irrigation system, however, has been redone three times since its implementation. All other schools surveyed rarely use drip irrigation (See Appendix B). Pix Verendia at USC says, “We do not have enough personnel to maintain a drip system.”¹⁶ As USC does not have the personnel to use a drip system, it follows that Occidental, a much smaller college, would not have the personnel to maintain a drip system.

Bubblers tend to be used as a compromise for a drip system. In fact, Peter Walker in an article in the Arizona Water Resource argues that bubblers are more efficient than drip systems for desert landscaping. He writes,

“In a controlled experiment in Phoenix, desert plants (mesquite, acacia, and cassia) in bubbler irrigation treatments generally had significantly greater canopy growth than in most drip irrigation treatments, and rodents were continually chewing up one of our drip irrigation systems.”¹⁷

Bubblers are similar to drip emitters in that they water a more specific area than spray heads, but bubblers are not as water efficient as drip emitters. Bubblers work by flooding an area and relying on the natural wicking action of the soil to distribute the water to the necessary roots. Small groupings of flowers and shrubs benefit from the use of bubblers.

At present, at Occidental as well as at LMU, bubblers are used for the irrigation of some groups of trees. USC uses multiple types of Rainbird bubblers including adjustable flood bubblers, pressure compensated bubblers, and stream bubblers with pressure compensating screen.

Station, Oregon State University website, <http://www.cropinfo.net/drip.htm> (18 July 2005).

¹⁴ Verendia, Pix. “Research – Irrigation at Occidental College.” 14 July 2005. Personal email. (18 July 2005).

¹⁵ Schock, Clinton C. (10 April 2005). *An Introduction to Drip Irrigation*. From the Malheur Experiment Station, Oregon State University website, <http://www.cropinfo.net/drip.htm> (18 July 2005).

¹⁶ Verendia, Pix. “Research – Irrigation at Occidental College.” 14 July 2005. Personal email. (18 July 2005).

¹⁷ Walker, Peter. *To Drip or Not To Drip, That Is the Question*. Arizona Water Resource, 8(3), November 1999. Arizona Water Resource website: <http://ag.arizona.edu/AZWATER/awr/dec99/drip.htm> (18 July 2005).

Part III: Graywater Use

Graywater (also spelled greywater) is untreated wastewater that comes directly from showers, bathtubs, bathroom sinks and washing machines, but not toilets, kitchen or photo lab sinks. According to Title 24, Part 5, Appendix G of the California Administrative Code, which is California's graywater use legislation, graywater can only be used for subsurface irrigation of non-edible plants. Originally only single-family residences could use graywater, but when the graywater code was revised in 1997, it was changed to include commercial, industrial and institutional projects as well. California's Graywater Systems Code specifies how to estimate graywater discharge, the type of surge tank to be used and provisions for irrigation construction.

Concerns regarding the use of graywater include:

- **Types of Plants and Soils That Can Be Irrigated:** As most graywater systems only filter hair and lint out of the water before use, chemicals from laundry detergent, soap and shampoo are present in graywater. Only certain types of plants and soils can tolerate these chemicals. Salt-tolerant plants, such as native desert plants, can handle being irrigated with graywater while plants that prefer acid conditions cannot. Sandy soils are more tolerant of graywater irrigation than clay soils because sandy soils drain better.¹⁸ (Type of soil on campus?)
- **Salt Build-Up:** Due to the salt content of graywater, salt tends to accumulate in the soil of the ground irrigated with graywater. In order to flush out the salts, the land must occasionally be irrigated with fresh water.¹⁹
- **24 Hour Rule:** Graywater must be used within 24 hours of collection.²⁰
- **Health Hazards:** Findings of a study done by the Water Conservation Alliance of Southern Arizona that sampled households' soil irrigated with graywater and with potable water show that there are health hazards that come with the use of graywater. Results of the study indicated "that irrigation with graywater does introduce *E. coli* into the soil that would not otherwise be present."²¹ Additionally, "the differences in levels between the two soils [one irrigated with graywater and the other with potable water] suggest that graywater irrigation introduces additional fecal streptococci into the soil."²² Also, "graywater irrigation does introduce fecal coliform contamination into the soil at levels above what is normally present."²³ These potential health hazards prevent a greater use

¹⁸Ludwig, Art. (2005). Oasis Design. www.oasisdesign.net (16 June 2005).

¹⁹ "Appendix G, Graywater Systems." *Title 24, Part 5, California Administrative Code*. (18 March 1997). <http://www.ciwmb.ca.gov/greenbuilding/design/guidelines.htm> (27 June 2005), Appendix.

²⁰ Roy, Gregg. "RE: From Alyce – Cisterns and Mono." 15 July 2005. Personal email. (18 July 2005).

²¹"Residential Graywater Reuse: The Good, The Bad, The Healthy." (1998). *Water Conservation Alliance of Southern Arizona*. <http://www.watercasa.org/research/residential/summaryoffindings.pdf> (22 June 2005), p. 24.

²² "Residential Graywater Reuse: The Good, The Bad, The Healthy." (1998). *Water Conservation Alliance of Southern Arizona*. <http://www.watercasa.org/research/residential/summaryoffindings.pdf> (22 June 2005), p. 24.

²³ "Residential Graywater Reuse: The Good, The Bad, The Healthy." (1998). *Water Conservation Alliance*

of graywater. It is also due to these health hazards that the LADWP does not recommend the use of graywater.

At Occidental it would only be feasible to use graywater from the new residence hall; re-plumbing existing buildings to separate toilet water from shower and sink water is cost prohibitive. Little water would be conserved for the high price of creating a graywater irrigation system. Due mostly to the health hazards associated with graywater use, the potential for graywater use was not pursued. If Occidental is interested in using graywater from the new residence hall for irrigation of the landscaping of the hall, Art Ludwig of Oasis Design is the person to contact.

Part IV: Waste Water Treatment and the Use of Reclaimed Water

Recycled or reclaimed water is waste water from all sources, “which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur.”²⁴ Like graywater, reclaimed water is used mostly for irrigation and groundwater recharge; it is not considered a potable water source. Unlike graywater, reclaimed water must comply with health regulatory standards. In the Los Angeles area there are four wastewater treatment plants that pump reclaimed water back into the city. They are:

- Hyperion Treatment Plant
- West Basin Water Reclamation Plant
- Donald C. Tillman Water Reclamation Plant
- Los Angeles/Glendale Water Reclamation Plant
- Terminal Island Treatment Plant

In 2000, the plants provided 41,500 acre-feet of reclaimed water to a number of LADWP water recycling projects. By the year 2020, LADWP’s water recycling programs are expected to produce over 102,000 acre-feet of recycled water.²⁵ The cost of recycling water and public acceptance of recycled water are two factors that will greatly influence the use of reclaimed water.

Schools in Southern California that use reclaimed water include Loyola Marymount University, Pepperdine University and the University of California – San Diego (See Appendix B).

Bringing Reclaimed City Water to Campus

The Los Angeles/Glendale Water Reclamation Plant, Los Angeles’ first reclamation facility, is the closest wastewater treatment plant to Occidental. The plant serves the Glendale/Burbank area and the eastern San Fernando Valley. In 2004, the 1,662 acre-feet of reclaimed water produced at the plant was used to irrigate portions of Griffith Park, Mt. Sinai Memorial Park, the Lakeside Golf Course as well as other customers.²⁶

Wastewater that enters the plant must pass through four different levels of treatment:

- Preliminary treatment: Removal of coarse debris
- Primary treatment: Removal of organic and inorganic solids, primarily sludge and oils
- Secondary treatment: Micro-organisms added for the removal of additional organic solids
- Tertiary treatment: Disinfected with chlorine

Treatment to the tertiary level ensures the highest degree of safety for the use of the reclaimed water. Unlike with studies on graywater use, studies on the use of reclaimed

²⁴ California Department of Water Resources. *California Water Plan Update 2005, Public Review Draft, Vol. 2, Ch. 16*. California: California Public Affairs Office, April 2005, p. 1.

²⁵ “Urban Water Management Plan, 2000.” (Ch. 5) *City of Los Angeles Department of Water and Power Online*. <http://ladwp.com> (7 June 2005), p. 57.

²⁶ “Urban Water Management Plan, Fiscal Year 2003-2004 Annual Update.” *City of Los Angeles Department of Water and Power Online*. <http://ladwp.com> (7 June 2005), p. 12.

water continuously show that irrigating with reclaimed water is safe. According to a study by the WateReuse Foundation, “Exposure to pathogens in fecal matter from bird droppings or domesticated animals and chemical contaminants from fertilizers or pesticides may present a greater risk to children than that from reclaimed water used for irrigation.”²⁷

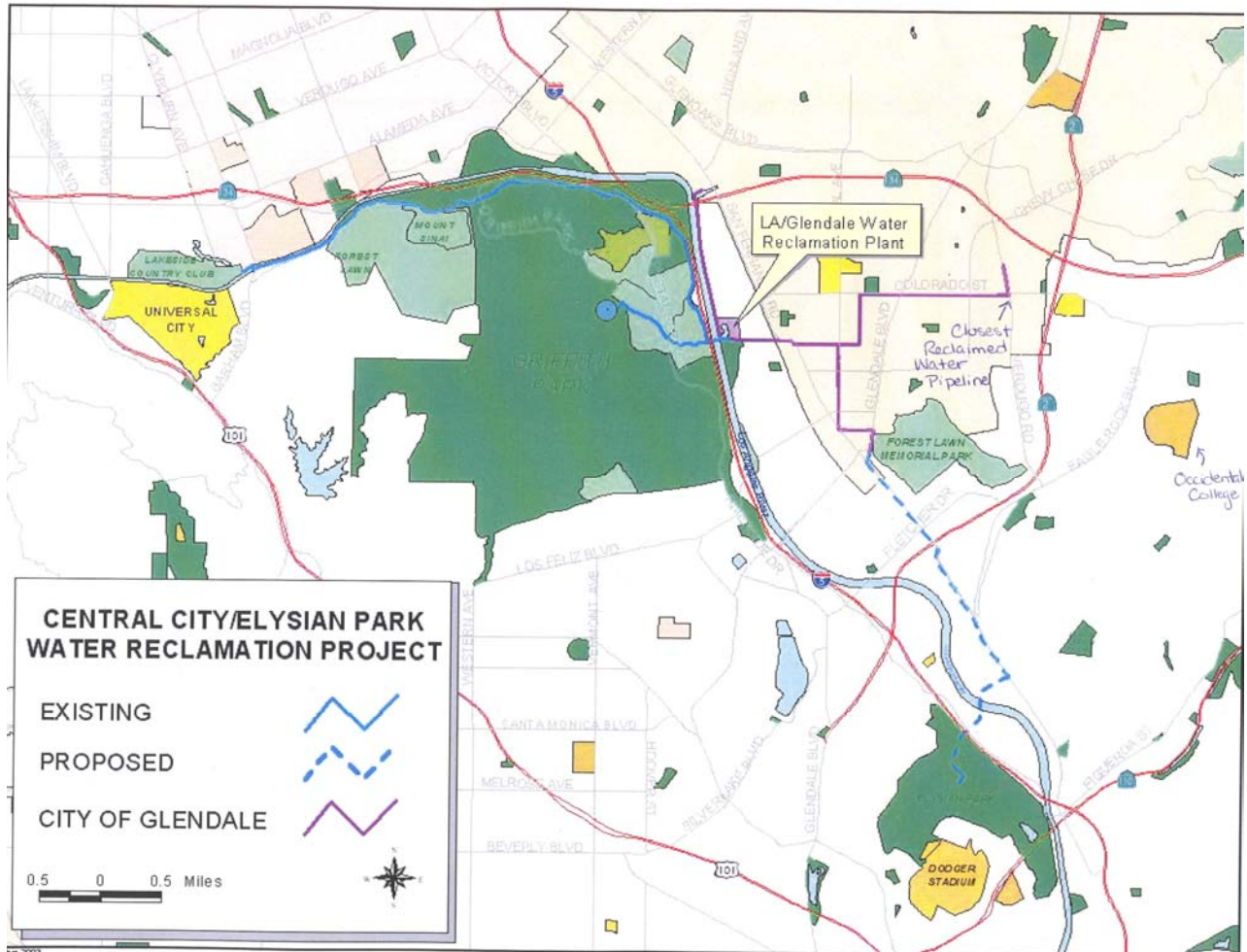


Diagram 4.1: Los Angeles/Glendale Water Reclamation Pipeline

The closest reclaimed water pipeline to Occidental College is located at the intersection of Colorado Blvd. and Verdugo Rd. in Glendale, according to Raja Takidin, a Civil Engineer at GWP Water Resources (See Diagram 4.1). The minimum cost to bring reclaimed water pipeline to campus, which means placing 12,000 feet of pipeline, is \$900,000.²⁸ Although the city may help to defray some of this cost, this project is not cost effective. Additional concerns for bringing reclaimed water to campus include:

²⁷ Crook, James. Irrigation of Parks, Playgrounds, and Schoolyards with Reclaimed Water: Extent and Safety. Virginia: WateReuse Foundation, 2005, p. 20.

²⁸ Takidin, Raja. “Water Recycling and the LA Glendale Water Reclamation Plant.” 22 June 2005. Personal email (22 June 2005).

- Existing Irrigation Infrastructure: If recycled water is brought to campus it could not be used in the existing irrigation system unless the irrigation infrastructure (piping, sprinkler heads, etc.) was replaced with purple piping. The cost of replacing this piping is not included as part of the base cost quote of \$900,000. The infrastructure can be replaced on an area-by-area basis starting with the sports fields, the greatest users of water.
- Elevation: As Occidental is built on an incline there is the possibility that the existing pressure in the reclaimed water city piping may not be great enough to pump water to the top of campus. The pressure in the reclaimed water piping and the elevation of campus would have to be looked at to determine this.
- Use with Native Plants: Using reclaimed water to irrigate native plants can be problematic due to chemical components in the reclaimed water.
- Salt Build Up and Smell: At LMU, soil tests show that the salt content of the soil is increasing as the duration of the use of reclaimed water increases. LMU also experienced problems with the smell of sulfates in reclaimed water. Students complained about the smell radiating from the landscaping of a dorm irrigated with reclaimed water. For the moment, DWP has put LMU back on potable water.

Trucking reclaimed water to a site is not “far fetched,” but it is “very labor intensive.” The reclaimed water would have to be pressurized which means that the truck would have to be connected to a pump. For agencies that have done this for construction dust control, “it was way more trouble and expense than it was worth.”²⁹

Until reclaimed water pipeline runs closer to Occidental, bringing municipal reclaimed water to campus does not appear cost effective. The city, however, does allow the use of purple piping without the use of reclaimed water for an irrigation system with its own water meter.³⁰ Thus, as irrigation renovations and improvements are made, Occidental should consider using purple piping where possible.

On-Site Wastewater Treatment and Reuse

On-site wastewater treatment systems are also available for purchase. Types of systems include:

- Equaris Infinity
- Orenco’s AdvanTex AX100
- Norchem’s Ultrapure

The Equaris Infinity disinfection and filtration network is used at the National Resources Defense Council building located in Santa Monica. Graywater from the facility’s sinks and showers, as well as rainwater is collected in a cistern on-site and then pumped

²⁹ Cross, Victoria. “summaryoffindings.pdf.” 20 June 2005. Personal email. (22 June 2005).

³⁰ Cross, Victoria. “Recycled Water – One More Question.” 12 July 2005. Personal email. (18 July 2005).

through the disinfection system. The recycled water is used for on-site irrigation and the flushing of toilets. (Note: Santa Monica has different legislation pertaining to the use of reclaimed water; reclaimed water can be used in toilets.) The wastewater treatment and recycling system along with dual low flow plumbing provides the NRDC building with “60 percent water savings compared to a conventional building of the same size, resulting in an annual water savings of over 60,000 gallons.”³¹ According to Moule and Polyzoides, the designer of the NRDC building, the cost of implementing the treatment system is supposed to be paid back over the course of four years; additional research would have to be done to determine how this figure was calculated.

Orenco’s AdvanTex AX100 Treatment System is used at the Audubon Center in Debs Park to treat the facility’s wastewater. The facility does not use this recycled water for irrigation or domestic purposes. The plumbing was designed to allow the recycled water to be used in toilets, but the pipes are not connected. The City of Los Angeles does not allow recycled water to be used in toilets in public facilities.

The LADWP recommends the use of Norchem’s Ultrapure System for wastewater treatment.³² See Diagram 4.2 and 4.3 for the design of the system.



Diagram 4.2: Ultrapure System

³¹ “Water Conservation.” *Residential Water Use, The Green Gate from NRDC. Natural Resources Defense Council Online.* <http://www.nrdc.org/cities/building/smoffice/guides/water.pdf>. (13 June 2005).

³² Cross, Victoria. “summaryoffindings.pdf.” 20 June 2005. Personal email. (22 June 2005).

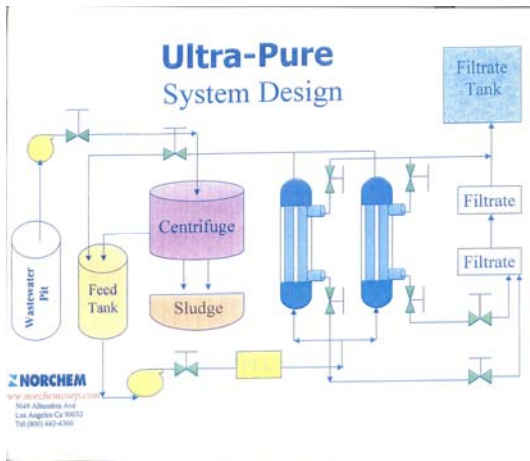


Diagram 4.3: Ultrapure System Design

The placing and use of one of these waste water treatment systems on campus would allow domestic waste water from showers, sinks and washing machines to be captured, treated and reused for irrigation. The only building on campus where a wastewater treatment system could feasibly be placed is the new residence hall; re-plumbing existing buildings to separate toilet water from sink and shower water is cost prohibitive. Additionally, treated wastewater could not be pumped into an existing irrigation system; the infrastructure must be replaced with purple piping. According to Kevin Minissian at the Norchem Corporation, an Ultrapure system which treats approximately 5000 gallons of water, costs between \$25000 and \$30000. The pay back period for this project would be at minimum nine years (See Appendix E). If Occidental is interested in implementing an on-site wastewater treatment system for the new residence hall, the architect for the new hall must be consulted.

Use of Corrugated Metal Pipe (CMP) Sand Filter System Recycled Water

A corrugated metal pipe (CMP) sand filter water recycling system was installed under the Upper Parking Lot in order for Occidental to be in compliance with the Clean Water Act. The CMP system collects storm water runoff from the parking lot, filters out trash and hydrocarbons, and sends the storm water through a sand filter. According to Bruce Steel, the CMP system cost approximately \$67,000 to build and install, and can hold a ¾" rain event. The storm water captured by the system is supposed to percolate into the ground; however, the infiltration rate is very slow to due the chemical make-up of the soil.

The water collected by the CMP system can be used for partial irrigation of the landscaping around the upper parking lot or partial irrigation of the soccer fields. In order to utilize this water, a portable pump and irrigation system would have to be devised. The water would have to be collected and stored in a cistern after each rain fall. As the CMP system does not collect a significant amount of water, the time, labor and cost of creating a system to utilize this water appears to outweigh the benefit of using this water.

Conclusion

This research sought to examine water conservation and recycling projects as pertain to irrigation that Occidental College could undertake as part of the upcoming Master Plan. Projects considered range from the use of centralized, satellite-controlled irrigation to graywater reuse to the use of municipal recycled water. Water efficiency, cost and practices by other schools in Southern California were factors used to analyze each project. Recommendations as a result of this research include:

- Implementation of the Rainbird MaxiCom centralized irrigation system for the entire campus. Although a full cost-benefit analysis could not be conducted, the use of centralized irrigation for the entire campus will conserve the most water at the least cost in the long run. Conversion to centralized irrigation also ensures that Occidental will remain competitive with its peer schools in Southern California in the field of irrigation. Continued implementation of the MaxiCom system should start with the landscaping surrounding Thorne Hall as both Ron Seymour and John Frederick give this area highest priority. The landscaping for the New Residence Hall should be placed directly on the MaxiCom system. The soccer fields, the area with the greatest consumption of irrigation water, should also be a high priority.
- Continued use of bubbler irrigation where appropriate. At present, bubblers are used to irrigate the trees at the top of the Greek Bowl. The use of bubbler irrigation should be done opportunistically; as new groups of trees and/or shrubs are planted, bubblers should be used. Further research needs to be conducted to determine additional uses for bubbler irrigation.
- When municipal reclaimed water pipeline comes closer to campus, Occidental should seriously consider using reclaimed water for irrigation purposes. In the mean time, purple piping should be used as irrigation infrastructure renovations are made. When Occidental can finally use reclaimed water, the entire irrigation infrastructure will not have to be replaced.
- If Occidental wishes to be a trendsetter in the field of environmental sustainability and water conservation then an on-site wastewater treatment system should be used in the New Residence Hall.

Ultimately, Occidental should continue to keep track of environmental sustainable actions as pertain to water conservation for irrigation at other colleges and universities. This can be done through the US Council Green Building's link "Campus Initiatives" and the International Institute for Sustainability Development. Future research should include creating "Sustainable Building Guidelines" based on LEED certification standards. These would be guidelines to benefit the environment that all architects and contractors must work by when building at Occidental. In the area of water conservation as pertains to irrigation, sustainable building guidelines include "install, use and maintain high efficiency irrigation technology that reduces potable water consumption for irrigation by

50%.”³³ Thus, implementation of the centralized, satellite-controlled MaxiCom irrigation system for the entire campus should be Occidental’s next step to conserve water.

³³ Bush, Alan; Curran, Emily & Ichsan, Tony. (May 2003). *Sustainable Building Guide*. Pomona College.

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Conclusion

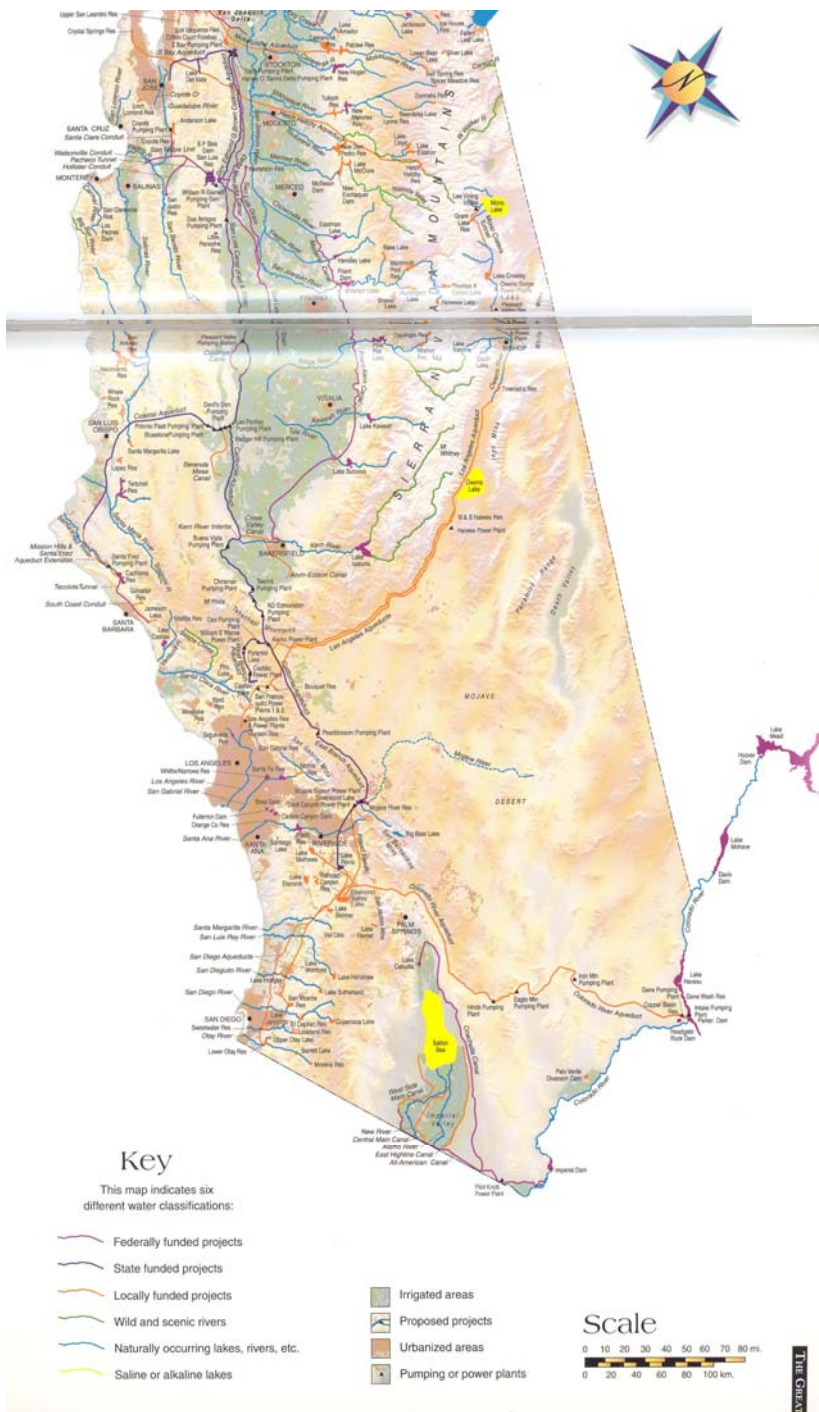
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Appendix A:
Map of California's Water Distribution Systems
 (Diagram from McClurg, Sue. *Water and the shaping of California*. California: Water Education Foundation and Heyday Books, 2000. p. 90.)
California's Transformed Waterscape



**Appendix B:
Summary of Water Conservation Actions at Schools in Southern California**

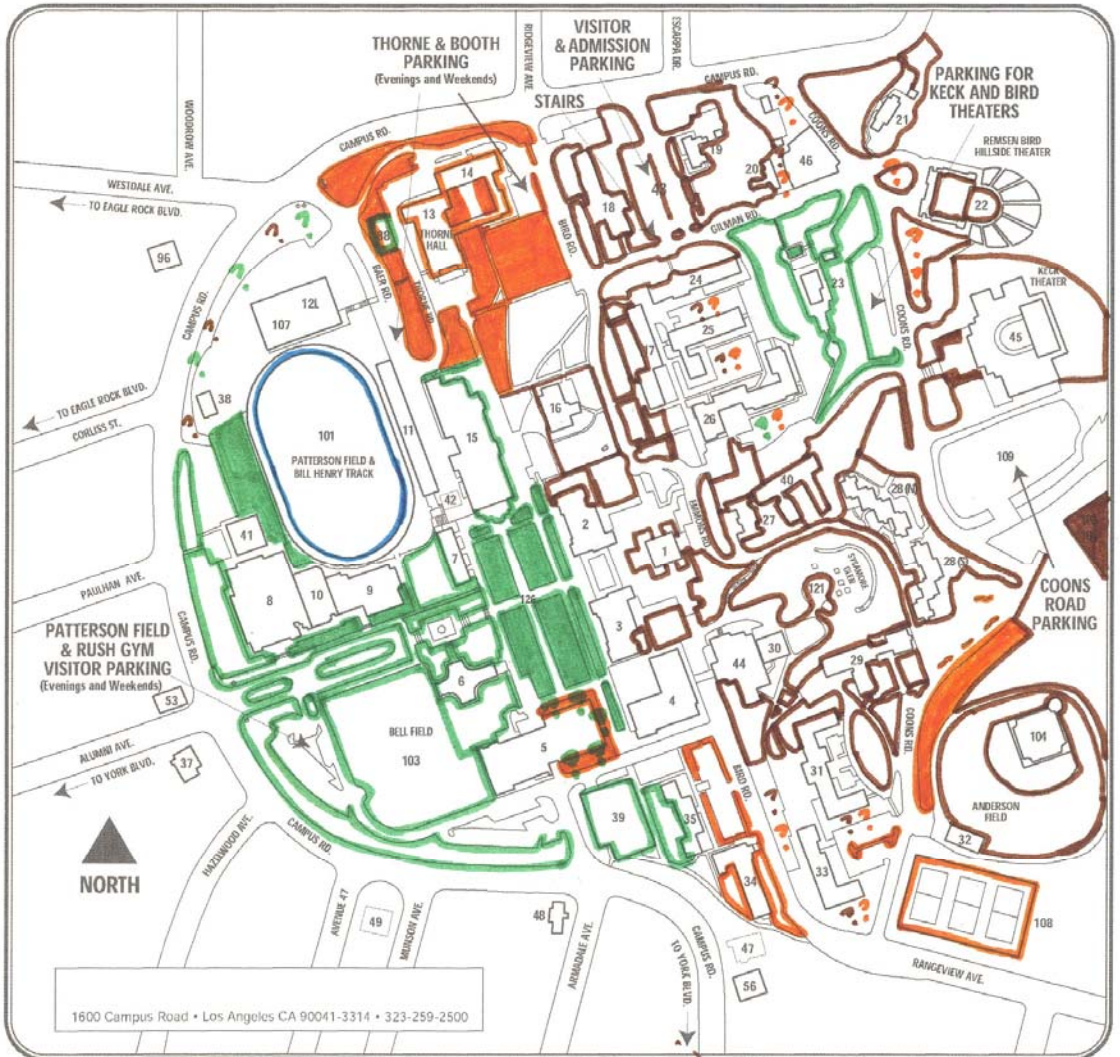
School	Centralized Irrigation?	Type of Irrigation System	
LMU	Yes. Approx. Half of Campus. Being Implemented for Rest of Campus	RainMaster Evolution DX	
Pepperdine	Yes. Entire Campus.	RainMaster Evolution DX	
Pomona	Yes. Entire Campus.	Rainbird MaxiCom	
USC	Yes. Being Implemented for Entire Campus. Almost Complete.	Calsense	
Occidental	Yes. Parts of Campus. Being Implemented for Entire Campus. Funding needed.	Rainbird MaxiCom	

School	Drip Irrigation?	Recycled Water?	Graywater?
LMU	Rarely Used.	Yes. From Municipal Plant. Problems with smell.	
Pepperdine	Rare. Not used with reclaimed water.	Yes. From Municipal Plant. Sewage water sent back to recycling plant.	No.
Pomona	Yes. Used as Renovate	No.	No.
USC	No. Bubblers Instead.	No.	No.
Occidental	One Area, but No.	No.	No.

School	Contact Name	Contact Information
LMU	Robert Haffen	310.338.2747
	Gerald Robinson	310.338.1944
Pepperdine	Rick Leach.	Rick.Leach@Pepperdine.edu 310.384.0875
Pomona	Ronald Nemo	909.621.8242
USC	Pix Verendia	wverendia@fms.usc.edu
Occidental		

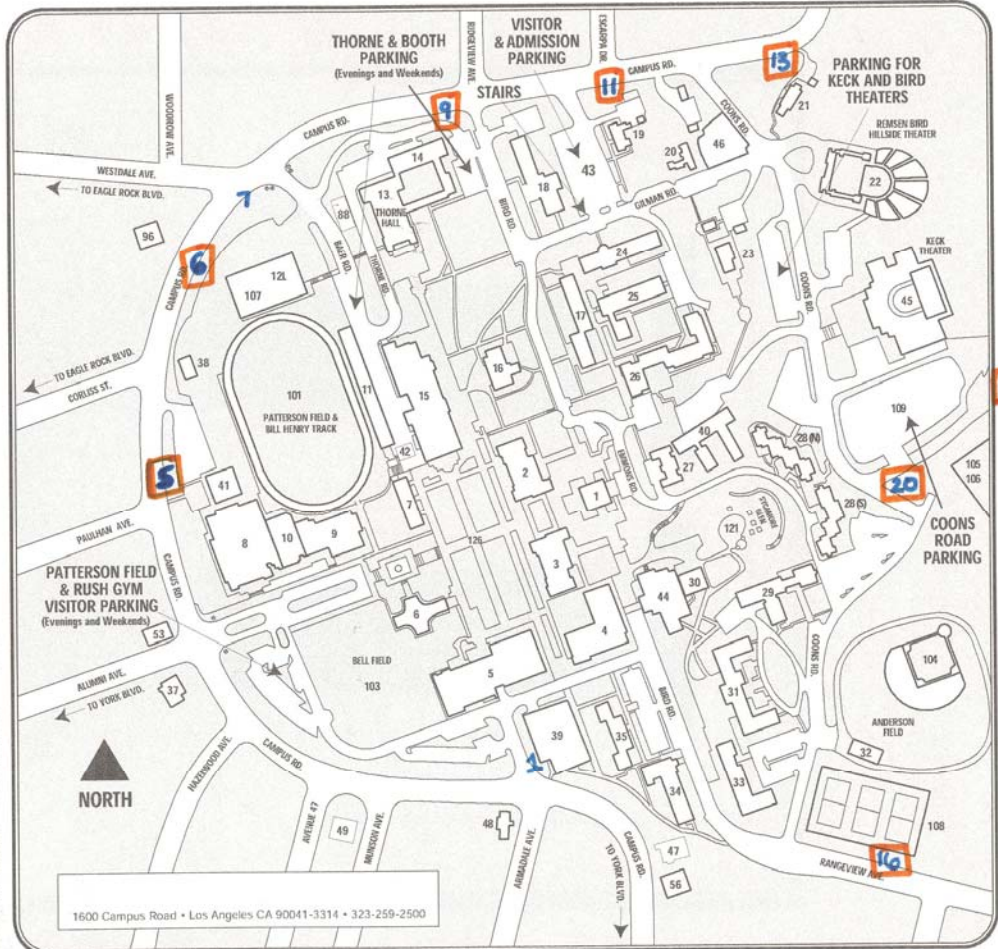
Appendix C: Layout of Occidental's Irrigation

Alumni Relations (1541 Campus Road)	49
Remsen Bird Hillside Theater	22
Campus Safety/Facilities Management (lower level)	12L
Central Chiller Plant	38
Central Quadrangle	126
Child Development Center (1824 Campus Road)	20
College Guest House (1480 Campus Road)	47
Collins House (Admission)	19
Coons Administration Center	1
Coons Road Parking Lot	109
Emmons Health and Counseling Center	27
Herrick Memorial Chapel/Interfaith Center	6
Intercultural Community Center (1501 Campus Road)	48
Institutional Research (11737 Campus Rd.)	96
Johnson Student Center and Freeman College Union	15
Keck Theater	45
Mullin Family Studio and Art Gallery	46
President's House (1852 Campus Road)	23
Samuelson Campus Pavilion	16
SideTrack Cafe and Snack Bar	42
Sycamore Glen	121
Thorne Hall	13
Visitor and Admission Parking	43
Women's Center (1599 Campus Road)	37
ACADEMIC FACILITIES	
Anthropology Office (11737 Campus Road)	96
Bioscience Building	44
Booth Music and Speech Center (Site of Bird Studio)	14
Mary Norton Clapp Library/Jeffer's Room	5
Fowler Hall	3
Hameetman Science Center	39
Johnson Hall/Alumni Auditorium	2
Moore Laboratory of Zoology	30
Norris Hall of Chemistry (Site of Mosher Lecture Hall)	4
Psychology Laboratory	38
Swan Hall	7
Urban and Environmental Policy Institute (1882 Campus Road)	21
Weingart Center for the Liberal Arts (Site of Weingart Art Gallery)	17
ATHLETIC FACILITIES	
Alumni Gymnasium	9
Anderson Field	104
Boil Field	103
Culley Athletic Facility	41
Patterson Field / Bill Henry Track	101
Patterson Stadium	11
Rush Gymnasium	8
Lower Soccer Field	105
Upper Soccer Field	106
Spencer Field House	32
Taylor Pool/Field Building	10
Tennis Courts (North—upper level)	107
Tennis Courts (South)	108
RESIDENCE HALLS	
Bell-Young Hall	34
Braun Hall	29
Chilcott Hall	25
Erdman Hall	24
Haines Hall	25
Newcomb Hall	18
Norris Hall North & South	28
Pauley Hall	33
Stearns Hall	40
Stewart-Cleland Hall	31
Women's Dormitory (1601 Campus Road)	53
Wylie Hall	35



— = Manual
— = Automatic/stand alone
— = Turf

Alumni Relations (1541 Campus Road)	49
Remsen Bird Hillside Theater	22
Campus Safety/Facilities Management (lower level)	12L
Central Chiller Plant	88
Central Quadrangle	126
Child Development Center (1824 Campus Road)	20
College Guest House (1480 Campus Road)	47
Collins House (Admission)	19
Coons Administration Center	109
Coons Road Parking Lot	27
Emmons Health and Counseling Center	6
Herrick Memorial Chapel/Interfaith Center	48
Intercultural Community Center (1501 Campus Road)	56
Institutional Research (1478 Campus Rd.)	15
Johnson Student Center and Freeman College Union	45
Keck Theater	46
Mullin Family Studio and Art Gallery	23
President's House (1852 Campus Road)	16
Samuelson Campus Pavilion	42
SideTrack Cafe and Snack Bar	121
Sycamore Glen	13
Thorne Hall	13
Visitor and Admission Parking	37
Women's Center (1599 Campus Road)	37
ACADEMIC FACILITIES	
Anthropology Office (1737 Campus Road)	96
Bioscience Building	44
Booth Music and Speech Center (Site of Bird Studio)	14
Mary Norton Clapp Library/Jefferis Room	5
Fowler Hall	3
Hameetman Science Center	39
Johnson Hall/Alumni Auditorium	2
Moore Laboratory of Zoology	30
Norris Hall of Chemistry (Site of Mosher Lecture Hall)	4
Psychology Laboratory	38
Swan Hall	7
Urban and Environmental Policy Institute (1892 Campus Road)	21
Weingart Center for the Liberal Arts (Site of Weingart Art Gallery)	17
ATHLETIC FACILITIES	
Alumni Gymnasium	9
Anderson Field	104
Bell Field	103
Culley Athletic Facility	41
Patterson Field/Bill Henry Track	101
Patterson Stadium	11
Rush Gymnasium	8
Lower Soccer Field	105
Upper Soccer Field	106
Spencer Field House	32
Taylor Pool/Field Building	10
Tennis Courts (North—upper level)	107
Tennis Courts (South)	108
RESIDENCE HALLS	
Bell-Young Hall	34
Braun Hall	29
Chilcatt Hall	25
Erdman Hall	24
Haines Hall	26
Newcomb Hall	18
Norris Hall North & South	28
Pauley Hall	33
Stearns Hall	40
Stewart-Cleland Hall	31
Women's Dormitory (1601 Campus Road)	53
Wylie Hall	35



— : Water Meters
 □ : Irrigation Only Water Meter

Appendix D:

The CIMIS Equation, One Way to Calculate an ET Rate

Copied From: <http://www.cimis.water.ca.gov/cimis/infoEtoCimisEquation.jsp>

The CIMIS Equation is a modified version of the Penman Equation by Pruitt and Dorrenbos (1977).

Variables:

- ea = Mean hourly vapor pressure (kPa)
- RH = Mean hourly relative humidity (%)
- Rn = Mean hourly net radiation (Wm^{-2})
- T = Mean hourly air temperature (Celsius)
- U = Mean hourly wind speed at 2 meters (ms^{-1})
- Z = Elevation of the station above mean sea level (m)

Steps:

Convert temperature from Celsius to Kelvin

$$T_k = T + 273.16$$

Saturation vapor pressure

$$es = 0.6108 * \exp(T * 17.27 / (T + 237.3))$$

VPD - Vapor pressure deficit

$$VPD = es - ea \text{ (kPa)}$$

DEL - Slope of the saturation vapor pressure vs. air temperature curve at the average hourly air temperature

$$DEL = (4099 * es) / (T + 237.3)^2$$

Barometric pressure

$$P = 101.3 - 0.0115 * Z + 5.44 * 10^{-7} * Z^2$$

GAM - Psychrometer constant ($kPa C^{-1}$)

$$GAM = 0.000646 (1 + 0.000946 * T) P$$

W - Weighting function

$$W = DEL / (DEL + GAM)$$

FU2 - Wind function

$$\text{For } R_n \leq 0 \text{ (nighttime)}$$
$$FU2 = 0.125 + 0.0439U$$

$$\text{For } R_n > 0 \text{ (daytime)}$$

$$FU2 = 0.030 + 0.0576U$$

NR - Convert Rn from Wm^{-2} to mm

$$NR = R_n / (694.5 (1 - 0.000946 * T))$$

Hourly ETo is approximately equal to RET

$$RET = W * NR + (1 - W) * VPD * FU2$$

Daily ETo equals the sum of 24 hours RET (mm)

**Appendix E:
Estimated Payback Period Calculations for Installing a Norchem Ultrapure System
in the New Residence Hall**

Number of Students Residing in Erdman: 80

Number of Students Projected to be Residing in the New Residence Hall: 237

month	Erdman:			New Residence Hall:			gals reclaimed/year*
	Erdman: gals/month	gals/day	gals/day/student	NewRes Hall: gals/day	gals reclaimed/day* (95 % of gals/day)	gals reclaimed/month*	
Jun-04	4000	133	1.6	393	373	11190	
Jul-04	11000	355	4.4	1051	998	30938	
Aug-04	12000	387	4.8	1138	1081	33511	
Sep-04	53000	1767	22.1	5238	4976	149280	gals reclaimed/year*
Oct-04	48000	1548	19.4	4574	4345	134695	1072049
Nov-04	52000	1677	21	4977	4728	141840	HCF reclaimed/year*
Dec-04	26000	839	10.5	2488	2364	73284	1433
Jan-05	29000	936	7.9	1872	1778	55118	
Feb-05	45000	1552	19.4	4598	4368	126672	
Mar-05	48000	1548	19.4	4574	4345	134695	
Apr-05	44000	1467	18.3	4337	4120	123600	
May-05	20000	654	8.2	1943	1846	57226	

*These amounts are actually smaller than shown; they include blackwater from the new residence hall. Blackwater cannot actually be processed by an Ultrapure System.

Number of HCF Reclaimed by the Ultrapure System per School Year: 1433*
(748 gals/HCF)

*This amount falls between the amount of water used by the 1882-UEPI Irrigation Water Meter, 2099 HCF, and the amount of water used by the Rangeview Irrigation Water Meter, 1130 HCF. Rather than being used for irrigating the landscaping of the new dorm, the reclaimed water could be used to partially irrigate Anderson field or one of the soccer fields.

Average Cost of HCF of Water: \$2.40

Savings from Using Reclaimed Water for Irrigation per year: \$3439

Cost of 5000 gallon Ultrapure System: \$25000 to \$30000

Payback Period: 9 years

Cost of Ultrapure System divided by Savings per year: \$30000 / \$3439

Additional Considerations:

1. The cost of the Ultrapure system does not include:

- A. The cost of the holding cistern for the graywater before it passes through the system
 - B. The cost of the pump needed to pressurize the water so that it can be pumped through an irrigation system.
- Estimated increase in payback period: 2 years.
2. In order to use an Ultrapure System, the plumbing for the new residence hall must be specially designed so that sewage from toilets is separated from that of sinks and showers. The architect for the new residence would have to be consulted to determine this cost.
 3. As residence halls are not used to full capacity for the entire year, the months of December, January, May, June, July and August could be problematic especially as May, June, July and August are months of heavy irrigation needs. An additional holding cistern would probably have to be built. This cistern would hold reclaimed water produced during times of full capacity for months when the hall is not in full use.
 4. The price of water is expected to rise over the next couple years, which would potentially decrease the payback period slightly.
 5. Storm water runoff from the roof of the new residence hall could be included in this system. This would increase the amount of reclaimed water produced by the Ultrapure System, but would also increase the initial cost of a reclaimed water system.
 6. A different system, such as Equaris Infinity, might cost less; the resources to determine this were not easily available.
 7. Installation of an Ultrapure System would decrease storage space in the new residence hall.
 8. Depreciation of an Ultrapure System over time is not considered in this analysis.