INTEGRATING UNICAMP WITH THE NATURAL ENVIRONMENT

Environment 180 | Senior Practicum
University of California, Los Angeles
June 2015

By: Emily Donnelly, Jalmeen Dhaliwal, Shalini Kannan, Kristina Kayatta, Sharline Kim, and Ethan Singer

Advisor: Dr. Michael McGuire

Client: Mr. Wally Wirick

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Last year's practicum report was designed to revitalize UniCamp's water system through a series of recommendations. First, it addressed the improper contact time citation that UniCamp received for water disinfection. They also recommended a new dosage valve, a prefilter system to protect the current bag filters, and a series of pilot projects including greywater and composting toilets. We were able to build off some of their suggestions for this year's practicum, such as analyzing data from river water monitoring and cabin water meters. We also expanded on some of the 2014 practicum team's findings, notably by reinvestigating solar energy options, which the previous team advised against installing at the camp.

The current bag filters are successful at removing any turbidity produced by the river and would be enhanced by the addition of the pre-filter bags recommended by last year's practicum team. The current water treatment system does not meet required disinfection contact time as the dissolved chlorine is in contact with the water for an insufficient amount of time to attain the desired 1-log reduction. The current 1-pipe system is responsible for the improper contact time, as it allows newly treated water to bypass the water storage tank and enter the camp distribution system directly. Last year's practicum report recommended a two-pipe system to address this problem. Unfortunately, UniCamp was unable to obtain a grant to fund the proposed solution and needed a cheaper, yet still effective, alternative. An ultraviolet disinfection system would not only meet, but exceed disinfection standards as it would provide a 3-log reduction of *Giardia* at a fraction of the cost of the previously recommended 2-pipe system. The UV lamp requires a constant flow of water, while the treatment system at Camp River Glen has a variable flow, controlled by an automated pump operating based on preset cistern water levels. A water recirculation system would need to be installed within the current system for the UV lamp to be viable solution.

Based on the 2014 summer sampling data, it was found that UniCamp is having no adverse effects on the nearby Santa Ana River. Despite the unknown fate of kitchen and washer water, for now, the camp poses no measurable anthropogenic impact on the river.

At UniCamp, wastewater must be pumped out of the underground storage tanks and hauled away by a truck daily while camp is in session. By diverting greywater to an on-site irrigation field, costs and risks associated with wastewater handling can be reduced. Currently, the amount of greywater produced is low. With potential changes in water usage associated with hot water introduction into the cabins, there could be an increase of more than 10 times the current amount of greywater. The payback periods for two greywater irrigation systems, self-installation and professional installation, were investigated for both the current amount of greywater and projected amount of greywater. Though greywater system installation based on the current water usage has a longer payback period, the payback for the projected greywater amount is shorter, both for professional and self installed systems. Based on these findings, UniCamp should consider a greywater irrigation system to accommodate potential increases in greywater. In the case of increased greywater, UniCamp should consider both self-installed and professionally installed greywater irrigation systems.

In order to encourage sustainable water use, changing the current kitchen practices was investigated. Specifically, it is suggested that UniCamp kitchen personnel thaw meat in a refrigerator, as opposed to the current method of running water over the meat for several hours.

In terms of renewable energy, decentralized solar thermal heating of cabin water was considered, but found to pose too many challenges for implementation at Camp River Glen. Issues of rooftop strength, temporal variability in heating, and high costs make these systems infeasible. However, solar thermal water heating could be considered if centralized showers are utilized instead of individual cabin showers. Photovoltaic (PV) panels were also considered as an option for heating water in the cabins. Issues with rooftop weight, shading around the cabins, potential for theft, and cost make the system infeasible. Cycle power was considered as an innovative form of renewable energy that could be used to create hot water for showers. We found that creating hot water is too energy intensive, and it would take thirty-eight kids pedalling at a time to create the needed hot water. Thus, using cycle power to heat the showers is not recommended. However, research into specific products led us to discover that bike-powered blenders would be an innovative education technique. Thus, we do recommend that the client pursue cycle power as an educational tool.

To reduce the solid food waste disposed by the camp, we looked into various forms of composting that would be appropriate for the camp setting. The greatest stumbling block in this area is a serious safety concern - bears in the area are likely to be attracted to the smell of decaying food. There are composting options that alleviate this risk: small indoor vermiculture (worm) composting, diversion of food waste to local composting facilities, and constructing a bear-proof concrete composter with aluminum vents and lid.

Currently, UniCamp has a specific week focused on environmental science, but Mr. Wally Wirick, the camp director, hopes to incorporate an environmental curriculum into every session of camp. The practicum team produced a series of deliverables that can be implemented into weekly camp sessions. First is an activity book, which contains a variety of interactive exercises and experiments that can be incorporated into UniCamp's rotational programming, specifically for an environmental science rotation. Next, our team created green challenges and a water saving pledge to stimulate an environmental consciousness among campers. We also created signs to be posted around camp, reminding campers and counselors to act in an environmentally friendly way. Our goal for the environmental curriculum is for the deliverables to be integrated into a typical camp session in order to educate and inspire everyone at UniCamp to be environmental stewards, both at camp and at home.

Improvement Area	Recommendations
Water	
Disinfection	❑ Install UV disinfection system in line with current treatment system. ❑ Install water recirculation system in tandem with the UV lamp. ❑ Replace chlorine dosage valve with Accu-Tab valve ❑ Install pre-filter bags recommended by last year's practicum team.
River Impacts	❑ Re-sample river every other year to detect possible changes in the camp's impact on water quality, adding chloride as a parameter.
Greywater	❑ Install a pilot greywater irrigation system. ❑ Measure actual flow rates of water fixtures to refine analysis. ❑ Mandate use of eco-friendly products in all cabins with greywater irrigation systems. ❑ After installation, assess irrigation field operation to determine if it can accommodate the increase in water.
Kitchen Efficiency	❑ Defrost meats in the refrigerator to conserve water.
Energy	
Solar	❑ If showering is made a priority, conduct feasibility study on centralized, solar-thermal heated showers.
Bicycle	❑ Consider purchase of cycle power equipment for educational purposes.
Solid Waste	
Composting	❑ Small indoor vermiculture composting at camp, diversion of food waste to nearby composting facility.
Education	
Curriculum	❑ Implement deliverables into weekly curriculum.

INTRODUCTION

UCLA UniCamp is a wilderness retreat that brings together underserved youth of Los Angeles County and UCLA student volunteers in a nurturing camp environment. The camp resides along a small stretch of river in the San Bernardino National Forest at a site called Camp River Glen. Breezes flow through rustic cabins without windows or electricity. Steps away, a cistern collects water from the river to supply the camp. A clearing in the pine needle floor marks the outdoor eating area. The small site stands in stark contrast to the home of its attendees: the metropolis of Los Angeles. Each summer, the camp hosts about 1,100 children from low-income families, 500 volunteers, and, a few permanent staff members. UniCamp is a nonprofit 501.c3 organization, and UCLA's official student-run charity. For 80 years, UniCamp has endeavored to function in harmony with its forest environment, using its natural resources sustainably, while acting as a good steward of the land.

UniCamp seeks to become better integrated with the environment that hosts it. In 2013 UniCamp proposed this transition as a project to the UCLA Environmental Science Senior Practicum class. This proposal was partially sparked by recent attention to a water disinfection regulation, which required system upgrades to address citations from San Bernardino County. The practicum group of 2013-2014 investigated ways to address this citation and looked for other opportunities to make the camp more environmentally friendly. They also recommended data collection from various sectors of the camp to evaluate potential environmental impacts.

With the foundation of the 2013-2014 practicum report and the resulting data collected from UniCamp, our project group investigated sustainable technologies in the areas of water, energy, and waste as well as practices that would lessen the environmental impact of the camp. Another challenge UniCamp faces this year is the possibility that the camp will need to provide hot water for handwashing and showers as a health requirement. Additionally, we put a large focus on developing a program to instill in campers an understanding and appreciation of the environment and sustainability. Our recommendations and educational materials are designed to improve the camp's exchange of materials and energy with its environment, but also to fuel a passion for conservation and environmental science in the children long after they leave the wilderness and counselors of their week-long camp home.

SUMMARY OF 2014 PRACTICUM REPORT

With the mission of better managing UniCamp's water and wastewater through new infrastructure, technology, and education, last year's UniCamp practicum team formed a number of suggestions for improving Camp River Glen's sustainability. The main focus of their report was water quality and treatment, alternative energy, and sustainable water management. In order to develop a reliable and safe drinking water system for UniCamp, they analyzed the current transient non-community water system, which consists of chlorine disinfection and bag filtration. Their recommendations were largely guided by the need to address a 2012 citation issued by the San Bernardino County Department of Public Health for inadequate disinfectant contact time for eliminating waterborne pathogens. As a solution to this, the 2014 practicum group consulted with Hazen and Sawyer to design a new two-pipe system to lengthen contact time. One pipe would connect the water treatment system to the holding tank, and the second would connect the holding tank to the camp. UniCamp would be responsible for paying for this expensive system, and at the time of last year's report, had applied for a state grant to finance the project.

Last year's group also addressed a problem with an unreliable valve that controls the amount of chlorine applied for disinfection. As a solution, they recommended replacing the dosage valve with one that does not periodically open.

In addition, the installation of a pre-filter directly in line with the current bag filters was recommended. This is to prevent the filtration system from clogging in the event of a storm, which causes an increase in debris. The practicum team also advised that UniCamp use the EPA approved DPD Colorimetric method to measure free chlorine residual. The team recommended that UniCamp analyze both daily effluent turbidity and chlorine residual direct downstream from the filters.

The previous group considered possible solar systems for the camp: mainly photovoltaic panels. They decided that implementing a solar system would not be viable due to potential damage from snow, the seasonality of camp power usage, and the risk of theft. The previous team looked into micro hydropower systems and made recommendations as well. Specifically, they advised against using a run-of-the river system, because it would lead to severely limited electricity production. They found that it was a poor investment because of security issues at Camp River Glen. An in-pipe turbine system was also not advised because it would be too costly.

Additionally, they recommended installing a pilot greywater irrigation system for the camp director's cabin, as this cabin was determined to have the greatest water use. The system would irrigate the wild plants already existing on site. They also suggested that the camp mandate the use of non-toxic, natural, biodegradable soap, shampoo, and detergent to minimize ecological impacts of a greywater system. The group examined steps necessary for county approval such as sending a Forest Service letter and manual to County Land Use Services to obtain a construction permit. They also looked into composting toilets. However, Mr. Wirick recommended we not examine them further due to their high cost.

For behavioral and operational water conservation, the previous group suggested reusable water bottles, changes in hygiene habits, routine leak detection, and an alternative meat defrosting method. A few of the group's recommendations for an environmental education program at camp include having campers make water conservation films and miniature filtration systems.

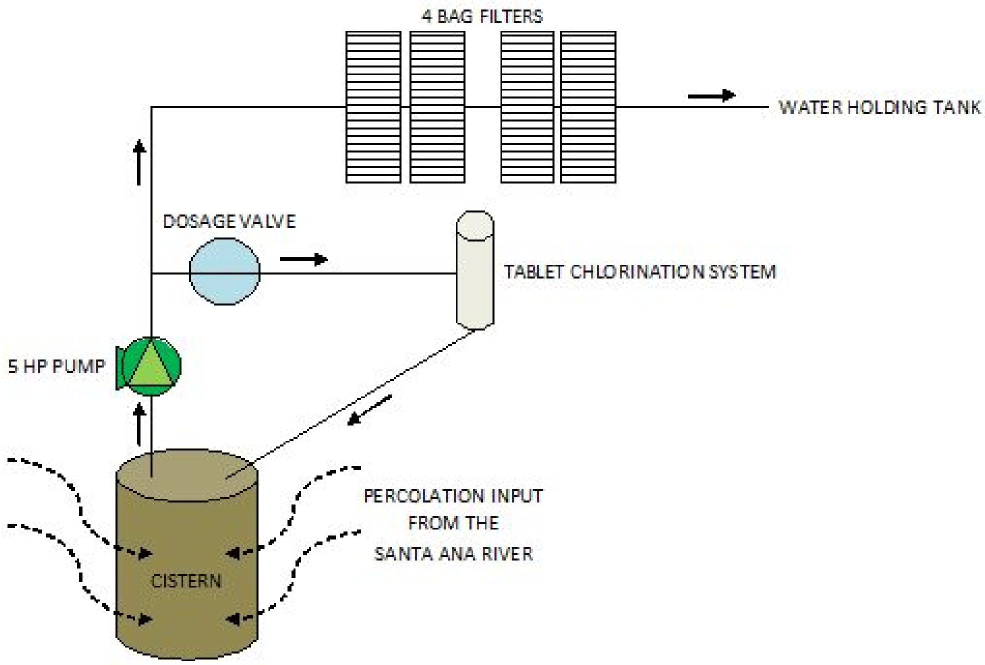
WATER

WATER DISINFECTION

UniCamp's current water system operates only during the summer season and is fed by an upper tributary of the Santa Ana River. A 12-foot deep and 3-foot diameter enclosed cistern pulls water from the river and diverts it to a chlorine disinfection and bag filtration system to serve Camp River Glen. As the water is not directly removed from the river but percolates through the ground into the cistern, the water source is considered groundwater under the direct influence of surface water.

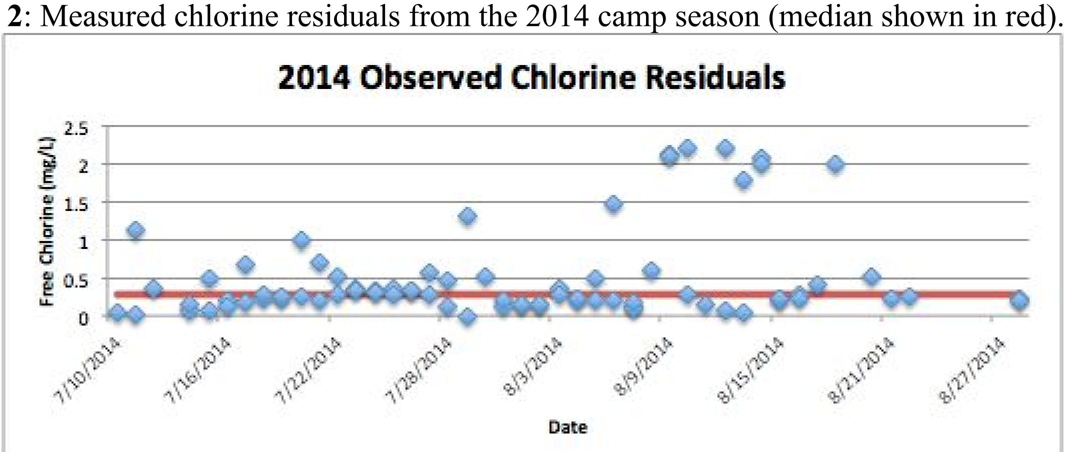
Water production from the cistern is controlled by an automatic pump that delivers river water to the treatment system when the holding level reaches a maximum and shuts off once a the minimum level is reached. The water is sent to a calcium hypochlorite chlorinator and back to the cistern, as shown in Figure 1. A dosage valve along the pipe between the cistern and the disinfection system controls the flow of water through the chlorinator, increasing the flow increases the amount of chlorine dissolved.

Figure 1: Diagram of current water disinfection system.



The system utilizes solid calcium hypochlorite tablets, "hockey pucks" about 3 inches in diameter, manufactured by Accutab. The tablet feeder is made from PVC pipe and allows water to flow across and dissolve the bottom tablet, delivering chlorine to the remainder of the system. While the chlorinator is set to maintain a chlorine residual of 1 mg/L in the cistern to achieve adequate disinfection, residual data collected during 2014, graphed in Figure 2 below, shows that the median chlorine residual after the bag filters was 0.27 mg/L. This residual is inadequate for disinfection.

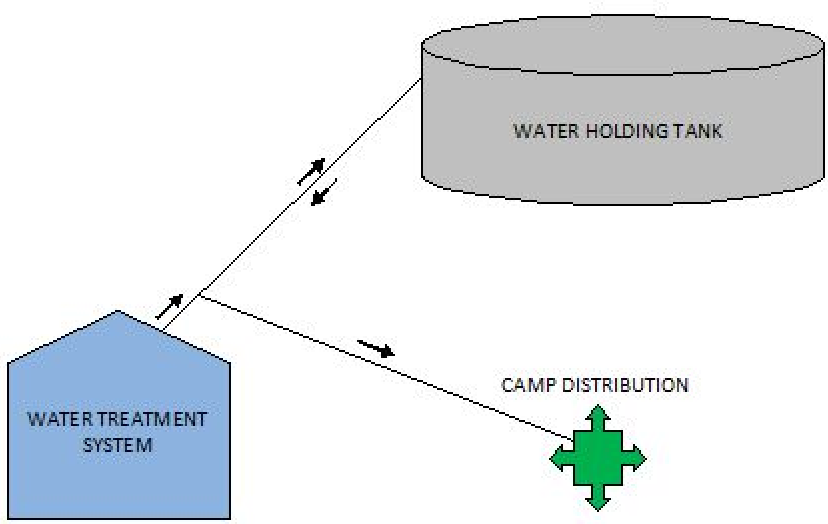
Figure 2: Measured chlorine residuals from the 2014 camp season (median shown in red).



Once the water has gone through the chlorination loop, it flows through a series of bag filters for particulate and pathogen removal. UniCamp utilizes a Rosedale stainless steel bag filtration system consisting of 2 fine filters and 2 *Giardia* reduction bags, ridding the water of pathogens and turbidity through size exclusion. Two of the main pathogens regulated by the Surface Water Treatment Rule are *Cryptosporidium* and *Giardia*. When operating at optimal levels, the current filtration system has removal credits of 0-log viruses, 1-log *Cryptosporidium*, and 2-log *Giardia*. Unfortunately, the filtration process results in the accumulation of particulates and biological growth on the bag filters, which require replacement after a certain extent of fouling. Last year's team recommended the installation of the NCO pre-filter bag, which costs about $8 per replacement, as an inexpensive solution to the fouling of the main filtration system, which costs $200-$300 each to replace. We support this recommendation as it would benefit the current bag-filters and proposed UV-treatment system.

Figure 3 shows the current single-pipe system in use at Camp River Glen. After water passes through the chlorination and filtration systems housed in a shed adjacent the river, it is propelled via the 5-horsepower pump through a 4-inch pipe to a 32,000 gallon drinking water storage tank. The tank is located uphill of Camp River Glen, 2,100 feet from the shed. This current system allows water from the storage tank as well as recently treated water from the disinfection system to flow into the main pipe that delivers water to camp. The average flow rate, the volume of fluid that passes through a given surface per unit time, was determined to be 35 gallons per minute (gpm) from a flow meter in the treatment shed.

Figure 3: Diagram of current single pipe water system.



Inadequate Contact Time

On August 15, 2012, the San Bernardino County Environmental Health Services Department cited UniCamp's water disinfection system for a failure to meet the minimum disinfectant contact time required to inactivate waterborne pathogens. As mentioned previously, a single pipe transports water from the treatment system to the holding tank and back. A secondary pipe branches off near the treatment shed and goes directly into camp. This one-pipe system allows both properly treated water from the holding tank and freshly treated water direct from the treatment shed to enter the distribution system. Therefore, the newly treated water has inadequate contact time for the chlorine to properly inactivate waterborne pathogens.

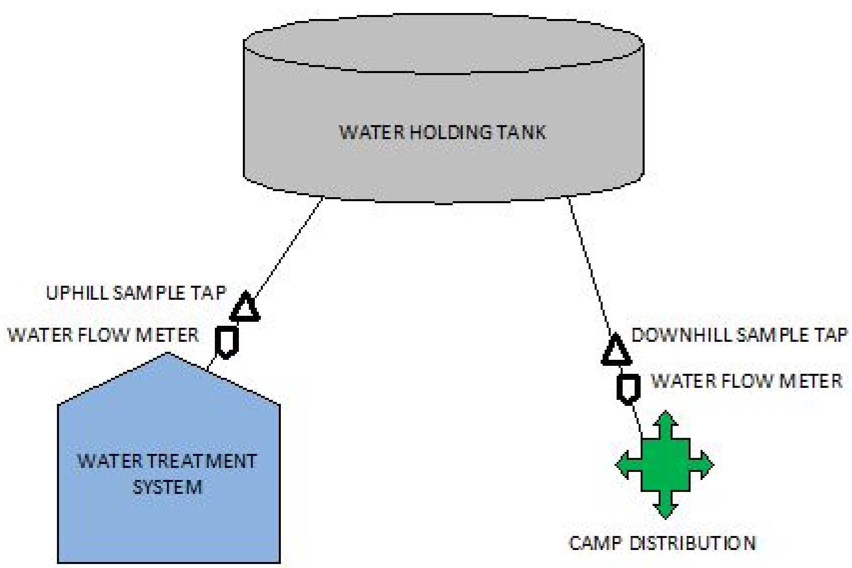
The Surface Water Treatment Rule states that UniCamp's disinfection system must achieve a minimum of 3-log reduction (99.9%) of *Giardia*. The combined bag filters remove 2-log *Giardia*, therefore the calcium hypochlorite tablets must meet the remaining reduction with an additional 1-log. In order to achieve this level of *Giardia* reduction, the chlorination system must meet a minimum contact time (CT).

Two-Pipe Solution

In looking for a solution to the inadequate contact time, UniCamp collaborated with engineers from Hazen and Sawyer to design a new system which would utilize two pipes, one that pumped the water up to the holding tank, and the second to draw it from the tank back to the camp distribution system, shown in Figure 4

. Passing water through the holding tank before its delivery to camp would ensure the required contact time for disinfection is met. The two-pipe system would utilize 4-inch diameter, high-density polyethylene (HDPE) pipes that attach to the bottom of bridge at the entrance of camp and run underground, following a paved road, to the holding tank. The current pipe would be abandoned and left underground to reduce the cost and environmental disturbance of removal.

Figure 4: Diagram of proposed two-pipe system.

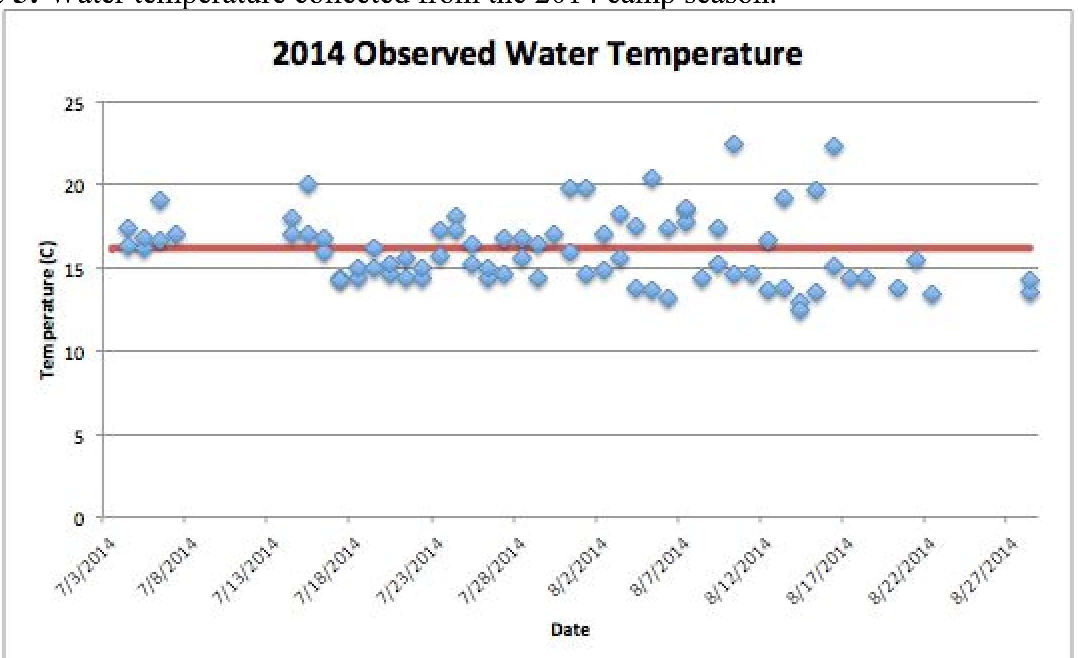


The proposed two-pipe system was estimated to cost around $150,000, an expenditure UniCamp hoped to alleviate by applying for a grant supported by state revolving funds. When contacted, the Senior Water Resource Control Engineer for the State Water Resources Control Board, Kyle Ochenduszko, replied that UCLA UniCamp (Water System No. 3600772) is a nonprofit and is not a community water system, nor a public school. Current policy dictates that non-profit, non-community water systems are not eligible for grants, and are only eligible for low interest loans. Because UniCamp was unable to obtain the grant and their primary objective is to use their own funds to send kids to camp, the client is looking for an alternative solution.

Empirical Contact Time for Two-Pipe Solution

Last year's practicum report calculated CT for the proposed two-pipe system with assumptions of parameters, such as minimum chlorine residual, river water temperature, and river pH. Temperature and residual data were collected in the 2014 camp season, so that CT could be calculated once again with the empirical data values. Figures 2 above and 5 below respectively show chlorine residual and temperature data collected, from which we estimated an average temperature and median free chlorine residual (shown in the figures as red lines) for use in calculating a more realistic CT. While mean value was appropriate for temperature, we utilize the median chlorine residuals due to a number of outlier values. Values of pH were consistently reported as 7.

Figure 5: Water temperature collected from the 2014 camp season.



Additionally, chlorine residuals were measured at a few locations around camp one day in August of 2014. Data collected at the kitchen sink, Alpine biffy, and Unit 15 cabin showed residual values of 0.31, 0.22, and 0.29 mg/L, respectively.This is a good sign, as residual values seem to remain around the same as the median value of 0.27 mg/L by the treatment system, signalling that chlorine remains in contact with the water throughout the distribution system.

Based on the above data, more accurate calculations of CT can be done. Known and assumed parameters from the 2014 report and for this report are below in Table 1, with the altered values bolded.

Table 1: Known & assumed parameters from 2014 Report and for this report.

Parameter	2014 Value	2015 Value	Units
Linear length of pipe	2,100	2,100	feet
Diameter of pipe	4	4	inches
Peak flow	20	**35**	gpm
Max volume of water in tank	32,000	32,000	gallons
Minimum chlorine residual concentration	1.0	**0.27** (median of 2014 recorded data)	mg/L
Holding tank fullness at peak flow	50	50	%
Minimum river water temperature	5	**16.1** (average of 2014 recorded data)	
Maximum pH	8.0	7 (average of 2014 recorded data)	pH units
Baffling factor (BF) for tank	0.3	0.3	-
BF for pipes	1.0	1.0	-

Determining CT_{req}

Based on the pH and temperature of the river water and the 1-log giardia inactivation required by chlorination in Camp River Glen's disinfection system, the required CT (CT_{req}) is 23 mg-min/L (See Appendix B). Tables for 15ºC were used because this temperature is close but still colder (resulting in a more conservative calculation) than our actual average temperature of 16.1ºC. Chlorine concentration was rounded up to 0.4 mg/L because the tables do not show concentrations below this. It is important that this chlorine residual level is increased for proper disinfection.

Calculating CT_{act}

CT was calculated using the following formula:

CT = concentration x contact time, where

C = concentration

T = contact time = theoretical detention time (TDT) x baffling factor (BF)

TDT = Volume/ Peak Flow

First, contact time is calculated for the two pipes and the water tank, in the same manner as last year's report. The result is a total of 215 minutes: 39 minutes for each pipe and 137 minutes for the holding tank. To calculate CT, this time is multiplied by the median chlorine residual of 0.27 mg/L. Thus, CT_{act} is 58.2 mg-min/L.

For CT to be sufficient, CT_{act}/CT_{req} must be larger than 1. In this case, $CT_{act}/CT_{req} = 2.5$, which validates that the two-pipe system would meet disinfection requirements. The calculated ratio allows a safety factor of 2.5. In order for this level of disinfection to be maintained, the chlorine residual cannot drop below 0.27 mg/L, and should be increased. The valve adjusting flow through the calcium hypochlorite tablet feeder will need to be adjusted to ensure that this residual concentration or higher is maintained. Replacing the current gate valve with a new

Accu-tab valve should maintain a reliable dosage. If this valve vibrates open as the original Accu-tab valve did the camp should consult the Accu-Tab system manufacturers.

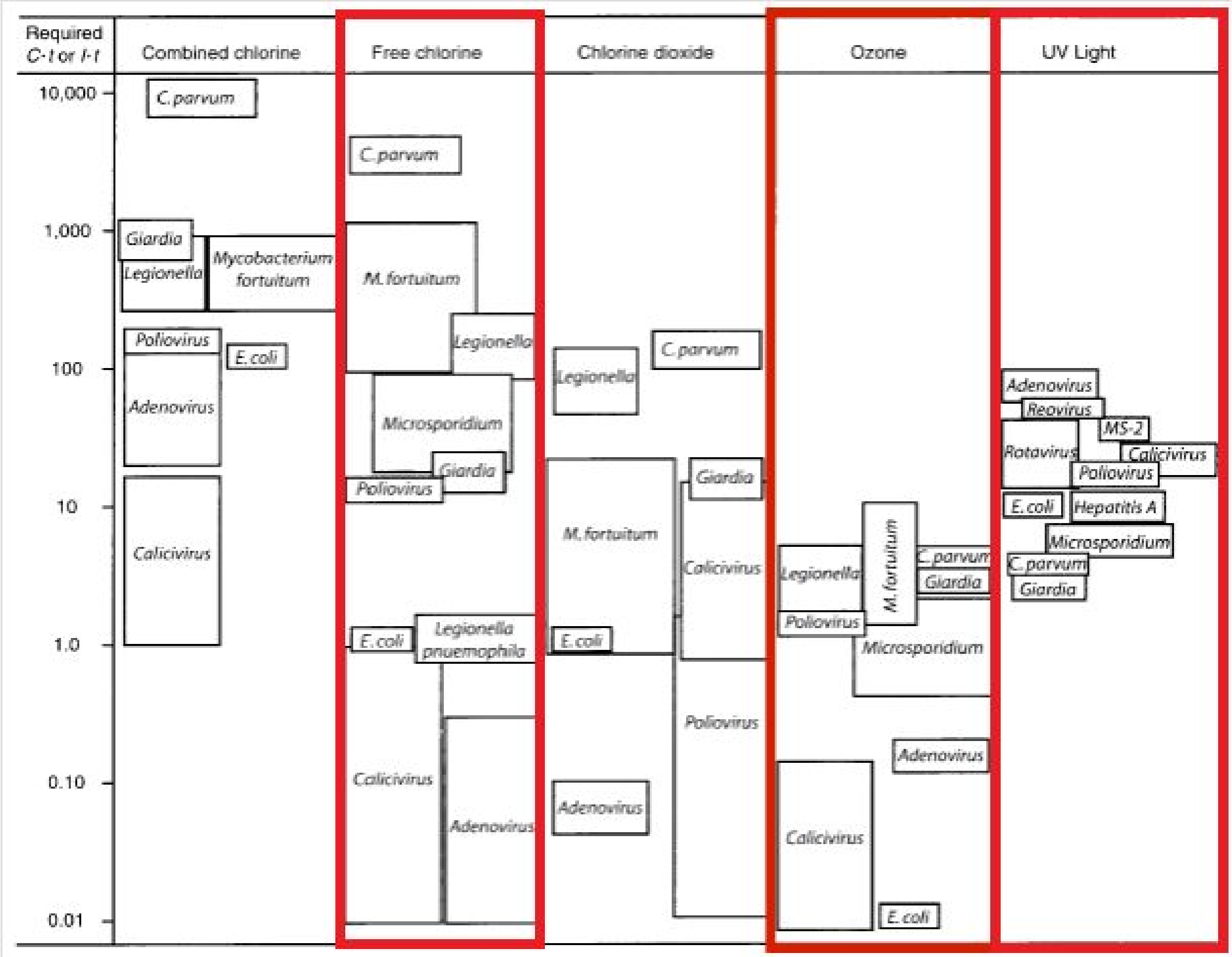
Alternative Solutions

The current disinfection system's bag filters remove 2-log Giardia, and the County of San Bernardino requires an additional 1-log reduction for proper treatment. Therefore, a primary disinfection system, alternative to the two-pipe system, can be engineered to meet the County's requirements, while continuing to utilize the chlorine tablets as secondary treatment and distribution residual. An alternate disinfection protocol would meet the County requirements before the water left the treatment structure, regardless of its contact time with the chlorine and holding tank.

Concern over the low and inconsistent chlorine residual (see Figure 2) even in a two-pipe system led us to investigate alternative methods of dosing chlorine. Large and small scale water treatment systems, while often chlorine based, can vary in chemistry and design. We explored three alternative disinfection systems: chlorine gas, ozone gas, and ultraviolet light (UV), in an attempt to comply with the EPA requirements of the County citation. As shown in Figure 6, all three systems are capable of a 23 mg-min/L required CT, with the proper contact time and disinfectant residual/dose.

While many varieties of effective water treatment systems exist, not all are properly suited for the rustic nature of Camp River Glen. A chlorine gas injection system utilizes chlorine as a strong oxidizing agent, disintegrating the lipids that compose the cell wall of organic molecules, rendering microorganisms nonfunctional. Unfortunately, a chlorine gas system would not be ideal as it requires pressurized tanks of chlorine gas to be stored on-site. If inhaled, the pressurized gas can irritate the respiratory system, resulting in difficulty of breathing, increased heartbeat, chest pains, and even death. Similarly, an ozone disinfection system kills bacteria by destroying the cell wall. However, ozone is a highly unstable gas that cannot be stored and must be generated on-site. Also, many ozone generation and injection systems are too large, require contact tanks, and exceed the power capabilities of Camp River Glen.

Figure 6: Diagram of the required contact time for inactivating common pathogens and viruses through multiple processes (Crittenden et al. 2012).



UV DISINFECTION

While the chlorine gas, ozone, and current calcium hypochlorite systems all rely on the injection of chemicals into the water for proper disinfection, there is no direct chemical contact associated with ultraviolet light (UV) disinfection. UV light consists of wavelengths just beyond that of the visible spectrum, and has an effective germicidal range between 200 and 300 nm. While chlorine and ozone systems are directly toxic to pathogens, UV light damages bonds in the DNA responsible for replication of targeted microorganisms, effectively inactivating the organism. The photon based principle of a UV lamp system may not produce any harmful disinfection by-products typically associated with chemical based treatments. However, a lack of residual and residence time require another measure of disinfection effectiveness.

As there is no direct chemical interaction, UV systems are limited by three important factors: turbidity, residual, and lamp preservation. The point source nature of UV light disinfection systems does not allow the same selectivity as other chemical treatments, as the incompletely treated water passes through the lamp irradiation only once, and turbidity and other substances in the water can interfere and absorb the UV light meant for pathogens. Additionally, turbidity presents a fouling issue and the UV bulbs must be cleaned regularly. Currently at

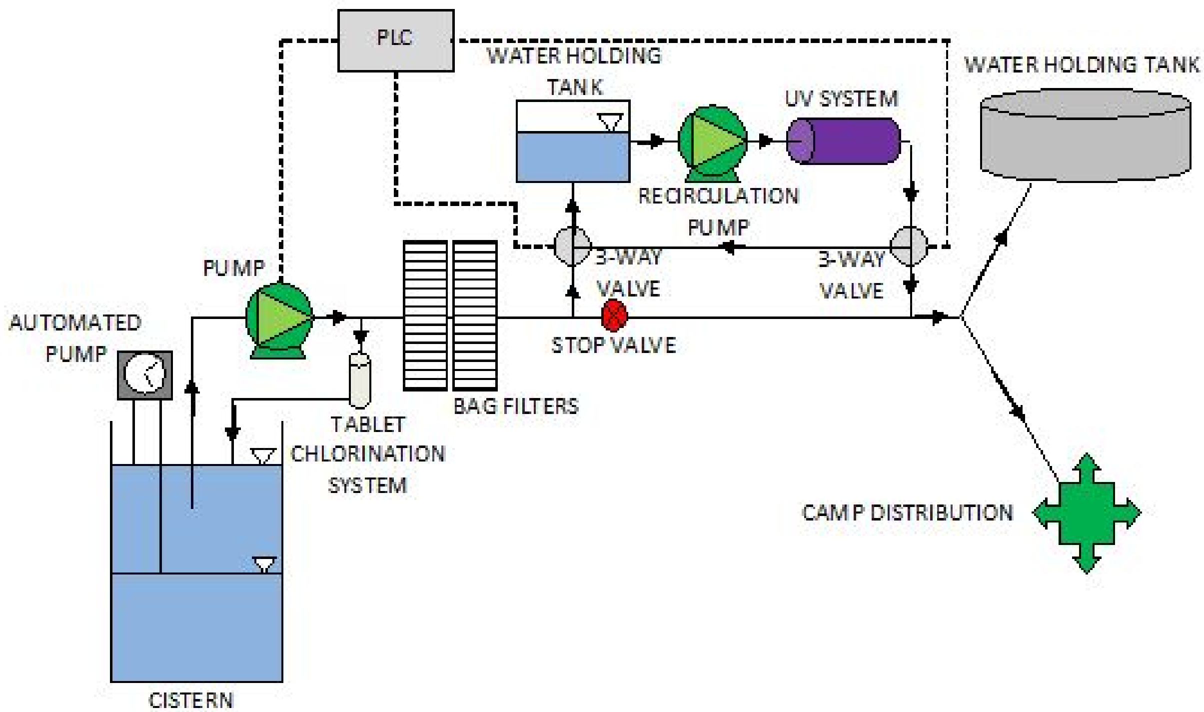
UniCamp, turbidity is lower than is detectable, except in the case of a storm or the tank emptying, as noted in the records shown in Appendix C. While UV light does effectively inactivate unwanted organisms by inhibiting the ability of their DNA to undergo replication, a residual disinfection method is necessary to ensure the complete and lasting pathogen destruction within the distribution system. Lastly, UV lamps are prone to overheating and require a constant flow of water at all times. Most UV bulbs experience a 60% UV light output reduction after one year of continuous use and require . Turning the system on and off further reduces the lifetime. To ensure proper and complete irradiance, UV lamps (around $100 per bulb) must be wiped clean on a monthly basis using lint-free cloth soaked in isopropyl alcohol and must be replaced at the end of their lifetime of typically one year.

Regardless of some inherent drawbacks, a UV light treatment system has the potential for efficacy when working in tandem with the current chlorine disinfection system at Camp River Glen. In order to address the problem of turbidity, the UV system must be placed at the end of the current treatment process. The series of Rosedale filter bags effectively rid the water of any unwanted turbidity and allow for constant and even UV light emission with minimum fouling of all treatment components. Although UV treatment is capable of a 3-log reduction of pathogens, a residual is still necessary to ensure lasting disinfection. The current calcium hypochlorite tablets would no longer be responsible for a complete 1-log reduction, alleviating the contact time requirement. Instead, chlorine would only serve as a residual within the distribution system.

A major drawback of the UV treatment system is its reliance on a constant flow of water. The cistern at Camp River Glen automatically draws in and pumps out water at when it reaches minimum and maximum levels, therefore the current disinfection system can be dry for hours at a time. In order to alleviate this problem, the UV system will need a series of pipes constantly recirculating water over the bulb, regardless of the variable cistern levels. As seen in Figure 7, the recirculation system is the last treatment step, installed after the filter bags, and utilizes a series of 3 way valves and a reservoir of water within a secondary loop of constant flow. The current stretch of pipe delivering water from the filter bags to the main holding tank and camp will need to be closed off in order to first direct water through the UV recirculation loop. During times of no flow, a reservoir at the beginning of the loop will ensure sufficient water levels for constant circulation. Flow from the reservoir will be drawn by a pump to match the current average water flow of 35 gpm. After flowing over the UV lamp, the circulating water will then pass through a series of three way valves, actuated by a program logic controller (PLC), a digital computer that would automate the electromechanical operational processes of the variable valves. Finally, the water will remain in the UV recirculation loop until the cistern resumes pumping and the water is directed to the main holding tank and camp.

Figure 7: Potential disinfection system with added UV disinfection and water recirculation

system.



While the recirculation and PLC system should be custom engineered to fit the current water treatment infrastructure, UV disinfection systems are manufactured to handle standardized flow rates and vary in complexity with regard to automated maintenance. Most systems are comprised of an inlet for water, a housing sleeve for the germicidal lamp, usually made of quartz, an outlet, and an operational monitor. Rick Wagner of Applied Membranes, Inc. recommended a NeoTech D222 Ultraviolet system, designed for flow rates varying from 1 gpm to 60 gpm. The inlet chamber series meets or exceeds FDA and other regulatory requirements and the relatively small size, 23.6" x 8.2" x 6.3", allows easy installation within the current treatment shed. Unlike larger gas-injection treatments, the UV system requires only 120 Volts of electricity and can be powered by a standard wall outlet. The NeoTech system utilizes UV lamps with a 9000 hour life-span and operating temperature range between 36 and 104 . The manufactured system does allow for a standby time (without flow) of 60 minutes, but the current cistern pump is off for longer than 60 minutes; therefore, a recirculation system is necessary. The NeoTech D222 Ultraviolet system can be purchased for around $10,000 while other systems range between $5,000 and $15,000, depending on the complexity of automated cleaning and maintenance, a fraction of the $150,000 cost of the two-pipe solution.

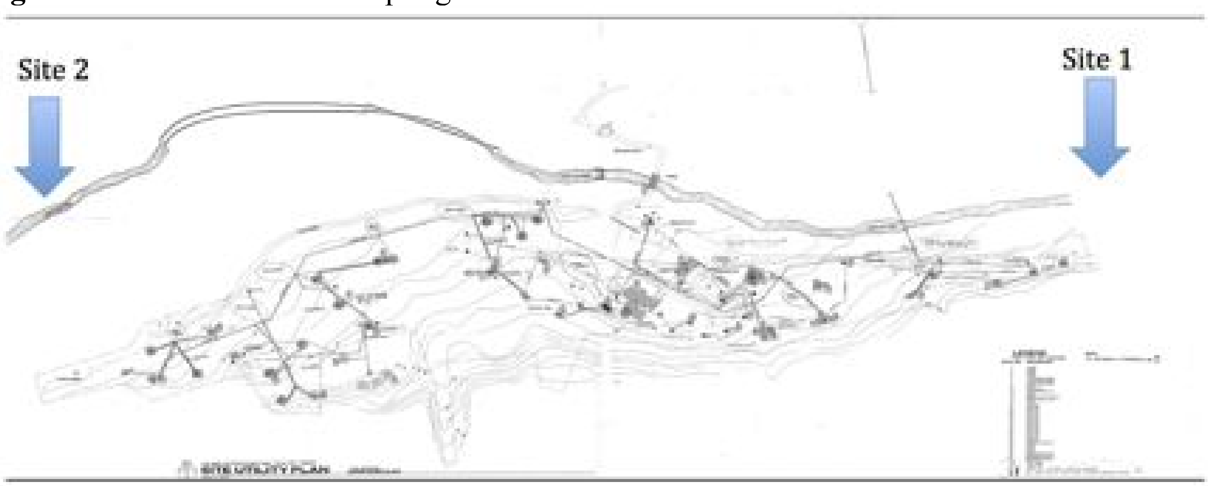
Recommendations

In order to alleviate the current improper contact time citation by San Bernardino County, we recommend the installation of a UV light water disinfection system. To ensure the efficacy of the UV lamp, a water recirculation system, automated by a PLC, would also need to be installed. Both the UV lamp and current bag-filters are prone to fouling and would benefit from the installation of the pre-filter bags recommended by last year's practicum team.

IMPACTS ON SANTA ANA RIVER

Camp River Glen is adjacent the Santa Ana River, therefore it is important to measure the camp's potential impacts on the river. The Camp's wastewater is piped to 11 underground sewage holding tanks at the west end of the site. Five of these tanks were previously connected to leach fields, but were sealed off when the water table was deemed too high to allow leaching. Mr. Wirick suspected that the sealing process may have been insufficient, but the tanks' underground location makes it extremely difficult to detect potential leaks. Additionally, the fate and transport of wastewater from the kitchen and washing machine are unknown; these hold potential for contaminating the river as well. Last year, monthly sampling of the Santa Ana River above and below the camp was recommended during the summer to ensure that UniCamp was not causing negative impacts on the river. Due to resource restrictions and lack of necessity, sampling was instead done just two times last summer, in two locations each time, depicted below in Figure 8**.** **Site 1** is located above the camp and **Site 2** is below, potentially under influence of the camp. Sampling was carried out by Arrowhead Consulting and samples were lab tested by E.S. Babcock & Sons. Parameters tested included indicators of detergents that could stem from kitchen wastewater (sodium, MBAS, phosphate, boron), and indicators of sewage leakage (nitrate, specific conductance, E. coli, total coliform, total organic carbon). Total phosphorus and pH were also measured.

Figure 8: Santa Ana River sampling scheme used in 2014.



2014 Data Analysis:

Table 2 below shows sampling results from last year, categorized by type of indicator. Those in blue might indicate detergents from the kitchen or washer. Orange parameters indicate sewage, and those in grey have broader significance.

Many indicators were found at non-detectable (ND) levels, either above or below camp, which means they are of no concern to Camp River Glen at the moment. Other parameters were found in varying levels at Site 1 and Site 2, requiring further analysis to understand whether there were any indications of camp having adverse impacts on the natural environment. Figures 9 and 10 below show sampling results comparing river water quality above and below the camp.

Table 2: 2014 Santa Ana River Sampling Results

Sampling Parameters	8/7/14		9/9/14	
	Site 1	Site 2	Site 1	Site 2
Boron (ug/L)	ND	ND	ND	ND
MBAS (mg/L)	ND	ND	ND	ND
Sodium (mg/L)	8	8.4	8	8.5
Total P as PO4 (mg/L)	ND	ND	ND	ND
Total Organic Carbon (mg/L)	0.9	0.7	3.1	0.99
E. Coli (MPN/100mL)	2	13	14	17
Total Coliform (MPN/100mL)	900	500	170	130
Fecal Coliform (MPN/ 100mL)	30	30	80	50
Nitrate (mg/L)	ND	ND	ND	ND
Specific Conductance (umhos/cm)	150	170	160	170
pH (pH Units)	7.8	9	7.5	7.8

Figure 9: August 2014 sampling outcomes above (Site 1) and below (Site 2) UniCamp.

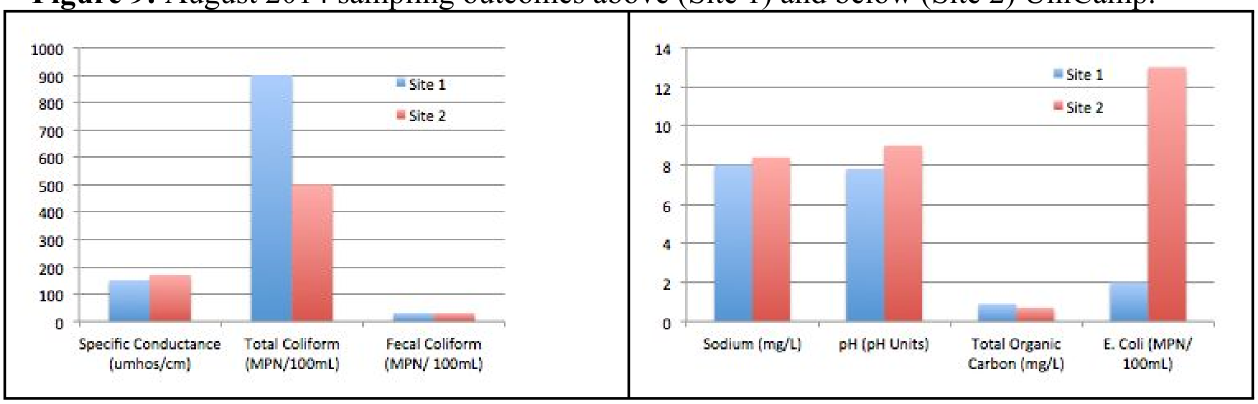
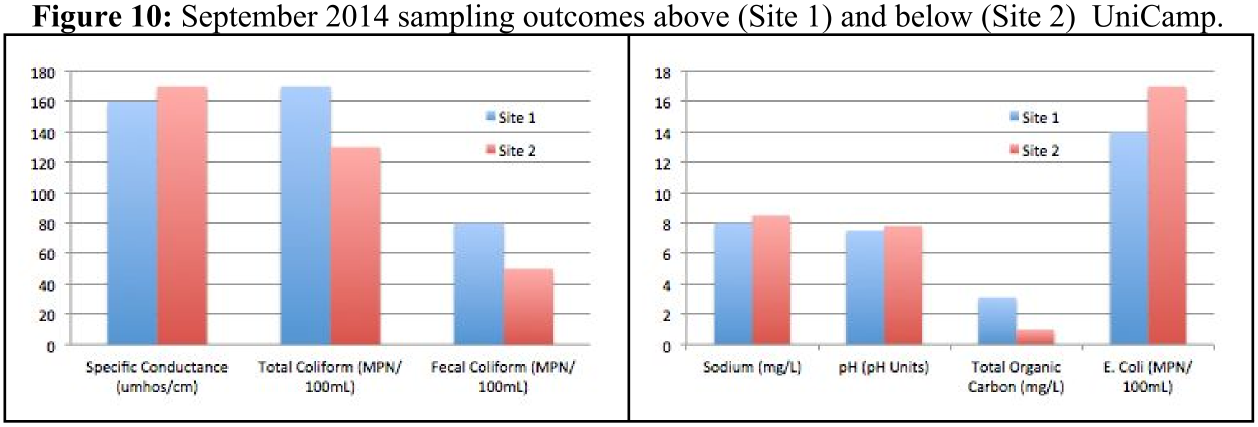


Figure 10: September 2014 sampling outcomes above (Site 1) and below (Site 2) UniCamp.



Although the fate of kitchen and washer wastewater remains unknown, it is clear from levels of detergent indicators that they are not contaminating the river. MBAS, phosphate and boron are at non-detectable levels, and variability in the sodium concentrations are natural and do not indicate any sources of contamination.

Results from sewage indicators also suggest that UniCamp is not adversely affecting the river. The concentrations of bacterial indicators, including *E. coli*, fecal coliform and total coliform, either decrease or remain constant as the river flows from above to below camp. This suggests that there is no fecal contamination coming from camp. Specific Conductance is measured because conductivity indicates the presence of chloride, phosphate or nitrate ions from wastewater. Although there is variance in conductivity, slight increases by 10 or 20 umhos/cm, do not indicate anything more than seasonal and temporal changes in stream water quality. Total organic carbon levels, which can signal the presence of decaying plant and animal matter and/or petroleum-based products (such as pesticides, fertilizers, and more), decrease downstream. These factors combined with non-detectable levels of nitrate show that sewage holding tanks do not appear to be leaking.

The above factors and the natural variation in pH and total phosphorus indicate that UniCamp is having no adverse impacts on the Santa Ana River.

Recommendations

As Camp River Glen is having no detectable negative impacts on the Santa Ana River, no immediate action need be taken. To ensure that camp continues to exist in harmony with the natural environment, samples should be taken and tested every other year via the same 2014 scheme. Chloride should be added to the suite of parameters tested in any future monitoring.

GREYWATER SYSTEMS

The United States Environmental Protection Agency (EPA) defines greywater as "reusable wastewater from residential, commercial, and industrial bathroom sinks, bathtub drains, and clothes washing equipment" (EPA). Though slight variations of the definition exist, all definitions exclude water from toilets and urinals. Water that has come into contact with human waste is considered blackwater and cannot be reused on-site.

At Camp River Glen, wastewater is collected and stored in 11 underground sewage holding tanks. Five of the tanks are located in the lower, west-end of the camp and the rest of the tanks are located near the upper part of camp. During camp season, wastewater is pumped and transported away daily by trucks. Each trip costs approximately $320 and removes about 2,000 gallons of wastewater from the tanks, a unit cost of about $0.16 per gallon. Figure 11 and Figure 12 show the total amounts of wastewater pumped and the costs associated with pumping for 2009-2014. In addition to the considerable costs for wastewater removal, the storage tanks occasionally reach maximum capacity and overflow. As a result, the bathrooms must be closed until the wastewater is removed. Implementing a greywater recycling system could help reduce the cost, impacts, and risks of the tanks by diverting greywater away from the storage tanks and reusing it for other approved purposes, such as irrigation.

Figure 11: Total wastewater pumped and removed by trucks from 2009 - 2014.

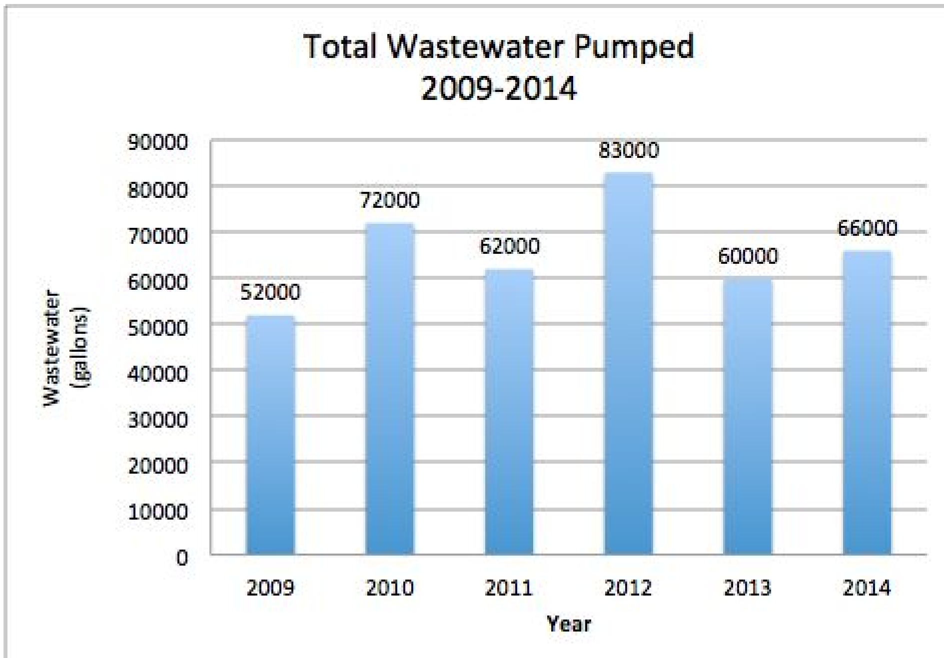


Figure 12: Estimated cost of wastewater removal from 2009 - 2014, each gallon of wastewater costs $0.16 to pump and remove.

Current Status

As suggested by the previous practicum team, Mr. Wally Wirick attempted to obtain a permit to begin construction of the pilot greywater irrigation system on his personal cabin. The greywater irrigation system proposed by the previous practicum team was designed to divert water from the shower and sink to an outdoor irrigation field covered with mulch. The pilot system would have served as a model before implementing a greywater system for all the other cabins. However, according to Mr. Wirick, due to the lack of clear greywater policy in San Bernardino County, he was unable to obtain the proper permit. As a result, no pilot greywater irrigation system was constructed.

While San Bernardino County's greywater policies are indeed unclear, by contacting the Land Use Services and the Planning Division we discovered that the lack of greywater policy or standards in the county's code defers regulation to the state's standards. The county generally leaves overseeing greywater design to water providers, but because Camp River Glen's system is decentralized, greywater system requirements default to the requirements elaborated in California Plumbing Code section 1602. Water systems in the county are approved and overseen by the Building and Safety Department as well as Environmental Health Services. Once created, designs and other required materials should be submitted to Building and Safety for review. Contact information to obtain approval can be found in Appendix A.

In addition to obtaining a construction permit and installing a pilot greywater irrigation system, the previous practicum team recommended gathering water usage data to refine cost-analysis benefits. Mr. Wirick was able to have four cabins monitored during two sessions of the 2014 camp season by installing water meters. The results are discussed below. A typical water meter is shown in Appendix D.

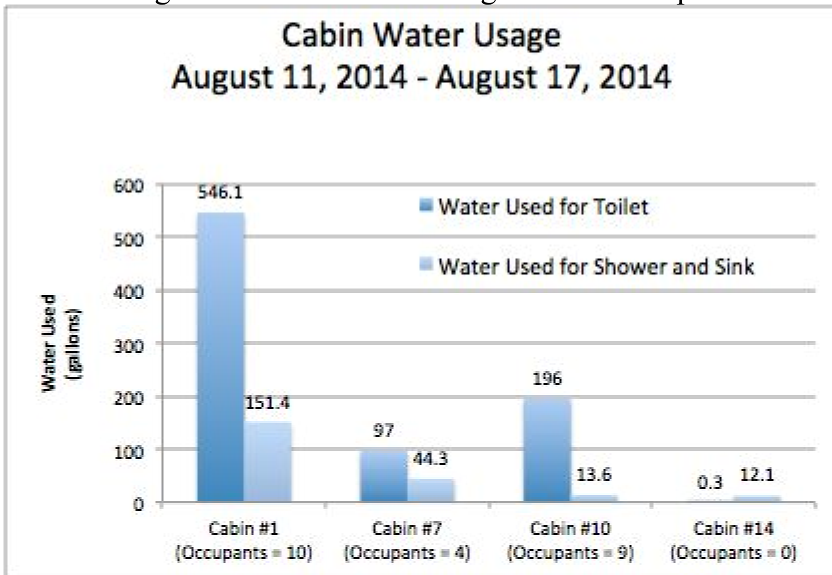
Potential Changes in Water Use

Figure 13 shows current cabin water usage data for four cabins collected by UniCamp staff during a single session. Currently, the "Woodsey Challenge" encourages campers to not shower during their stay at Camp River Glen. Additionally, there is no hot water in the cabins used by campers, further discouraging campers from showering. As shown in Figure 13, it is clear that most of the water used in the cabins is for the toilets and little water is used for the showers and sinks.

However, water usage may change in the future. Mr. Wirick has expressed his desire to encourage campers to shower twice a week to maintain personal hygiene. Also, there have been phone calls by parents suggesting unfair treatment of their children (not allowing them to shower) because of their socioeconomic standing. In addition to the social factors involved, in 2014, the San Bernardino Environmental Health Department issued UniCamp a warning for the lack of hot water in the cabin bathroom sinks, necessary for proper sanitation after bathroom use. Thus, efforts will be made to make hot water available in the cabin showers to encourage personal hygiene maintenance and at the cabin sinks to comply with county health regulations.

In the upcoming years, the water use pattern at Camp River Glen may change drastically due to these factors. Hot water delivered to the cabins will result in more water use for the cabin sinks and showers. With the current wastewater disposal infrastructure, which is already under stress under current water usage patterns, UniCamp will either have to pay for more frequent truck trips or risk more frequent overflowing. This section will seek to analyze potential benefits of installing greywater systems to support the wastewater disposal infrastructure under a potential increase in cabin water usage.

Figure 13: Cabin water usage data of 1 session during the 2014 camp season.



Estimate of Total Greywater

Case 1: Current Amount of Greywater

During the 2014 camp season, four cabins were monitored for water usage. Figure 13 shows the resulting water usage data, based on the raw data collected, shown in Appendix E. Assuming the collected data depicts a typical weeklong session, Cabin #1 has the highest overall amount of water use compared to the other cabins. This is expected due to the cabin's central location. It receives the highest number of visitors who use the toilet, sink, and possibly shower, in addition to the actual occupants of the cabin. Based on Mr. Wirick's description, cabin #10 demonstrates a representative amount of water usage for an almost fully occupied cabin in a given session. Cabin #7, which was only occupied by 4 people during this time, had an unusually high proportion of water usage to its number of occupants when compared to cabin #10, the nearly fully occupied cabin . Data from cabin #14 shows the use of water in an unoccupied cabin during the session. Based on the data collected, it is clear that there is not a lot of greywater (sinks and showers) compared to blackwater (toilet).

We used this data to estimate the total amount of greywater produced in a single typical season. A single camp season is essentially equivalent to the total year's water use, as UniCamp is only operational during the summer. The estimate depends on the number of cabins used during the session and assumes the same number of cabins are used in each camp session. The following equation assumes each additional cabin adds 14 gallons per session to the 150 gallons per session contributed by cabin #1. One cabin is subtracted from the number of cabins used to account for cabin #1 being already represented as 150 gallons per session. On average, 7 sessions are held during the summer season. The equation for greywater used follows, where N is equal to the average number of cabins in use during each session of the camp season:

Estimated amount of greywater per year = ((150 gallons/session) + (14 gallons/cabin/session) x (N - 1 cabin)) x 7 sessions

We will assume for this calculation that 15 cabins (including cabin #1) are in use during each of the 7 sessions of camp (N=15), the resulting estimated amount of resulting greywater for the season is:

Estimated amount of greywater per year = ((150 gallons/session) + (14 gallons/session/cabin) x (15 cabins - 1 cabin)) x 7 sessions

= 2,422 gallons/year

According to values from the data collected and the above equation with given assumptions, 2,422 gallons of greywater is produced from showers and sinks each year. Appendix F can be used to determine the estimated amount of greywater produced per season if the number of cabins in use changes.

Case 2: Projected Amount of Greywater

To calculate future greywater amounts, a few assumptions must be made:

1) Approximately 1,100 campers visit Camp River Glen over the course of 7 sessions.
2) Each camper will be allowed a maximum of 2 showers.
3) Each shower will be limited to 5 minutes to minimize excessive use of water.
4) The flow rate of showerheads at camp is 2.5 gpm, which is the current federal standard for showerhead flow rates (EPA).

Based on these assumptions, the equation to determine the amount of water used for showers is as follows, where 7 sessions are equivalent to a year for UniCamp due to its seasonal occupation:

Future water use for showers = (2.5 gallons/minute) x (5 minutes/shower) x (2 showers/camper) x (1,100 campers/7 sessions)

=27,500 gallons/year

Based on future projections, 27,500 gallons of greywater will result from showers each year. The amount of water used for showers will compose the majority of greywater produced at camp because the amount of water for handwashing will not change. In fact, water for handwashing will be insignificant compared to the amount of water used for showers. As a result, the equation only takes into account the amount of water that will be used for showers in the future.

Comparison of Case 1 and Case 2

As expected, the amount of greywater at camp will drastically increase once showering increases, as shown in Figure 14. Based on these estimations, there may be an eleven-fold increase in the amount of greywater. Each gallon costs $0.16 to remove, resulting in a cost equation as follows:

Cost of greywater removal per year =
Amount of Greywater (gallons/year) x ($0.16/gallon)

Without greywater irrigation systems, UniCamp is currently paying about $387.52 per year to remove the greywater. Due to the large projected increase in shower water use, the camp will pay approximately $4,400.00 per year in the future to remove greywater, displayed in Figure 15.

Figure 14: Comparison of current vs. future amounts of greywater.

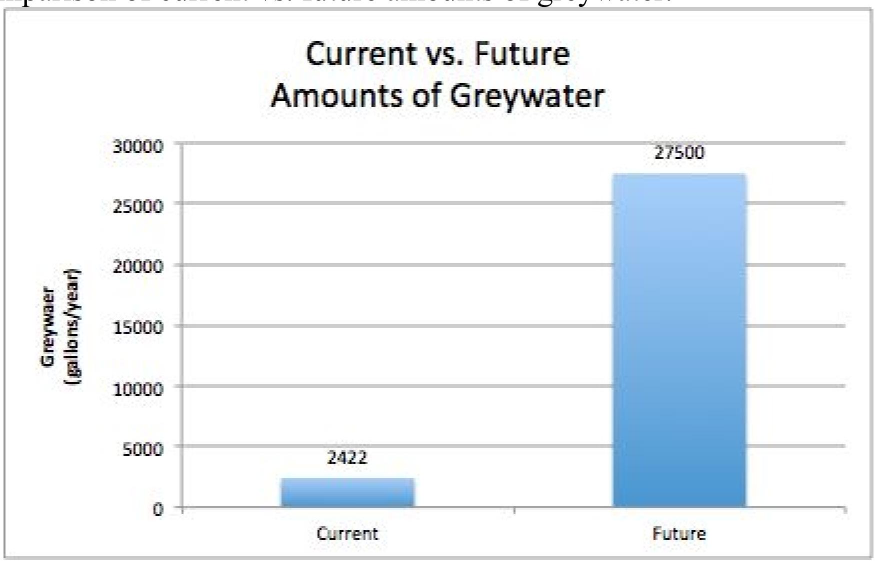
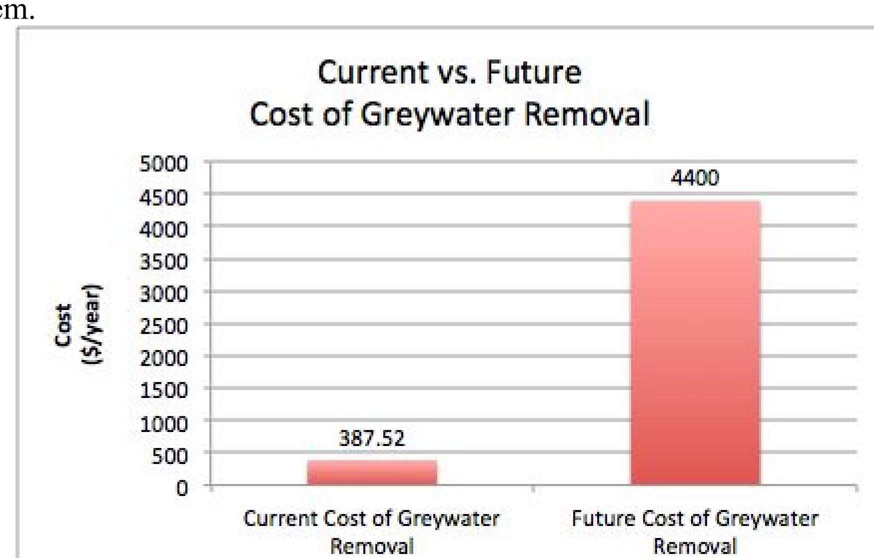


Figure 15: Comparison of current vs. future costs of greywater removal based on current disposal system.



Greywater Installation Options

UniCamp can install the greywater irrigation systems using UniCamp staff or through a professional greywater installation vendor. Depending on which one UniCamp decides to fund, costs will vary. However, both have advantages and disadvantages.

Option 1: Self-installation

Based on the previous practicum group's calculations, the self-installed greywater irrigation system would initially cost $127.52 per cabin. Assuming on average that 15 cabins are in use, 15 of the cabins will need a greywater irrigation system. As a result, it would cost $1,912.80. This cost includes only the material cost. It does not include the maintenance cost and labor costs.

Option 2: Professional Installation

A professional greywater installation vendor, 2G Water Solutions, was contacted to obtain a cost estimate. A professional installation of the greywater irrigation systems would cost $1,000 for the consulting fee (for contractors) and an additional $1,500 per cabin. The approximate breakdown is $500 for equipment and materials, $500 for labor, and $500 for insurance on the job, transportation, and final profit margin. This does not include maintenance costs. Because UniCamp can provide labor, it can reduce costs per cabin by $200, resulting in a minimum of $1300 per cabin. To professionally install greywater irrigation systems for 15 cabins, it would cost $20,500.00

Though the cost is relatively high, it includes assistance with procurement of construction permits and approval of the Forest Service, all equipment costs, and labor costs. Obtaining permits can be difficult because it requires submission of a detailed operations and maintenance manual, which may be difficult to develop without some professional assistance. A professional vendor overseeing the project will likely reduce the risk of system infrastructure failure. Furthermore, it is likely that the cost estimate of the system provided by the professional vendor is more accurate than self-installation calculations due to their practical experience. Refer to Appendix A for professional greywater installation contact information.

Payback Period

To determine the payback period for each system, the time required for an investment to earn back its initial costs, the following equation was used:

Payback Period (years) = (Cost of System)/(Cost of Greywater removal/year)

Table 3 summarizes the payback periods for the two systems for each case. If the amount of greywater at camp does not change, option 1 remains an attractive choice. If the amount of greywater increases as projected, both greywater installations become reasonable options. However, the reduction in payback period from case 1 to case 2 is drastically larger for option 2. In the event of an increase in greywater, even though the payback period for option 1 is less than the payback period for option 2, with the potential benefits and reliability of a professional installation, option 2 may be the better option in the long run. In the future, a greywater irrigation system, regardless of which installation is decided upon, would relieve the stress upon the current wastewater disposal system and its associated risks, costs, and impacts.

Table 3: Summary of payback periods for varying cases and options.

	Cost of Removal of Greywater	
	Case 1: Current Amount of Greywater ($387.52/year)	Case 2: Future Amount of Greywater ($4,400.00/year)
Option 1: Self-Installation ($1,912.80)	4.9 years	0.4 years
Option 2: Professional Installation ($20,500.00)	52.9 years	4.7 years

Recommendations

With the current amount of greywater at camp, there is a weak cost incentive to install a greywater irrigation system. If desired, a self-installation may prove beneficial. However, with potential increase in the amount of greywater, UniCamp will need an alternative way to accommodate the additional greywater. In the future, installing a greywater irrigation system would be a cost-effective way to divert greywater from the underground storage tanks and save approximately $4,400 per year. Depending on which system installation option UniCamp decides, the number of years to begin earning a return on their investment varies.

Similar to the previous team's recommendation, we recommend installing a pilot project greywater irrigation system for one cabin to see what issues may be encountered before installing systems for other cabins. A cabin with the water meters already installed would be preferable. With this single pilot greywater irrigation system, a refined cost-analysis of payback period can be obtained. We also recommend installing greywater irrigation systems for cabins used by permanent UniCamp staff. Because they remain at camp during the entire season, they take more frequent showers than campers. Measuring actual flow rates of showers and sinks on-site will assist in obtaining a better estimate of future water usage and resulting greywater. If any fixtures are determined to be water intensive, they should be replaced with low-flow fixtures.

After installing a pilot greywater irrigation system, the greywater irrigation field should be assessed to determine if the ground can handle the extra incoming water. Frequent irrigation with greywater can result in muddy and damp areas near the cabins. As many of the cabins are in close proximity to each other, a properly sized irrigation field in a reasonable location will be necessary to handle the water. After assessing the pilot system's irrigation field, UniCamp should proceed with installation of greywater irrigation systems for the remainder of the cabins. There is a risk that the surrounding environment may not be suitable for the potentially large amounts of greywater to be diverted to irrigation fields over a relatively short span of a single summer season. This should be taken into account when proceeding.

As suggested in last year's report, with the installation of greywater irrigation systems, UniCamp will need to mandate the use of non-toxic, natural, biodegradable personal hygiene products in all showers and sinks to minimize impacts on the environment due to greywater irrigation. Furthermore, due to the expected increase in water usage, showers should be limited to 5 minutes and 2 showers per camper.

KITCHEN WATER EFFICIENCY

In order to make UniCamp more sustainable, we looked into changing the kitchen practices, specifically the food preparation practices. After our visit to the site, we were notified that to defrost chicken, the kitchen staff leaves it under constant running water until it is thawed. Leaving the food out on the counter to thaw is not allowed by county health regulations.

Recommendations

We recommend that UniCamp defrost chicken in the refrigerator. According to the United States Department of Agriculture (USDA), it is more safe and efficient to plan ahead and thaw in the refrigerator, where it will be at a constant temperature of 40 °F or below.

ENERGY

Currently, UniCamp's rustic cabins do not require or possess infrastructure for energy. Mr. Wirick has expressed the desire to provide hot water for camper hand washing and showering. A recent informal citation was given by the San Bernardino County Department of Public Health's Division of Environmental Health Services (DEHS) that mandated there be hot water available for hand washing in the cabins. According to the camp inspector, sink water temperatures should reach 110 in a reasonably short amount of time, and last for a minimum of 20 seconds. While this regulation is strictly enforced for kitchen and food preparation facilities, there is more flexibility in the camper cabins. While the need for cabin hot water is not immediate, UniCamp should actively work to find a solution for the production of hot water. In order to provide campers with a more comfortable and hygienic camp experience, Mr. Wirick asked the Unicamp team to explore the option of providing hot water for both showers and sinks.

Camp River Glen is connected to the grid, and the water pump, lights, kitchen appliances, and washing machine all utilize Southern California Edison's electrical distribution network. Last year, solar and micro hydroelectric energy systems were explored as decentralized alternatives to the fossil fuel combustion that partially generates grid electricity. This would reduce UniCamp's carbon footprint and utility bills, while better integrating camp into the natural environment. While micro hydroelectric energy was explored in depth and deemed impractical by the 2014 practicum team, there was more research to be done regarding distributed solar energy systems, including photovoltaics and solar thermal. This section assesses the options of PV and solar thermal, as well as cycle power for cabin water heating. Propane could be considered a fallback option for cabin energy supply, in case Camp River Glen is pressured by the county Camp River Glen to quickly produce hot water in cabins. However, this group did not explore the option of propane heating, for its fossil fuel nature is contrary to our mission of sustainability. In addition, because this form of heating water is not uncommon or novel, purchasing and installation do not pose any foreseeable challenges.

PHOTOVOLTAIC PANELS

Adding on to last year's research, we looked into Photovoltaic systems. Solar PV systems could be placed on each cabin's rooftop to heat water. Cost estimates were not obtained due to difficulties in communication and cooperation with PV panel vendors.

After consulting with several camps about their sustainable practices, many stated that weather, such as snowfall at camp, has not been a problem for Photovoltaic systems. However, the trees surrounding Camp River Glen shade the camp area, which would decrease the efficiency of solar PV panels. Decreased efficiency would make these systems less cost effective.

Camp River Glen struggles with theft during its off seasons. During the off seasons, there is a lack of security and surveillance, which would especially be a problem when valuable PV installations are made. This would be a problem because disassembling and storing all of the PV panels needed at the campsite to prevent theft is very complicated and time consuming.

UniCamp only operates for three months out of each year. This increases the payback period for solar PV by decreasing the amount of time the solar panels will produce electricity in a single year. While the solar panels continue to degrade at the same rate, they will be generating electricity at one third to one fourth of the rate they could be for a given year.

SOLAR THERMAL

Solar thermal water heating is an option for decentralized, cabin water heating. There are two solar thermal water heating options – active and passive solar. Active systems involve a series of copper tubes that run from a water tank to a solar panel on the roof. A pump circulates water up to and through the solar panel, which heats water and then returns it to the tank, or to another tank. This type of system requires electricity for the pump and would require either a connection to the grid, or the installation of a PV panel. These systems begin at around $12,000 just for the hardware; installation and storage tanks will cost more. For UniCamp, this option can become complicated and expensive, so solar vendors recommended passive solar water heaters as the more viable option. Passive solar employs a water tank on the roof, which uses sunlight to circulate hot water through the system without a series of solar panels. They are easier to install and more durable than active systems. The following two quotes (Table 4) were approximated as the most viable options.

Table 4: Vendor quotes for solar thermal cabin water heating

Company	Type of System	Sink and/or Shower?	System Size	Price estimate per cabin
All Valley Solar	passive	only sinks	40 gallons	$3,600
Suntrek Industries	passive	sinks & showers	116 gallons	$9,000

Challenges may be encountered if this option is further pursued. Both solar companies agreed that installation feasibility would have to be assessed with a site visit if UniCamp is interested in installation. Potential complications may include issues of tree shade, excessive weight for existing roof structures, and high financial costs. For any form of solar energy, tree shade can physically block systems and reduce their energy harvesting potential. Part of what forms Camp River Glen's cabin charm is its location amongst the trees. Unfortunately, this means that cabin rooftops are at least partially shaded for much of the day. This may severely limit the amount of sun the panels or tanks will receive, as they must also be situated on either south or west facing roofs. Limited sun exposure reduces system efficiency and effectiveness. Additionally, hot water will not be constant in cabins; it will only be available when the sun is out to heat the water. While showers will be effectively heated during the middle of the day and afternoon, through the night, water will cool down. This fluctuation in water temperature will not meet San Bernardino County's hot water standards at all times of day.

As for system weight requirements, All Valley Solar's 4'x8' rooftop system weighs 264 lbs when dry and 600 lbs when loaded with water. The roof construction of the cabin will have to be strong enough to withstand this weight, with the potential added weight of snow in the winters. In addition, with the potential for theft that has been demonstrated at camp in the past, covers may be needed in the camp off-season – covers that may add even more weight atop the roofs. It is expected that Suntrek Industries' tank will weigh much, much more. The weight bearing ability of cabin rooftops may be a serious limitation to the installation of solar thermal water heating.

While the cost of the solar heating systems is outlined in Table 4 above, it is important to take into account the added costs of installation, especially in such a remote location. This could add $3,000-$5,000 to the cost per installation. County-level permitting may be an additional $200-$500. For 17 cabins, the system, permitting, and installation costs will quickly add up.

The only way this option may be more feasible is if solar thermal heaters are installed for centralized showers – such as the "Sail" biffy (biffy stands for bathroom in the forest for you). One large system will be much cheaper than multiple decentralized systems. However, this does not address the citation requiring hot water in cabins for hand washing. Unicamp may want to ask the County if hand sanitizer stations in the cabins would be an acceptable alternative.

Recommendations

It is recommended that UniCamp not pursue solar thermal heating or photovoltaic panels, for decentralized water heating for hand washing in cabins, due to the high costs, risks of insufficient sun exposure, and uncertain ability of rooftops to carry heavy loads. If warm showers are deemed a priority, a feasibility study should be done to evaluate the option of using solar thermal power for off-grid heating of showers in the larger, centralized "Sail" biffy.

CYCLE POWER

Mr. Wirick requested that we look into cycle powered generators as a source of sustainable energy to provide hot water to the cabins. Often used for powering concerts, these systems consist of bikes or bike attachments connected to generators and create power as riders pedal. We originally had hoped to adapt these bikes so that they could be attached to a water heater in order to heat the shower and sink water for the cabins. Adam Boesel, CEO of cycle power supplier The Green Microgym, explained that cycle power for heating water would not be feasible because producing heat is extremely energy intensive. At about 1500 watts needed to heat water, creating hot water would require at least 10 times the wattage of an everyday appliance, such as a television. Specific calculations for the system are difficult because key information for the product, such as efficiency of the generators, is missing. Furthermore, according to cycle power supplier Rock The Bike's website, an average person creates 40 watts while pedaling, but this is an estimate for an undisclosed amount of time. Although this information is incomplete, we can estimate that if it takes 1500 watts to heat water, it will take 38 pedalling children to generate the required energy to heat water. This is excessive and is not a feasible option for UniCamp.

Though deemed not feasible for water heating purposes, we evaluated the Rock the Bike product "Fender Blender Universale Stationary Kit" (shown in Figure 16 below), specifically for educational purposes. This product consists of a frame with a generator, which is connected to a blender. The advantage of this system is that any bike can be connected, so UniCamp can attach its own mountain bikes, cutting costs. This specific system costs $309, but due to the innovative nature of the cycle power as a learning tool, we believe the cost is justified. The use of cycle power to power a blender was suggested to us by a sustainable camp that we surveyed named Eden Village Camp, which utilizes this device to create smoothies and incorporates it into their own curriculum.

Figure 16: Rock the Bike's Fender Blender Universale Stationary Kit.

Recommendations

Upon evaluation of cycle power for two uses, energy production and an educational supplement, we do not recommend it for water heating purposes. However, the Fender Blender Universale Stationary Kit has the potential to be a valuable educational tool, thus we recommend it for UniCamp. The system could be used to supplement an environmental curriculum in a number of ways, such as actively teaching kids about renewable energy. Furthermore, the blender attached could be used to teach about nutrition, as well as provide a healthy snack that could be created to fall under the nutrition guidelines. The contact information for Rock the Bike is located in Appendix A, should the client choose to follow this recommendation.

SOLID WASTE

Currently, Camp River Glen freezes all of its food waste until a waste hauling truck can take it away in order to prevent bears from being attracted to the waste. We looked into alternative solutions for removal of food waste.

COMPOSTING

Composting, the process of turning food waste into a soil amendment, would not only reduce the waste produced by UniCamp, but also serve as a valuable hands-on learning experience for campers. Composting food scraps diverts them from landfills, where they rot and become a significant source of methane. Methane is a very potent greenhouse gas: it has 21 times the global warming potential of carbon dioxide. According to the EPA, landfills in the U.S. produce more than 20% of all methane emissions (EPA).

In the past, UniCamp has not considered composting due to potential safety risks of the decomposing food attracting bears near cabins. With this concern in mind, there are still options for UniCamp to implement composting.

Recommendations

Option 1: Small Indoor Vermicomposting

This serves mainly as a learning opportunity for campers. Vermicomposting uses worms to break down food scraps, producing a mix of worm castings and decomposed food scraps. The worm castings are full of microbes and nutrients, making them an ideal fertilizer. The camp can purchase worms and composting bins from nearby distributors: Triformis Corporation located in Los Angeles on Sepulveda Blvd or Redlands Redworm Farm. It is also very simple to make a worm composting bin: take a plastic storage container with a tight fitting lid (min 10" tall, 12"x24" base) and drill several ventilation holes on the upper half of the bin.

Option 2: Divert Food Scraps to Local Facility

California BioMass Inc. and American Organics are composting facilities located in Victorville that collect food scraps and other compostable waste from San Bernardino County.

Option 3: Construct Bear-Proof Composting

Constructing a concrete composter in a remote area of Camp River Glen, far from the cabin and dining areas, would reduce the amount of waste trucked away from camp, and may not attract bears to the camp. A design has been implemented in British Columbia, and "bears have shown interest, but once they check it out, they know they can't get inside, and they go away (Critter-Proof Composting)." This design shown below in Figure 17 provides a reasonable option for UniCamp, if someone is able to construct it. The composter has a concrete framework, faced with stone, with an aluminum lid, front and back vent held by recessed bolts. Inside the composter a screen angled across the bottom allows air from the back vent to move up through the compost then out through the top vent. A manual with photos explaining how to construct this composter is available for $39 from Critter-Proof Composting.

Figure 17: Bear-Proof Composter

EDUCATION

Currently, there is a specific week dedicated to environmental science education at UniCamp. UniCamp hopes to provide an environmental education curriculum to campers all summer long. As part of our deliverables, we have created materials that can be incorporated into each weekly session at camp, so that campers can leave with an understanding of how to reduce impacts on the environment. We feel that this portion of our project has the most potential for implementation because there is no cost and it can easily be added into existing programs. Included in the curriculum is information about water conservation, sustainability, green energy, and waste, with emphasis on both problems and possible solutions. It is our goal that campers take home the lessons they learn and apply them to their everyday lives to become better environmental stewards. Furthermore, we hope that counselors who are unfamiliar with environmental practices can learn from the activities as well. Overall, our goal is to instill in the campers and counselors of UniCamp a higher understanding and appreciation for the environment, at camp and at home. In order to do so, we recommend the following deliverables be implemented into the weekly sessions in order to create an ongoing environmental curriculum.

ENVIRONMENTAL SCIENCE ACTIVITY BOOK

The Environmental Science activity book, which has been sent to Mr. Wirick for his review, consists of activities meant to appeal to various age groups in UniCamp's already existing rotational programming. The book focuses on a variety of environmental topics, such as climate change, biodiversity, and renewable energy. Each topic comes with background material on the subject, so that any counselor is well equipped to inform the campers, regardless of his or her knowledge of environmental issues. Each topic also contains activities with information on the materials needed and the steps necessary to complete the activity. These activities range from active games to crafts, and are meant to foster understanding of a specific topic related to environmental science. Located in Appendix G is an example page from the activity book, illustrating structure and content and containing an activity specifically designated for the biodiversity and ecology section.

GREEN CHALLENGES

UniCamp currently has specific challenges, referred to as "Camp Jams," for the campers to complete throughout the week. As part of our deliverables, we have created an additional segment to Camp Jams, which consists of green challenges for the campers to complete at UniCamp. The document containing these challenges is located in Appendix H. These challenges are meant to increase campers' awareness of their actions, as well as to further instill environmental knowledge in a fun and active way. These challenges include minimizing food waste by eating all the food on their plate, using less water, and identifying local plants. They must be signed off by counselors when completed and can be turned into a competition with a fun reward given to the cabin that completes the most green challenges.

We also created a "UniCamp Water Warriors" pledge to encourage campers to save water, located in Appendix I. This pledge consists of an agreement to conserve water, and is signed by the camper. It is designed to be printed and sent home with at the end of the week. This way, campers can be reminded of the environmental mindfulness that they learned at camp, while encouraging family members to act the same.

PASSIVE EDUCATION SIGNS

In order to incorporate passive learning into the curriculum, we have created signs to be posted in various places throughout camp. The signs are designed to be posted near sinks, toilets, trash cans, and food areas and contain information related to the area they are placed. They are meant to encourage campers and counselors to conserve water, eliminate food waste, dispose of waste properly, and respect the environment. We hope that the students who read the signs intermittently throughout the week will gain a sense of why and how to be environmentally aware. An example of a passive education sign meant to be hung in trash disposal areas is located in Appendix J.

CONCLUSION

UCLA UniCamp has acted as a good steward of the San Bernardino Forest for the past 80 years. However, there are still ways that camp can become better integrated with its natural environment in the areas of water, energy, and waste. The camp can also have an indirect yet powerful impact on the environment by fueling a passion for conservation and environmental science in its campers.

Water

UniCamp must first and foremost address a citation of their water disinfection system. Our group has suggested that this can be resolved by installing a UV disinfection lamp in line with the current chlorine disinfection system, as well as the required water recirculation system and PLC for the lamp. If in the future the camp is required by health regulation to provide hot water in showers, this will result in a 10 fold increase in greywater produced by the camp. Additionally Mr. Wirick plans to encourage more showering at the camp due to the fact that the current camp culture of not showering may be unsanitary. Considering the large increase in greywater produced by these changes, we recommend installing a pilot greywater irrigation system, and an assessment of its percolation impacts after use. Water use can be reduced by a change in kitchen practice: defrosting meats in the refrigerator rather than under running water. Data collected from the river above and below the camp shows that the camp is not currently having an adverse effect on the river, however the camp should continue to take samples at least every other year, especially if a greywater system is implemented.

Energy

We found that photovoltaic panels are not a viable option to provide energy for camp. However, if warm showers are required, the camp should conduct a feasibility study on solar thermal water heating for centralized showers. Upon investigating the possibility of bike-powered water heating, we have found that cycle power does not produce the amount of power needed to heat water for showers. A cycle-powered appliance such as a blender is electrically feasible and would serve as a memorable educational experience for campers.

Solid Waste

Despite the presence of bears in the San Bernardino Forest, it is possible for UniCamp to adopt composting. A small, well-managed indoor vermiculture (worm) bin would not produce significant bear attracting odor, and though it would not significantly reduce camp food waste, it would be a valuable hands-on education tool. Diverting food scraps from the landfill to nearby San Bernardino compost facilities may be possible for the camp. Lastly, a concrete bear-proof composter at a remote location of camp could reduce waste hauled from camp, but must be constructed independently and still has a possibility of attracting bears.

Education

We developed active and passive methods of education to improve each camper's understanding of environmental science and fuel a passion for conservation. Active methods include an activity book and challenges, which can be implemented in every session of camp. Passive education takes the form of signs to be put up around camp. We feel strongly that the natural setting of camp along with enthusiastic UCLA counselors provide the ideal classroom for environmental science; with the curriculum we developed, UniCamp can instill in its campers an environmental consciousness. Ideally, curiosity about nature and the environment will remain with the campers, even when they leave Camp River Glen.

FINAL RECOMMENDATIONS

Improvement Area	Recommendations
Water	
Disinfection	❑ Install UV disinfection system in line with current treatment system. ❑ Install water recirculation system in tandem with the UV lamp. ❑ Replace chlorine dosage valve with Accu-Tab valve ❑ Install pre-filter bags recommended by last year's practicum team.
River Impacts	❑ Re-sample river every other year to detect possible changes in the camp's impact on water quality, adding chloride as a parameter.
Greywater	❑ Install a pilot greywater irrigation system. ❑ Measure actual flow rates of water fixtures to refine analysis. ❑ Mandate use of eco-friendly products in all cabins with greywater irrigation systems. ❑ After installation, assess irrigation field operation to determine if it can accommodate the increase in water.
Kitchen Efficiency	❑ Defrost meats in the refrigerator to conserve water.
Energy	
Solar	❑ If showering is made a priority, conduct feasibility study on centralized, solar-thermal heated showers.
Bicycle	❑ Consider purchase of cycle power equipment for educational purposes.
Solid Waste	
Composting	❑ Implement small indoor vermiculture composting at camp, diversion of food waste to nearby composting facility, or remote bear-proof composter.
Education	
Curriculum	❑ Implement deliverables into weekly curriculum.

ACKNOWLEDGEMENTS

We would like to thank Dr. Michael McGuire for his expert guidance and encouragement throughout this school year. We would also like to thank our client, Mr. Wally Wirick, for his warm assistance and cooperation, as well as Mr. Michael Starr for his enthusiastic cooperation.

References

Betzelberger, J. (2013) Environment 188A Session 1-8 [PowerPoint Slides].

Connell, Hunter, Charles Falconer, Daniel Fong, Kyle Graycar, Diana Nguyen, Emily Parker, and Nathan Tsang. "Rethinking Water at UCLA Unicamp." (2013).

Crittenden, John C., et al. (2012) *MWH's Water Treatment Principles and Design*. third edition, Hoboken, NJ:Wiley.

United States Environmental Protection Agency (EPA). WaterSense: Frequently asked questions. http://www.epa.gov/WaterSense/pubs/faq_showerheads.html (accessed May 18, 2015).

United States Environmental Protection Agency (EPA). Water recycling and reuse: The environmental benefits. http://www.epa.gov/region9/water/recycling/(accessed December 10, 2014).

Rock the Bike. How many people will it take to power my laptop and projector, pedalboard, (or any device)? http://rockthebike.com/how-many-people-will-it-take-to-power-my-laptop-and-projector-or-any-device/ (Accessed May 18, 2015).

United States Environmental Protection Agency (EPA).The Food Recovery Hierarchy. http://www.epa.gov/epawaste/conserve/foodwaste/ (accessed May 15 2015).

Appendix

Appendix A: Contact Information of various vendors, individuals, and organizations.

Name	**Organization**	**Contact Information**	**Purpose of Contact**
Operator	San Bernardino County Operator	(888) 818-8988	Direction to proper county departments
Various/ Operator	San Bernardino County Land Use Services Department	(909) 884-4056	Department encompasses building & safety, and planning
Various	County of San Bernardino, Planning Division	(909) 387-4999	Information on San Bernardino County greywater code
Various	San Bernardino	(909) 387-8311	Should be contacted for

	County Building and Safety	(never contacted, number referred for further info by the Planning Division)	further greywater questions or for reviewing greywater systems. Ask to speak with someone from Building & Safety
Aaron Kuehn	2G Water Solutions	E-mail: sales@2gwater.com	Professional greywater installation vendor
Patrick	All Valley Solar	(818) 489-7790	Solar thermal vendor
Ethan Heine	Suntrek Industries, Inc.	Office: (949)348-9276 Mobile: (949) 456-5914 eheine@suntreksolar.com	Solar thermal vendor
Adam Boesel	The Green Microgym	adam@thegreenmicrogym.com	Cycle power Vendor
Brittany	Rock the Bike	CustomerService@rockthebike.com	Cycle power Vendor
Yoni Stadlin	Eden Village Camp	yoni@edenvillagecamp.org	Sustainable Camp
Kyle Ochenduszko	State Water Resources Control Board	Phone: 916-539-1985 Fax: 916-341-5707 Kyle.Ochenduszko@waterboards.ca.gov	2-Pipe system grant
Rick Wagner	Applied Membranes, Inc.	Phone: 760-842-5344 Fax: 760-727-4427 rwagner@appliedmembranes.com	UV-disinfection vendor
Various	Sungevity	Phone: 866-786-4855 info@sungevity.com	Photovoltaic Panels vendor
Various	RGS Energy	Phone: 888-567-6527	Photovoltaic Panels vendor
Andrew Hoesly	Solar Forward	andrewhoesly@solarforward.com 707-239-1220	Solar Panels vendor

Various	Mohr Power Solar	323-261-7131	Solar Panels vendor

Appendix B: CT values for giardia inactivation at 15 .

Table C-4. CT Values for Inactivation of Giardia Cysts by Free Chlorine at 15°C

CHLORINE CONCENTRATION (mg/L)	pH<=6 Log Inactivation						pH=6.5 Log Inactivation						pH=7.0 Log Inactivation						pH=7.5 Log Inactivation					
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
<=0.4	8	16	25	33	41	49	10	20	30	39	49	59	12	23	35	47	58	70	14	28	42	55	69	83
0.6	8	17	25	33	42	50	10	20	30	40	50	60	12	24	36	48	60	72	14	29	43	57	72	86
0.8	9	17	26	35	43	52	10	20	31	41	51	61	12	24	37	49	61	73	15	29	44	59	73	88
1	9	18	27	35	44	53	11	21	32	42	53	63	13	25	38	50	63	75	15	30	45	60	75	90
1.2	9	18	27	36	45	54	11	21	32	43	53	64	13	25	38	51	63	76	15	31	46	61	77	92
1.4	9	18	28	37	46	55	11	22	33	43	54	65	13	26	39	52	65	78	16	31	47	63	78	94
1.6	9	19	28	37	47	56	11	22	33	44	55	66	13	26	40	53	66	79	16	32	48	64	80	96
1.8	10	19	29	38	48	57	11	23	34	45	57	68	14	27	41	54	68	81	16	33	49	65	82	98
2	10	19	29	39	48	58	12	23	35	46	58	69	14	28	42	55	69	83	17	33	50	67	83	100
2.2	10	20	30	39	49	59	12	23	35	47	58	70	14	28	43	57	71	85	17	34	51	68	85	102
2.4	10	20	30	40	50	60	12	24	36	48	60	72	14	29	43	57	72	86	18	35	53	70	88	105
2.6	10	20	31	41	51	61	12	24	37	49	61	73	15	29	44	59	73	88	18	36	54	71	89	107
2.8	10	21	31	41	52	62	12	25	37	49	62	74	15	30	45	59	74	89	18	36	55	73	91	109
3	11	21	32	42	53	63	13	25	38	51	63	76	15	30	46	61	76	91	19	37	56	74	93	111

CHLORINE CONCENTRATION (mg/L)	pH=8.0 Log Inactivation						pH=8.5 Log Inactivation						pH=9.0 Log Inactivation					
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
<=0.4	17	33	50	66	83	99	20	39	59	79	98	118	23	47	70	93	117	140
0.6	17	34	51	68	85	102	20	41	61	81	102	122	24	49	73	97	122	146
0.8	18	35	53	70	88	105	21	42	63	84	105	126	25	50	76	101	126	151
1	18	36	54	72	90	108	22	43	65	87	108	130	26	52	78	104	130	156
1.2	19	37	56	74	93	111	22	45	67	89	112	134	27	53	80	107	133	160
1.4	19	38	57	76	95	114	23	46	69	91	114	137	28	55	83	110	138	165
1.6	19	39	58	77	97	116	24	47	71	94	118	141	28	56	85	113	141	169
1.8	20	40	60	79	99	119	24	48	72	96	120	144	29	59	87	115	144	173
2	20	41	61	81	102	122	25	49	74	98	123	147	30	59	89	118	148	177
2.2	21	41	62	83	103	124	25	50	75	100	125	150	30	60	91	121	151	181
2.4	21	42	64	85	106	127	26	51	77	102	128	153	31	61	92	123	153	184
2.6	22	43	65	86	108	129	26	52	78	104	130	156	31	63	94	125	157	188
2.8	22	44	66	88	110	132	27	53	80	106	133	159	32	64	96	127	159	191
3	22	45	67	89	112	134	27	54	81	109	135	162	33	65	98	130	163	195

Source: AWWA, 1991.

Appendix C: Chart of Turbidity Monitoring Data.

Date	Turbidity Test	Comments	Date	Turbidity Test	Comments	Date	Turbidity Test	Comments
8/1/2007	0	** calibrated 7/11/07, 0.32 prior to calibration						
8/2/2007	0		7/9/2012	0		7/1/2013	0	
8/3/2007	0		7/10/2012	0		7/2/2013	0	
8/4/2007	0		7/11/2012	0		7/3/2013	0	
8/5/2007	0		7/12/2012	0		7/4/2013	0	
8/6/2007	0		7/13/2012	0		7/5/2013	0	
8/7/2007	0					7/6/2013	0	
8/8/2007	0		7/16/2012	0		7/7/2013	0	
8/9/2007	0		7/17/2012	0		7/8/2013	0	
8/10/2007	0		7/18/2012	0		7/9/2013	0	
8/11/2007	0		7/19/2012	0		7/10/2013	0	
8/12/2007	0		7/20/2012	0		7/11/2013	0	
8/13/2007	0					7/12/2013	0	
8/14/2007	0		7/23/2012	0		7/13/2013	0	
8/15/2007	0		7/24/2012	0		7/14/2013	0	
8/16/2007	0		7/25/2012	0		7/15/2013	0	
8/17/2007	0		7/26/2012	0		7/16/2013	0	
8/18/2007	0		7/27/2012	0		7/17/2013	0	
						7/18/2013	0	
8/22/2011	0		7/30/2012	0		7/19/2013	0	
8/23/2011	0		7/31/2012	0		7/20/2013	0	
8/24/2011	0		8/1/2012	0		7/21/2013	0	
8/25/2011	0		8/2/2012	0		7/22/2013	0	
8/26/2011	0		8/3/2012	0		7/23/2013	0	
8/27/2011	0					7/24/2013	0	
8/28/2011	0.01		8/16/2012	2.35	Tank completely empty 2 days ago, have flushed full systems	7/25/2013	0	
8/29/2011	0.08		8/17/2012	2.49		7/26/2013	0	
8/30/2011	0		8/18/2012	0.55		7/27/2013	0	
8/31/2011	0		8/19/2012	0.24		7/28/2013	0	
9/1/2011	0					7/29/2013	0	
			6/23/2013	0		7/30/2013	0	
6/29/2012	0		6/24/2013	0		7/31/2013	0	
			6/25/2013	0		8/1/2013	0	
7/3/2012	0		6/26/2013	0		8/2/2013	0	
7/4/2012	0		6/27/2013	0		8/3/2013	0	
7/5/2012	0		6/28/2013	0		8/4/2013	0	
7/6/2012	0		6/29/2013	0		8/5/2013	0	
			6/30/2013	0		8/6/2013	0	

Appendix D: Image of device used to monitor water usage of cabins.

Appendix E: Raw data collected from four cabins during two sessions. The data collected was the total amount of water ('Main Line') being used in the cabin and the amount of water being used for toilet flushing ('Bif Line'). To obtain the amount of water used for the showers and sinks, the amount used for toilet flushing was subtracted from the total amount of water being used for the cabin. (Units: gallons)

Water Use from Four Cabins during 2014 Season

	Cabin #1		Cabin #7		Cabin #10		Cabin #14	
	Occupants = 10		Occupants = 4		Occupants = 9		Occupants = 0	
Date	Bif Line	Main Line	Bif Line	Main Line	Bif Line	Main Line	Bif Line	Main Line
8.11.14	2.00	3.60	1.10	1.80	1.10	2.00	0.70	1.40
8.17.14	548.1	701.1	98.1	143.1	197.1	211.6	1	13.8
	546.10	697.50	97.00	141.30	196.00	209.60	0.30	12.40

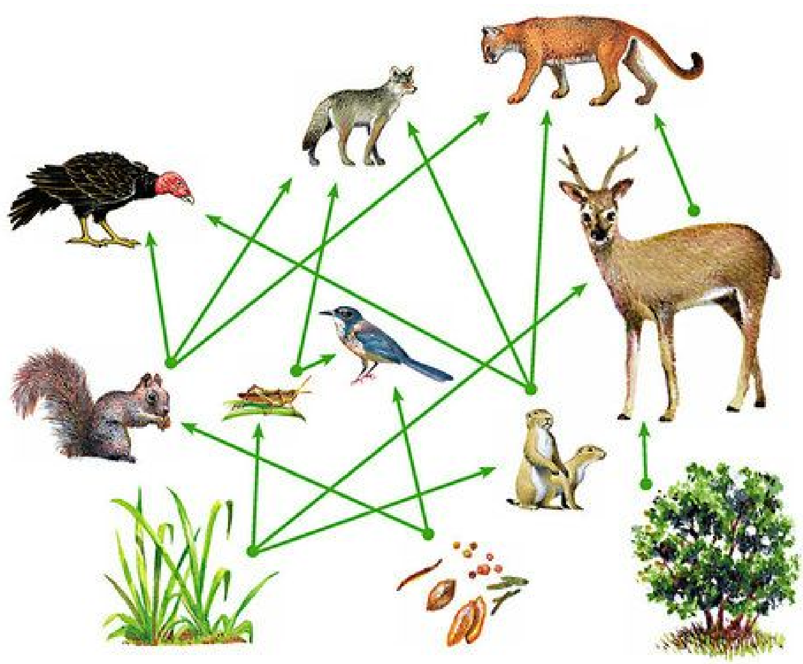
	Cabin #1		Cabin #7		Cabin #10		Cabin #14	
	Occupants = 10		Occupants = 10		Occupants = 13		Occupants = 13	
Date	Bif Line	Main Line	Bif Line	Main Line	Bif Line	Main Line	Bif Line	Main Line
8.24.14	612.50	784.90	100.60	160.40	201.10	230.00	1.00	31.40
	675.40	793.00	231.00	299.60	385.10	423.20	0.00	244.40
	62.90	8.10	130.40	139.20	184.00	193.20	-1.00	213.00

Note: Data from the 8/24/14 session was not used in the calculations as many of the readings result in negative values for the amounts of water used.

Appendix F: Greywater produced based on current water usage for varying number of cabins.

Number of Cabins in Use (N)	Resulting Greywater Per Session (gallons/session)	Number of Sessions/Year (*constant*)	Resulting Greywater Per Year (gallons/year)
1	150	7	1050
2	164		1148
3	178		1246
4	192		1344
5	206		1442
6	220		1540
7	234		1638
8	248		1736
9	262		1834
10	276		1932
11	290		2030
12	304		2128
13	318		2226
14	332		2324
15	346		2422
16	360		2520
17	374		2618
18	388		2716
Equation used: Estimated amount of resulting greywater per season (N) = ((150 gallons/session) + (14 gallons/cabin/session) x (N - 1 cabin)) x 7 sessions Where N is equal to the average number of cabins in use during each session of the camp season.			

Appendix G: Example of Environmental Activity Book: Web of Life.



Objective:

This activity teaches students in a visual way how energy is transferred from one organism to another.

Background:

A food chain is a simplified way of showing energy relationships between plants and animals in an ecosystem. For example, a food chain of sun, plant seed, mouse, owl shows that a plant seed that grows from the sun's energy is eaten by a mouse, which in turn is eaten by an owl. However, in reality it is rare for an animal to eat only one type of food. A food web represents the interaction of many food chains in an ecosystem.

Materials:

- Cards found at: http://www.nps.gov/grca/learn/education/upload/Web%20Of%20Life-4perPage.pdf
- String

Procedure:

1. Assign a card to each student, using the non-living cards (sun, water, air, bacteria, fungi, soil and fire) in addition to a variety of the cards found from pages 2-19. Ask each child to read their card and find one cool fact that they would like to share with the class or small groups.
2. Creating the web of life requires a long piece of string (possibly as long as 300 feet) to symbolize the connection of energy between organisms. Ask all the students to stand in a circle, facing the center.
3. The sun is the source of all energy; ask the student with the sun card to stand in the center of the circle and grab one end of the string.

4. Next, the string is passed from student to student, showing the connection of plants to herbivores, carnivores, and omnivores, successively. This activity can be general, connecting students by the category they fit in or can be specific, connecting the sun to cottonwood to beaver to water, etc. until all students are included.
5. After each student is holding onto the string, emphasize connections and introduce certain situations that commonly occur in nature, such as forest fires, predation, drought, and urban development. As you introduce different scenarios, discuss who will be affected. Plants can not relocate or move during a forest fire, they will die and thus students should drop their string. In turn, animals who are dependant on the plants for survival may die due to a lack of food, and should also drop their string. Soon, students will see how everything is connected and affected by natural and unnatural factors in the environment.

Measurable Objectives:

Campers gain an understanding of the interconnectedness of all living creatures. They appreciate the fact that the well being of each species depends on all others. They ideally will also gain greater understanding of how energy is transferred from the sun into ecosystems and from one species to another.

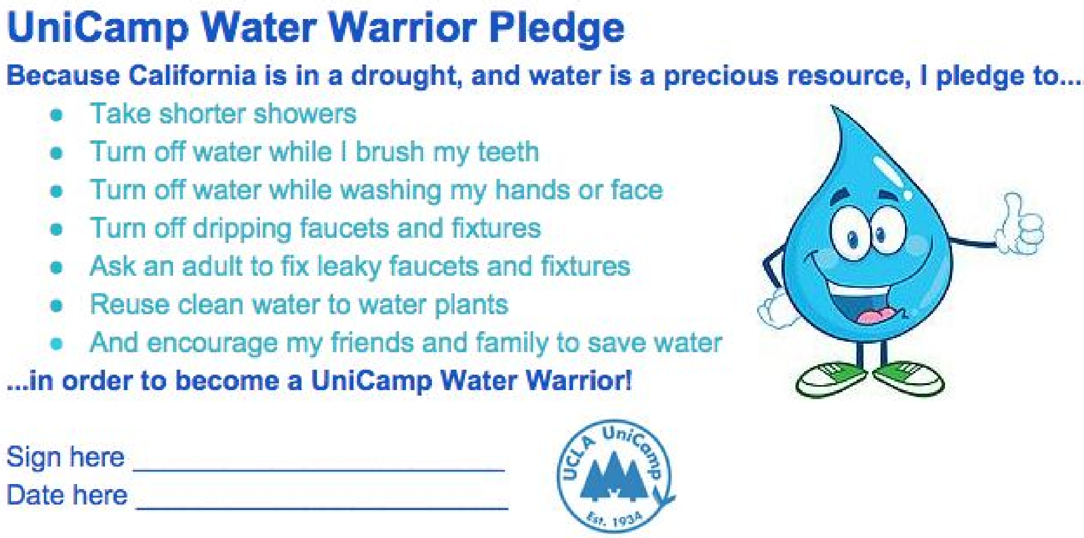
Sources:

http://ecosystems2.weebly.com/food-web.html
https://www.plt.org/family-activities-web-of-life
http://www.nps.gov/grca/learn/education/upload/Web%20Of%20Life-4perPage.pdf

Appendix H: Camp Jams Green Challenges addition.

Task	Why?	Signature	
Collective number of showers per cabin no more than 2 per person.	To save water.		
All showers shorter than 5 minutes.	To save water.		
Turn off water while brushing teeth.	To save water.		
Turn off water while lathering hands with soap.	To save water.		
Turn off water when lathering hair with shampoo/conditioner.	To save water.		
Take the Water Warriors Pledge at the end of the week.	To promise to continue saving water.		
One napkin per camper at every meal.	To reduce trash waste and decrease the number of trees cut down.		
Finish all of your food at mealtimes (collectively).	To reduce food waste.		
Pick up an item of trash daily.	To clean up our environment.		
Identify native species.	To understand and appreciate the natural environment.		
Win an environmental rotation activity.	To learn about the environment.		
Recite the sustainable cabin pledge.	To pledge to respect the environment.		
Make up a song about protecting the Earth and Camp's environment.	To show your appreciation for the environment.		

Appendix I: Water Warrior Pledge created as a deliverable for students to take home./



Appendix J: Example of a passive education sign created as a deliverable.