Water Reuse Through Subsurface Drip Irrigation Systems

By Elson C. Gushiken

The continuing effort to conserve and preserve potable water resources emphasizes using alternative water sources for irrigation. Agriculture, golf courses, highways, parks, playgrounds and cemeteries are among the heaviest users of irrigation water due to the large areas requiring irrigation. Potable water is less available for such nonpotable activities as irrigation and is being replaced with alternative sources such as nonpotable fresh water, brackish sources, or treated wastewater effluent.

In Hawaii, with approximately 80 percent of the state's population residing on Oahu, competition for water use has become a major planning issue. Reclaimed water is considered a great potential resource for various nonpotable applications such as irrigation, industrial processes, construction activities, dust control, etc. However, irrigation is construed to be the primary component for water reuse and is the focus of Hawaii's reuse guidelines.

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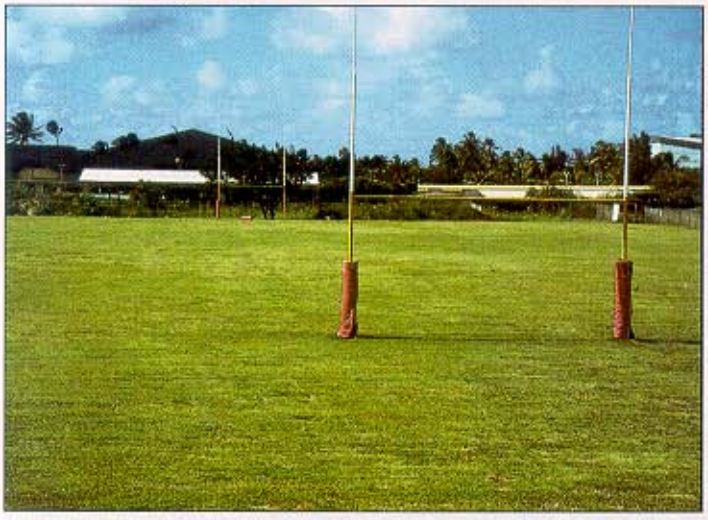


The Laie water reclamation project in Hawaii includes a drip-irrigated rugby field. Photos courtesy: Elson Gushiken.

Water reuse through a subsurface or buried drip irrigation system is a unique concept that speaks directly to the issues of acceptable wastewater disposal, water reuse and water conservation. However, public perception of wastewater has made reclaimed water the least desirable alternative for irrigation. Consideration of treated effluent for reuse is the last resort only when other water sources are unavailable and/or unsuitable. However, when water conservation is a significant issue, or when primary options for effluent disposal preclude conventional disposal methods, then irrigation, and more so, subsurface drip irrigation, becomes a very attractive conservation and/or effluent disposal component.

Using reclaimed water for irrigation requires closer examination of current irrigation design practices and current irrigation technologies for landscape and agricultural applications. Conventional potable water sprinkler irrigation systems are generally designed to complement operator skill levels for operations and maintenance. However, reuse irrigation systems must be designed, built and managed in accordance with reuse regulations that require higher operating and management skills. Subsurface drip irrigation water reuse necessitates even higher skill levels in design, construction, operations and management.

Hawaii Reuse Guidelines

The Hawaii Sate Department of Health released the "Guidelines for the Treatment and Use of Reclaimed Water" in November 1993. These guidelines promote water reuse and supplement, clarify and provide further guidance in promulgating existing rules that refer to wastewater effluent disposal systems. The reuse guidelines set the framework for the promulgation of administrative rules in the future. The guidelines provide more specifics in evaluating reuse projects to safeguard public health and preclude environmental degradation of aquifers and/or surface waters while seeking to maximize the potential of this relatively new resource.

The guidelines define reclaimed water as that which, as a result of domestic wastewater treatment, is suitable for a direct beneficial use or a controlled use that would not otherwise occur. Hawaii reclaimed water is classified and identified as:

- R-1, significant reduction in viral and bacterial pathogens
- R-2, disinfected secondary reclaimed water
- R-3, secondary reclaimed water without disinfectant

R-1 water, which is the highest quality, may be used in any form of irrigation served by fixed irrigation systems supplied by buried piping for turf and landscape irrigation of golf courses, parks, elementary schools, athletic fields, roadsides and medians, and residential property where managed by an irrigation supervisor. Spray irrigation of R-1 water does not have restricted times of operation. Only subsurface irrigation of turf and landscape in preschool yards

and playgrounds for preschool children is permitted. In Hawaii, wastewater treatment facilities do not yet produce R-1 water.

R-2 water may be used for subsurface irrigation of landscape and turf on golf courses, parks, elementary schools and residential properties that are managed by an irrigation supervisor. R-2 water may be used in any form of irrigation for landscape on cemeteries and around freeways. Spray irrigation of R-2 water is limited such that the outer periphery of the irrigated area must not be within 500 feet of a residential property or a place where public exposure could be similar to that at a park, elementary school or athletic field.

Overspray or runoff of R-2 water must be confined to the approved use area and is not permitted to come in contact with the public or equipment, facilities and areas with frequent human contact. Spray irrigation of R-2 water can only occur when the area is closed to the public and must end at least one hour before the area is open to the public. R-3 water is not permitted for landscape and turf irrigation.

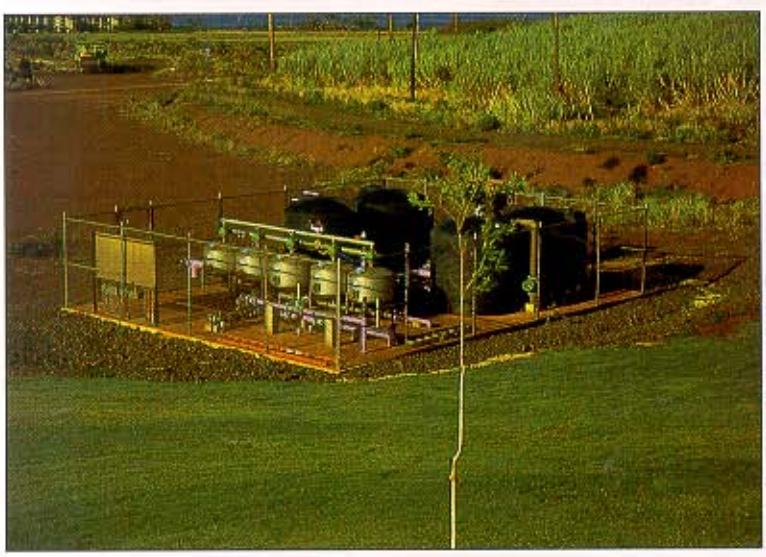
Subsurface Drip Irrigation

Drip irrigation, the slow, precise application of water to a plant's rootzone, has been used for more than 30 years. In Hawaii, more than 100,000 acres of sugar cane and pineapple are drip-irrigated. A high percentage of the drip irrigation development work in Hawaii was done in sugar cane through the Hawaiian Sugar Planters' Association and the University of Hawaii. In recent years, subsurface drip irrigation systems have gained greater acceptance in landscape and commercial turf applications.

Conventional effluent disposal in Hawaii generally has been via ocean outfalls, injection wells, leach fields, sprinkler irrigation, surface drip irrigation and various other land-application methods. A properly engineered and managed subsurface drip irrigation system using reclaimed water offers many advantages over conventional disposal methods:

At the Kukuiula project drip is being installed and will be followed by a covering of soil.

1. Minimizes health risks associated with exposure to reclaimed water;
2. Minimizes liability exposure associated with overspray and aerosol drift from conventional sprinkler systems, especially near residential properties;
3. Psychologically and politically a very acceptable method of disposal and reuse;
4. Eliminates odor, ponding and runoff problems;
5. Extends and conserves potable water resources;
6. Direct applications into plant rootzones achieve more manageable, balanced water distribution throughout a relatively shallow soil profile, thereby minimizing potential groundwater depletion;
7. Unrestricted irrigation scheduling;
8. Low pressure requirements, 20 to 35 psi average operating range;
9. Virtual elimination of vandalism and damage compared to conventional sprinkler systems; and
10. Favorable cost vs. benefit compared to other disposal methods.



The central irrigation filter and distribution station at the Kukuiula reclamation project provides water to turf and landscape plantings.

The primary challenges of long-term subsurface drip irrigation systems have been internal plugging potential of drip emitters and external root intrusion into the drip tubing. Internal plugging of emitters is caused primarily by sediment, algae and bacterial slime. This problem has been virtually eliminated with proper filtration, chlorine disinfecting and drip-emitter designs incorporating large flow paths and larger discharge orifices. External root intrusion has been prevented with the development of trifluralin-impregnated drip emitters. Trifluralin, as incorporated into the drip emitter, is a chemical root barrier that is registered and approved by the U.S. Environmental Protection Agency for use in landscape and crop application.

In Hawaii, the Laie and Kukuiula water reclamation projects both utilize automated reuse subsurface drip irrigation systems that incorporate the following primary components: central irrigation computer, weather station, filter system, booster pumps, chlorination system, flow meters, monitoring sensors, main control valve, main lines, submains and block control valves and polyethylene drip tube with emitters.

The central filter station receives reclaimed water from the wastewater treatment facility. The central irrigation computer and weather station located at the wastewater treatment facility provide overall management of the reuse irrigation system by initiating and monitoring water distribution and usage activity at the central filter station. The filter station consists of filters, booster pumps, a chlorination system, flow meters, various sensors, valves and controls. It is the central point for distributing and monitoring reclaimed water for the irrigation system. Main lines distribute reclaimed water from the filter station to individual irrigation blocks controlled by automatic valves. The automatic irrigation block valves deliver water through PVC submains to individual buried drip tube laterals. The buried drip tube laterals

continued on page 44

uniformly distribute and emit reclaimed water into the soil matrix for distribution within the plant rootzones.

The reuse irrigation systems at both Hawaii projects are flow-based managed programs and are not operated on a conventional irrigation time-clock basis. Weather stations at both project sites provide daily evapotranspiration (ET) data for determining application rates and updating irrigation scheduling. ET information is provided to the central irrigation computer by the weather station. The central irrigation computer, programmed with specific crop factors, automatically calculates water requirements of the various irrigation blocks and metered water is provided accordingly. Water demand for selected crops is equal to or slightly greater than pan evaporation, based on information from the University of Hawaii Water Resources Research Center and the College of Tropical Agriculture of the University of Hawaii. Phone modem hook-ups from each project allow additional daily monitoring of each reuse project from the reuse irrigation consultant's office.

Laie Water Reclamation Project

The Laie Water Reclamation Project (LWRP) is a cooperative venture between Hawaiian Reserves Inc. (HRI) and Brigham Young University-Hawaii (BYUH). The LWRP will eventually accommodate up to 900,000 gallons of reclaimed water per day. Reclaimed water for the LWRP is generated by the Laie community, which is currently served by the Laie Water Reclamation Facility (Laie WRF). The Laie WRF is privately owned and operated by HRI. Reclaimed water produced by the Laie WRF is classified as R-2 water, although provisions are under way to upgrade the Laie WRF to R-1 status. Only domestic wastewater from residences, commercial enterprises and institutions enters the Laie collection system. No industrial water is treated by the Laie WRF.

The drip-irrigated turf at the Kukuiula water reclamation site is maintained by outside contractors.

Approximately 57 acres of land owned by HRI and BYUH is being subsurface-drip irrigated with reclaimed water. The total subsurface-drip irrigated site consists of approximately 11.5 acres of BYUH campus, nine acres of baseball field and rugby field, a five-acre plot of tropical flowering trees, 11 acres of bananas, 17 acres of diversified crops, and four acres of other experimental turf and pasture grass plots.

The water reclamation project anticipates using between 300,000 to 350,000 gallons of reclaimed water per day for irrigation. The average application rate for the project area is approximately 0.22 inches per day.

Approximately 1.3 million feet of drip tubing was used on this project. The subsurface polyethylene drip tubing had a 0.040-inch wall thickness with 0.53 GPH trifluralin-impregnated emitters spaced 24 inches in the tubing. The drip tubing was injected six inches deep and spaced 15 inches from each side of the banana rows, 24 inches to one side of the papaya rows, 24 inches apart in the experimental turf plots and 48 inches apart in the pasture plot.

On the BYUH campus and baseball and rugby fields, the drip tubing was injected ten to 12 inches deep and spaced 24 inches apart. In the tropical flowering tree plot, emitter spacing is 36 inches on center in the tubing. The drip tubing is buried ten to 12 inches deep and spaced 48 inches apart. Future expansion of water reuse utilizing subsurface drip irrigation is anticipated for HRI and BYUH.

Kukuiula Development, Phase 1

The Kukuiula Development, Phase 1 residential community and golf course project on the island of Kauai is addressing turf and landscape irrigation needs by reclaiming domestic wastewater through a subsurface drip irrigation system. Initially, 54 acres out of the proposed 1,000-acre development are being subsurface-drip irrigated. Currently, the reuse irrigation system is designed to accommodate an average effluent flow rate of 422,000 gallons per day of secondary-disinfected effluent (R-2 water) from the new lagoon type wastewater treatment facility (WWTF). The future Phase 2 of this project will accommodate an average flow of 1.1 million gallons per day of reclaimed water.

This project utilizes two fully computerized nonpotable subsurface-drip irrigation systems for the turf and landscape application. One irrigation system blends R-2 water from the WWTF with nonpotable reservoir freshwater. The second irrigation system uses only nonpotable freshwater from the reservoir source. Reclaimed water from the WWTF will be the primary source for irrigating landscape areas around the WWTF and adjacent roads. When reclaimed water flows are insufficient to meet irrigation requirements, as expected during initial construction of the Phase 1 development, portions of the irrigation system will be supplemented by the nonpotable freshwater reservoir source.

Approximately 1.2 million feet of drip tubing was installed on the project. The subsurface polyethylene drip tubing had a 0.04-inch wall thickness with 0.65 GPH trifluralin-impregnated emitters spaced 24 inches in the tubing.

Underlying basaltic bedrock throughout the project site precluded injecting the drip tubing. When blasting and mass grading of the site was completed, screened soil was imported and spread over the entire rocky site designated to be subsurface-drip irrigated. Netting material was unrolled on the spread soil. The drip tubing was placed 24 inches apart on the netting and secured to the netting to prevent tubing movement during the soil covering process. Imported screened soil was spread over the drip tubing to an average depth of six inches. The area was then grassed with hydromulched Seashore Paspalum stolons.

Supplemental slow-release granular fertilizer is broadcast throughout the turf areas on a regular basis. However, the absence of a conventional sprinkler system that would normally provide overhead watering appears to have resulted in slower fertilizer dissolution, thereby lengthening the intervals between applications. The slower fertilizer dissolution probably results in less leaching of fertilizer beyond the turf rootzones. This lower fertilizer usage provided an extra cost savings to the project.

The Kukuiula wastewater treatment facility and the reuse irrigation system are each managed by outside contractors who are responsible for operating, maintaining and managing the systems in accordance with Chapter 62 of Title 11 Hawaii Administrative Rules and the Reuse Guidelines.

Water reuse needs to be included in the water-planning process. It is a concept that addresses the challenges of managing and extending our limited potable water resources and the safe and proper disposal of our wastewater effluent. The subsurface-drip irrigation concept presents a very viable and attractive alternative technology to conventional effluent disposal methods while simultaneously addressing the issues of water conservation and the irrigation needs of landscape and agriculture. ❑

Elson C. Gushiken is the vice president of ITC Water Management in Haleiwa, HI. *This article is reprinted with permission from* Journal AWWA Annual Conference Proceedings, *Vol. D, Water Quality,*