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Direct potable reuse

Overcoming challenges to adoption

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Subsurface drip irrigation conserves water, solves disposal issues

Subsurface drip irrigation (SDI) for disposal and reuse of treated effluent has significant advantages for communities limited in disposal options. **Peter Gearing** of Ecogent Ltd. and **Rodney Ruskin** of Geoflow Inc. explain how a New Zealand coastal community resolved technical, social, and environmental challenges, while conserving water to meet the needs of a growing community. Three very different areas with different needs successfully used SDI, thereby demonstrating the versatility of the technology for dispersal and reuse.

The seaside residential community of Pauanui, New Zealand relies on subsurface drip irrigation (SDI) to dispose of secondary ultraviolet (UV) treated effluent as part of a beneficial reuse project.

Pauanui is on a narrow sand bar located on New Zealand's North Island. The peninsula is a beautiful region visited by international and local vacationers. In order to protect the peninsula's pristine environment, the Thames-Coromandel District Council (TCDC) commissioned a new community sequential batch reactor water resource recovery plant at Pauanui-Tairua.

"The Pauanui community has, from the outset of consultation for the resource consent for wastewater reuse, expressed their desire for the wastewater to be used beneficially in the community for irrigation rather than simply disposed of," said TCDC Project Engineer Gordon Reynolds. "The consequence of this reuse requirement was a set of very high quality standards for the wastewater from the treatment plant."

The disposal of the treated effluent from the new plant had to resolve several technical, social, and environmental challenges before it could be accepted as the solution. The original treatment plant used aerated ponds with disposal via surface-applied, high-rate sand beds hidden under wooden covers in the median strip of one of the community's main streets.

Commissioned in December 2009, the new system was designed to cope with larger future flow rates, thereby requiring an improved disposal system. Other issues – such as blinding of the sand surface with biological growth, complaints about the aesthetics of the system, and sea disposal – were also considered. The Maori are opposed to sea disposal; land disposal is their preferred methodology.

One solution was to construct spray irrigation systems within forested plantations. Unfortunately, landowner resistance, capital and operational costs, problems with plantation management, poor soil drainage capacity, and the steep topography of the land excluded this option.

SDI enabled treated effluent from the Pauanui-Tairua treatment facility to be beneficially used – particularly for long, hot, dry summer irrigation in this restricted potable water area.

SDI option

Geoflow's technology of drip emitters – impregnated with both a sustained, slow-release herbicide to prevent root intrusion and an anti-microbial agent used in the dripline lining to reduce propensity for bacterial slime growth – meant that drip irrigation could be considered as a viable disposal option.

The SDI option brought many advantages to the treated effluent reuse, including:

- No public contact with the treated effluent
- No aerosols and no odors produced from the irrigation
- Disposal occurs while the irrigation areas are in public use, which simplifies system operation and effluent storage needs
- No need to purchase new lands for disposal
- Disposal is neither negatively affected by wind nor by cross contamination of surface rainfall runoff

Because Pauanui is an area with restricted potable water, a beneficial irrigation reuse solution combines the advantages of saving potable water currently used for community irrigation, while also irrigating community areas not previously watered.

The SDI system irrigates Kennedy Park, the community air strip, and road medians. It also has future potential to supply two golf courses and grassland behind the beach foreshore. All irrigation is via buried drip lines with electronic valves controlling each area. The irrigation has automated self-cleaning filter chambers and a pigging system to assist in keeping mainlines clean and prevent residue from building up.

The system is automated to rotate irrigation depending on fluctuations in output flow, applying different irrigation rates to different areas. It is designed to contend with the high flows resulting from extreme rainfall conditions and from summer holiday crowds.

System features and site-specific issues

The system configuration overcomes numerous issues unique to each site: namely, the specific needs of Kennedy Park, the airstrip, and the Vista Paku median systems, which all required different irrigation configurations and application rates, management regimes, and priorities for beneficial reuse. Additionally, the system needed to be built through the middle of a community going about its daily business, and also had to consider an operating wastewater treatment plant.

The original disposal system needed to be decommissioned and the wastewater immediately sent to the new system. The reuse system needed to be both unobtrusive and compatible with all other users and requirements – such as Parks and Reserves regarding maintenance as well as the Community Board and other key local stakeholders in terms of aesthetics, noise, odor, and other issues.

While the irrigation system provides beneficial reuse in periods of summer drought, it also handles effluent volumes in rainy periods without negatively affecting the medians,

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>
> TCDC Project Engineer Gordon Reynolds

air strip, or park. The wet periods require simple and easily implemented disposal, whereas, previously, the maximum predicted wastewater influent volume was so large that long-term storage was not a viable option.

The irrigation control system is integrated into both the wider treatment plant control system, and is compatible with TCDC's remote supervisory control and data acquisition (SCADA) telemetry system, and the reuse system meets requirements to log irrigation volumes to each individual area for resource consent purposes.

The daily flow rates currently range from 1,000 cubic meters per day (m^3/d) during non-holiday periods to 4,000 m^3/d during summer holidays. System capacity is currently measured at 11,300 m^3/d, but easily expandable to 20,000m^3/d.

Irrigation pump station

The underground irrigation pump station is located below a driveway with trucks parked on top. The station incorporates multiple dry well, vertically-mounted, centrifugal, multistage pumps and a wet well with automatic level-detection to effectively manage flow, capacity, and sudden changes in volume.

The irrigation system has banks of automatic field valves of approximately similar flow rates.

As the level rises within the pump-station when the treatment plant releases a batch of treated effluent, the control system detects the water level and automatically matches the number of pumps and active irrigation to suit.

The pump-station is designed to accommodate future growth.

Mainline design and volume management

The issues of large mainlines, typically low velocity during low-flow periods and bacterial slime growth, have been handled using a specialized mainline "pigging" system, which is the propulsion of a plug through pipes to perform cleaning functions; automatic self-cleaning filters in the irrigation fields themselves; and subsurface drip technology incorporating anti-microbial inner tube linings.

The mainline pigging system uses pipe sizes ranging from 160 millimeters to 355 millimeters – incorporating angles, bends, tees, manual valves, and more, and involving some very deep receiving manholes (including one that is estimated to measure deeper than 6 meters).

This system has already enabled successful pipe cleaning from bacterial slime and has allowed safe operation of launching and pig retrieval. The system has been designed to return all dirty flushed water back to the treatment plant through the existing sewer network, while also allowing full operator access for maintenance.

System controls

The control system incorporates a combination of wireless and hardwired automatic controls. The operators select the priority for the day – such as wet-weather mode, or dry-summer-peak mode, or other preset standards – and the system automatically sets the irrigation priorities throughout its entirety. It then runs automatically and sequentially around the irrigation zones as effluent becomes available from the water resource recovery facility.

At this time, no other commercial community effluent SDI system that operates in this order of application rates is known. The 2.4-acre Kennedy Park receives a moderately high rate of approximately 100 millimeters per day. The 14.83-acre airstrip handles an irrigation rate based on evapotranspiration, while the median strip can receive up to 1,500 millimeters per day.

The median system required a unique design and special techniques for installation due to the close spacing of the driplines required to achieve the high application rate. A close-spaced dripline was supplied by Geoflow, and a new high-rate disposal media bed was designed.

The newly developed areas also needed innovative engineering to ensure the curb design prevented stormwater from accessing the fields (and vice versa), and to maintain road integrity and strength.

Research for future expansion

Given the potential risk of applying treated effluent to the Pauanui sand aquifer, technical assessments were carried out to determine the possible effects on groundwater and surface water quality prior to the final selection of the disposal and reuse strategy in Pauanui. The identified risks to human health and the environment include pollution of potable water from water wells, contact within the groundwater discharge and surface water mixing zone, consumption of contaminated shellfish, and aerosols from spray irrigation of contaminated groundwater at the golf courses. The assessment demonstrated that risks were low after the installation of the SDI system, while it also identified solutions for future increased reuse at Pauanui that maximizes benefits to all stakeholders.

It was of primary importance to quantify loading rate in the initial assessment of reuse options both for design purposes and to assess the risks of breakout or ponding. Furthermore, the induced hydraulic gradients associated with groundwater mounding were critical to establishing the velocity and dilution factors important to contaminant transport in the aquifer.

Between 2003 to 2004 a trial SDI system – measuring 300 meters long and 30 meters wide – was installed and operated at rates that varied from 70 to 150 millimeters per day. A network of groundwater monitoring wells was also installed and water level and water quality data was collected from October 2003 to October 2004. Soil moisture probes were used to measure saturation at 10-centimeter-depth increments in the top 1 meter of the soil profile within the irrigation field.

Extensive two- and three-dimensional groundwater modeling was undertaken to assess the likely degree of groundwater mounding associated with the reuse at various application rates. Calibration of the flow models was achieved using observational data from the trials and compliance monitoring, data collected from a seven-day pump test of the municipal supply boreholes, and from the seasonal water level record from around an additional 30 other piezometers located around the peninsula.

Water quality data from the wells used for historic compliance monitoring at Vista Paku allowed direct observation of the aquifer's ability to reduce bacteria through filtration. The assessment of risk associated with pathogens for the proposed land reuse was undertaken using groundwater models to calculate travel times to determine die-off rates based on the predicted seepage velocities. The modeled scenarios indicated that following the high level of wastewater treatment prior to land reuse, pathogen concentrations would not present a risk to human health under any exposure pathways after reduction by dispersion effects, further microbial die-off, filtration, and absorption.

In order to further understand the actual risks that may be presented by viruses in groundwater (given the theoretical die-off times could be up to 12 months), TCDC's consultants undertook a collaborative research program with the Institute of Environmental Science and Research in New Zealand. Throughout the field experiments to measure viral die-off, consents were obtained to inject inert viruses, bacteria, and tracer chemicals at two sites during a number of pilot and live tests. The experiments were completed in 2009 and the results support extremely high removal rates of viruses, with adsorption being identified as the key mechanism for the attenuation.

Sound scientific data, complex predictive analysis using modern industry tools, and leading-edge scientific research confirmed the safety and effectiveness of the design and operations of the Pauanui beneficial reuse system. It also demonstrated the harmony of science and engineering in achieving the sustainable objectives set by the TCDC and the community.

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Events 2015

June

7-10 Anaheim, California, USA
ACE15, Annual Conference & Exposition, organized by American Water Works Association
www.awwa.org

8-10 Washington, DC, USA
Water and Energy 2015: Opportunities for Energy and Resource Recovery in the Changing World, organized by WEF, European Water Association, Japan Sewage Works Association
www.wef.org/WaterEnergy

15-16 Singapore
Workshop on Water Reuse Policies for Direct and Non-Direct Potable and Industrial Users Organized by National University of Singapore, Institute of Water Policy, National Environmental Research Institute
E: spphctq@nus.edu.sg

August

4-8 São Paulo, Brazil
FENASAN Brazil 2015: 26th National Congress and Exhibition on Sanitation and Environment Services. Includes WEF International Pavilion
www.fenasan.com.br

17-19 San Francisco, California, USA
Smart H2O Summit 2015: Sustainable Water Solutions. Held in partnership with The Water Innovation Project
www.smarth2osummit.com

23-28 Stockholm, Sweden
World Water Week in Stockholm Organized by Stockholm International Water Institute
www.siwi.org

30- September 4 San Diego, California
IDA World Congress 2015: Desalination & Water Reuse, Renewable Water Resources to Meet Global Needs
www.idadesal.org

August

9-11 Santa Marta, Colombia
58th International Congress of Water, Sanitation, Environment, and Renewable Energy, Organized by The Colombian Association of Sanitary and Environmental Engineering (ACODAL) Includes WEF International Pavilion
www.acodal.com

September

13-15 Seattle, Washington, USA
30th Annual WateReuse Symposium
www.watereuse.org

15-18 Johannesburg, South Africa
IFAT Environmental Technology Forum Africa: Water, Sewage, Refuse, and Recycling Solutions for the Mining and Construction Industry Includes WEF International Pavilion
www.ifatforum-africa.com

26-30 Chicago, Illinois, USA
WEFTEC 2015, 88th Annual Water Environment Federation Technical Exhibition & Conference
www.weftec.org

October

13-16 Koblenz, Germany
International Conference on Water Resources Assessment and Seasonal Prediction Organized by the German Federal Institute of Hydrology and the German IHP/HWRP Secretariat
www.worldwaterbalance.org

19-22 Dead Sea, Jordan
4th Water and Development Congress and Exhibition, organized by International Water Association
www.iwa-network.org/WDCE2015

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modifications in the feed, permeate, and reject piping.

During DO-HS a few processes take place simultaneously on the membrane:

Fouling lifting and sweeping: The high-salinity solution moves into the feed-brine side of the membrane, where foulants are deposited during normal RO membrane operation. Due to the high salinity, permeate cannot be produced. On the contrary, permeate is sucked up into the feed side, increasing its volume and thus increasing feed-brine velocity. Thus, two forces are active at the same time. The first force is the permeate water passing the membrane surface from the permeate side to the feed-brine side, lifting the foulants from the membrane surface. The second force is the cross membrane velocity in the feed-brine side, which sweeps the foulants out to the concentrate outlet. The combination of the increased feed velocity with the lifting of the fouling provides a strong cleaning effect of the contaminants deposited on the membrane surface.

Bio-osmotic shock: Bacteria are covered by a semi-permeable membrane similar to the RO membrane. The high osmotic pressure solution sucks the water from the bacteria and dehydrates them. This is the oldest salt curing method, which people have used for centuries.

Conclusion

After ten years of successful operation, IDE Technologies Ltd is going to offer the IDE PROGREEN and the DO-HS cleaning method in plants built and operated by other original equipment manufacturers.

Authors' Note

Dr. Boris Liberman, IDE Technologies' VP and CTO for membrane technologies, contributed this article along with Operational Solutions Services Manager, Miriam Brusilovsky and Manager Nathan Louzon in the Customer Support Department.

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Best sustainable solution

"In every respect this design has met the targets required, whilst including a substantial allowance for future-proofing," Reynolds said. "Wastewater reuse is a controversial and emotive problem for all communities and this solution is the best sustainable solution achieved to date in New Zealand. For Thames-Coromandel District Council, it is particularly problematic with five-fold seasonal increases in population in its coastal resort settlements."

The communities receiving the effluent were so pleased with the benefits of their new irrigation systems that they are seeking an increase in allocation in order to expand their irrigated areas.

"From a client perspective, it has been an excellent outcome as it has satisfied the desires of the community, the need to protect the environment, the requirement to conserve water, and to meet the future needs of a growing community," Reynolds added.

The SDI method of treated effluent disposal combined with reuse as shown by this system has advantages for situations where it is considered appropriate to dispose of the effluent in areas in close proximity to (or actively used by) the public.

In June 2010, the Pauanui beneficial reuse system won a prestigious local New Zealand INGENIUM (Engineers for Public Assets) Award – noted as "Highly Commended" in the projects category of more than $2-million. Today, in 2015, the system is continuing to work well.

Authors' Note

Rodney Ruskin is the CEO at Geoflow, Inc., based in Corte Madera, California, United States.

Peter Gearing worked as a consultant to design the Pauanui system, and is now a senior environmental engineer at Ecogent Ltd. in Auckland, New Zealand.

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