SCADA OPERATION AND MONITORING OF LARGE SCALE ON-SITE WASTEWATER TREATMENT AND REUSE SYSTEMS

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ABSTRACT

The Central Queensland University (CQU) and industry partner GBG Project Management Pty Ltd have been developing Supervisory Control and Data Acquisition (SCADA) technology to remotely operate and monitor large scale on-site wastewater treatment and reuse systems. The current trend towards decentralised systems is increasingly of interest in this area. Issues identified with these types of systems in the past have included the use of inappropriate technologies, hydraulic surges, difficulties in monitoring operation and identification of maintenance issues. The SCADA technology is used in association with KEWT systems, an innovative series of recirculating filter and evapotranspiration beds. It has allowed for the minimisation of hydraulic short-circuits and the calculation of evapotranspiration volumes. The SCADA system has also been designed to identify maintenance issues, especially in regards to pump performance and pump line blockages or ruptures.

KEYWORDS
Alarm, commercial businesses, CPU, hydraulic surge, KEWT, maintenance

1.0 INTRODUCTION

The majority of on-site systems in Australia are septic tanks and located at domestic premises (Beal, Gardner et al. 2003). Regulatory authorities have in recent years been focused on improving the legislative framework and operation of domestic on-site wastewater treatment plants (Asquith, Shelly et al. 2005). Less attention has been paid to systems with an equivalent person (EP) rating of 20 persons or greater (Asquith, Shelly et al. 2005). These types of systems are typically installed at schools, taverns/pubs, mining camps, child care centres, hospitals, caravan parks, camp sites, and highway service centres. Asquith, Shelly et al (2005) reported that common problems encountered with these systems include; poor understanding of wastewater generation patterns, no consideration of stormwater or trade-waste inputs, lack of management and operational resources, poor understanding on how the system works, vandalism or damage to the components, and inadequate monitoring of the system. It is thought that a real-time control mechanism and remote monitoring system will alleviate these concerns to some extent. Supervisory Control and Data Acquisition (SCADA) gathers information and controls on a supervisory level, a mechanical process and/or numerous processes. It is purely a software package that is located with the hardware to which it is interfaced, in general via Programmable Logic Controllers (PLCs), or other commercial hardware modules. This type of program has been commonly used to control and monitor local government water services, but has not occurred frequently in privately owned on-site wastewater treatment and reuse systems. The Central Queensland University has for the past seven years researched a technique of on-site wastewater treatment and reuse (Kele, Midmore et al. 2005). The technology is based on a type of recirculatory evapotranspiration channel (see figure 1). Primary treatment is obtained though the use of anaerobic sludge chambers and in-line filters. Secondary treatment techniques use a

combination of aeration, aggregate biofilms, and sand, soil and rhizofiltration.
Tertiary treatment relies on biological activity from microorganisms and selected plants as well as the cation exchange capacity of specific aggregates. Reuse is through evapotranspiration or if desired though a variety of surface applications. Non-transpired effluent can recirculate through the system until used. The treatment and reuse method that has been developed is marketed as the Kele effluent wastewater treatment (KEWT) system. The research into the KEWT system has examined microorganisms, particularly faecal coliforms, macro- and micro-nutrients, pH, plant transpiration, plant selection, as well as the potential limiting factors of heavy metals, salinity and sodicity. The system has been commercialised and licenced to GBG Project Management Pty Ltd, a company that specialises in large on-site wastewater treatment systems.

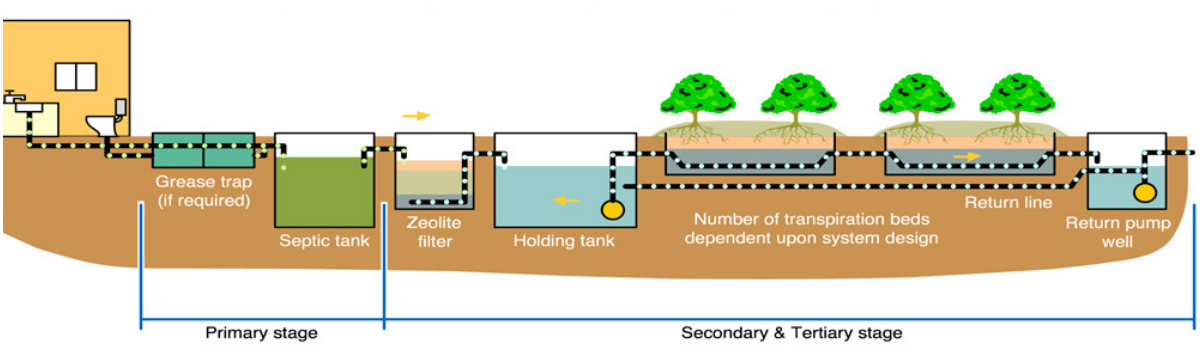


Figure 1: ***Schematic of KEWT Treatment System***

SCADA systems linked to KEWT treatment plants have, since June 2005, been installed at a pub with attached mining camp (100 EP), a motel with attached restaurant and licenced venue (250 EP), a child care centre (30 EP), a tavern (50 EP), and the Greenbank State School (600 EP). The Greenbank State School is the largest site and treats the wastewater from approximately 1000 primary and pre-school children and 100 teaching and support staff.

2.0 DISCUSSION

2.1 Infrastructure and Alarm Types of the SCADA System

The monitoring and control of the KEWT system is accomplished using SCADA arrangements in the field to control pump function and water flow, and to enable supervision of the operational aspects of the site. The on site alarm and control system are powered with an un-interruptible power supply (UPS) with a reserve capacity of at least 12 hours. The SCADA units communicate to a central monitoring location via redundant links of differing formats. These links consist of a physical link through the public switched telephone network (PSTN) and a redundant global systems mobile (GSM) link through the mobile network (MN). Both the PSTN modem and the GSM modem is powered via the UPS allowing site monitoring at all times.

Pumps are monitored for correct operation; alarms are raised in the event of a failure. Water levels in the holding tanks are continuously monitored and the pump run times are automatically modified to keep the levels within specified limits. Effluent flow rates are monitored in the feed lines to ensure correct operation of diversion and flow control valves and assist in the detection of system abnormalities. The SCADA control system, UPS, PSTN modem and GSM modem will be housed in a lockable stainless steel enclosure rated to IP 65 and mounted either on a pole, slab, or nearby shed, close to the

KEWT system.
Primary power circuit breakers, pump control relays and pump current monitors as well as any primary power metering will be housed in a separate lockable stainless steel enclosure also rated at IP 65 and mounted near the SCADA enclosure.

Urgent alarms will be reported immediately to the Central Monitoring station flagged for urgent action. Types of alarms in this category will directly and immediately affect system operation and should be attended to without delay. Non-Urgent alarms will be reported on the next scheduled site scan by the Central Monitoring station. Types of alarms in this category will not directly affect system operation or integrity but may indicate unusual operational parameters. Off-Normal alarms indicate manual intervention has been initiated and will be reported on the next scheduled scan by the Central Monitoring station. These alarm categories may be reported visually and/or audibly locally if required by legislation. The level sensors are placed in the lid of each tank, facing directly into the water. The sensors are PIL brand 50kHz 24 V DC ultrasonic transmitter/receivers with a 0 – 10 V analogue output proportional to the distance of the target from the sensor. Sensor range is 200 mm to 2000 mm. The sensors are power fed from the SCADA and the analogue output is processed directly by the SCADA. The output from these sensors is used to mitigate the pumping regime established in each tank. These sensors are also used to trigger some alarm conditions to be reported to the control station.

2.2 SCADA Software Instruction Summary for Greenbank State School KEWT System

The computer program behind the SCADA infrastructure is what determines its effectiveness. This next section describes the software instructions that control the operation and data collection procedures of the SCADA system at the Greenbank State School. A schematic of the KEWT system can be seen in Figure 2. One of the main aims of the computer program is too equalize flows through the treatment processes, as wastewater production at schools typically occurs in surges, in accordance with the school schedules. Very little wastewater is produced outside of normal school hours or school holidays unless a special event is occurring. The site also had installed an irrigation tank (tank 4) as the excess recycled water from the treatment system is used to irrigate a cabinet timber plantation and the school oval (sub-surface).

Tank 1 Requirements:

1. Pump P1 run for 15 minutes every 3 hours
2. No pump if tank level less than 50%
3. No pump if level sensor fails
4. Pump run immediately if tank 1 level more than 75%. Pump down to 60% then revert to 15 minutes every 3 hours
5. Stop pumping if emergency overflow pump is running

Tank 2 Requirements:

1. Pump P1 run for 15 minutes every 3 hours
2. No pump if tank level less than 50%
3. No pump if level sensor fails
4. Pump run immediately if tank 2 level more than 75%. Pump down to 60% then revert to 15 minutes every 3 hours
5. Stop pumping if emergency overflow pump is running

Tank 3 Requirements:

1. Pump P3 run if tank level more than 75%
2. No pump if tank level less than 25%
3. No pump if emergency pump P5 is running
4. No pump if level sensor fails
5. No pump to tank 1 if tank 1 level more than 75%

Emergency Overflow requirements

1. Pump P4 (to Tank 4) run if level in T3 is more than 90%. Pump down to 35%
2. No pump (to Tank 4) if Tank 4 is less than 85%
3. Revert to subsurface drip if Tank 4 is less than 85%
4. No pump if level sensors in Tank 3 or 4 fail

Tank 4 (irrigation tank) and commissioning root feed

1. Pump P4 run at 0530 for 3 hours
2. No pump if Tank 3 level below 25%
3. Pump P4 run at 1703 for 3 hours
4. No pump if Tank 3 level below 25%
5. Pump P5 run at 0530 for 3 hours
6. No pump if Tank 4 level below 25%
7. Pump P5 run at 1703 for 3 hours
8. No pump if Tank 4 level below 25%

Transpiration levels

1. Measure level in Tanks 2,3,4 before cyclic pump
2. Wait for 15 minutes then log the levels in Tanks 2, 3 and 4 again
3. Calculate difference in levels
4. Log difference

Pump Run Logs

1. Record the hours run for each pump
2. Log hours run

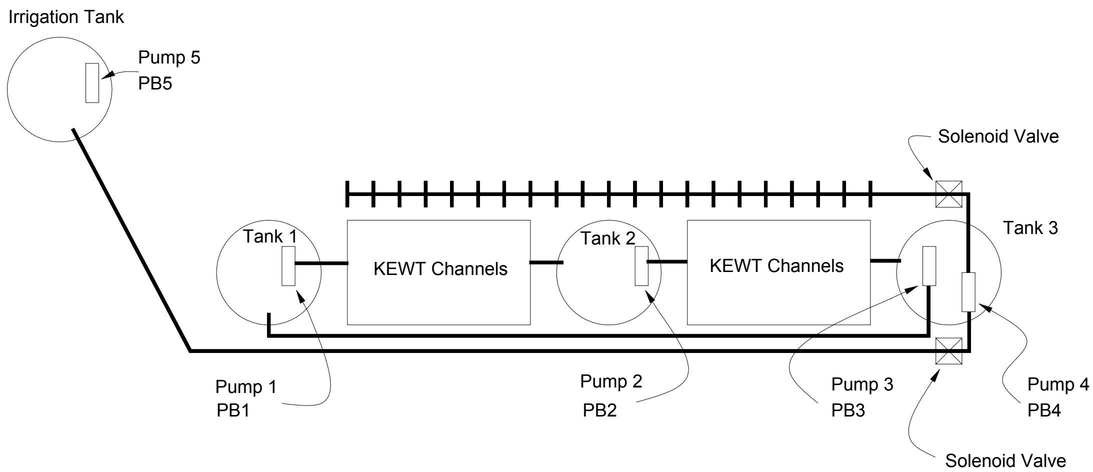
Tank Level Logs

1. Record tank levels every 3 hours halfway through pump cycle
2. Log levels

Alarms

1. If contractors operate without a valid pump run command raise an "OFF NORMAL" alarm and Exception Report to Control Centre
2. Sensor Fail raises "URGENT ALARM" and send Exception Report to Control Centre.
3. Total system reserve less than 20% Send SMS and Exception Report to Control Centre.

The data collection aspects of the program are aimed at providing information that would highlight any operating or maintenance problems within the KEWT system. Pump failures or line blockages are easily identified, as are stormwater intrusions and infrastructure failures at the school (eg malfunctioning urinal). The health of the plants in the KEWT channels can also be monitored via the evapotranspiration volume; if these decrease with no logical explanation, such as extended overcast weather conditions, it can be assumed that something is wrong and needs correction, and a visit to the site can be made.



<u>Figure 2</u>: ***Schematic of KEWT system at Greenbank State School***

2.3 Data collection and monitoring

In Table 1 the data acquired by the SCADA system at the child care centre are shown.

<u>Table 1:</u> ***Child Care Centre KEWT System Operating Statistics for January-February 2006***

Parameter	Pumping Time (Hours)	Average Percentage Tank Capacity	Average Evapotranspiration Volume (Litres) per day
Pump 1	247	-	-
Pump 2	99	-	-
Tank 1	-	62%	-
Tank 2	-	61%	-
KEWT system	-	-	2136

It is clear that the pump 1 (in tank 1) is working more frequently than pump 2 (in tank 2). In this KEWT system the primary treated effluent is gravity fed to Tank 1, pumped through the KEWT system and any excess effluent is gravity fed into tank 2 and pumped back to tank 1 so it can recirculate through the system. The effluent volume within each tank is balanced and equilibrium is being maintained. The evapotranspiration volume per KEWT channel over this time period was less than expected due to extended overcast conditions and relatively high rainfall.

Figure 3 shows the weekly wastewater generation patterns and the equalization processes undertaken by the SCADA program.

Figure 3: ***Tank Capacity for Child Care Centre KEWT System Over a Week***

Wastewater production ceased on the afternoon of Friday the 13th of January, and did not commence until the morning of Monday the 16th. The overcast conditions on that weekend reduced the amount of evapotranspiration effected by the plants in the KEWT channels; hence the relatively consistent tank volumes. The impact of the clear conditions and the associated increase in evapotranspiration rate on the Monday morning on tank volumes can be seen.

3.0 CONCLUSIONS

The operation of the SCADA technology in conjunction with the KEWT system has so far been successful. SCADA technology may solve some of the control and monitoring problems associated with medium to large on-site wastewater treatment and reuse systems.

4.0 ACKNOWLEDGEMENTS

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