Impact of Water Softeners on Septic Tanks
Field Evaluation Study

Final Report

Submitted to:
Canada Mortgage and Housing Corporation

Submitted by:
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January 6th, 2006

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Executive Summary

A field study of septic tank performance was conducted in order to determine whether water softener backwash addition to the septic tank had a significant effect upon tank performance. The sample group consisted of septic tanks receiving water softener backwash (n=27) and tanks not receiving water softener backwash (n=48). This study does not address impacts upon the performance of leaching fields.

Significant differences ($P<0.05$) in the sodium and chloride concentrations in tank sludges were found between the two groups with mean chloride concentrations increasing from 146 to 1515 mg/L and mean sodium concentrations increasing from 239 to 548 mg/L in tanks receiving water softener backwash. No significant differences ($P>0.05$) were found for indicators of tank performance including: septic tank effluent COD, $CBOD_5$, TSS, and *E.coli*, sludge VSS and the sludge and scum accumulation rate. The results from this study indicate that water softener backwash discharged to septic tanks has no significant effect upon the biological or physical functioning of the septic tank; however, elevated chloride concentrations from water softener backwash may accelerate the corrosion of reinforced concrete tanks.

Acknowledgements

We would like to thank René Goulet of René Goulet Septic Tank Pumping for the considerable effort he made in collecting samples for this study. His knowledge and expertise with onsite wastewater systems has been of great benefit to the project.

We gratefully acknowledge the financial support of the Canada Mortgage and Housing Corporation for sponsoring this research project.

Introduction and Study Objectives

This study involves a field evaluation of the impact of water softener backwash on the functioning of septic tanks treating domestic wastewater. The primary objective of the study is to evaluate the impact of sodium chloride addition from water softener backwash on the physical and biological treatment occurring in septic tanks under field conditions.

Systems with and without water softener backwash discharged to the septic system are compared using several indicators of system performance: COD, $CBOD_5$, TSS and *E.coli* outlet concentrations, bacterial populations in the tank, sludge and scum accumulation rates, and signs of bed failure. The significance of each indicator is tested using an ANOVA at a 5 percent level of significance.

Background and Literature Review

There have been several studies conducted over the past 30 years which have attempted to address the issue of water softener discharge effects on onsite systems. Study results and field observations have provided contradictory evidence as to whether water softener discharge is detrimental to onsite systems. The potential impacts addressed include: hydraulic loading to the septic system, septic tank microbiology, tank mixing and settleability of suspended solids, and leaching field soil permeability (CWRS, 2001). Another potential impact which has not been addressed in previous studies is the potential for chloride induced corrosion of concrete tanks.

How a Water Softener Works

Water softeners remove hardness (dissolved calcium and magnesium) through an ion exchange process. Incoming hard water passes through a tank containing ion exchange resin beads which are super saturated with sodium. As the water passes by the beads, the calcium and magnesium ions replace the sodium ions on the resin and sodium is released into the water. When the resin becomes saturated with calcium and magnesium, a backwash regeneration cycle is instigated. A concentrated salt brine solution (NaCl) is bachwashed through the resin, replacing the calcium and magnesium ions on the resin with sodium ions. The regenerate water, containing calcium, magnesium, sodium and chloride flows into the septic tank and eventually into the leaching bed. The amount of sodium added to the water and salts added to the septic system will depend upon the hardness of the water, household water use and the type and operation of the water softener. Potassium chloride (KCl) can be used instead of sodium chloride to regenerate the ion exchange resin. Potassium chloride, which is roughly twice the cost of sodium chloride, is typically used when a resident is on a sodium reduced diet or when the treated wastewater is reused for irrigation.

Septic Tank Hydraulics

It is generally agreed that the hydraulic load from water softener backwash regeneration should not have a significant impact upon the detention time in the septic tank (CWRS, 2001; Moore, 2001). Regeneration rates can create an additional discharge of up to 190L per cycle, which is comparable to the volume discharged from a typical washing machine (CWRS, 2001). Given that water softeners typically recharge 1 to 2 times per week, the additional volume is equivalent to one or two extra loads of laundry per week. In a study on home water use, Siegrist *et al.* (1976) found that water softener discharge accounted for only 6.2% of the total flow to the septic tank. Water softener discharge should in most circumstances have no significant impact on the hydraulics of the septic tank as the volume is relatively small, the wastewater is discharged quite slowly to the tank, and in most cases the regeneration backwash cycle occurs at night, when household water use is at a minimum.

It has been suggested by CWRS (2001) that the regeneration brine could cause density stratification within the septic tank and that this could lead to wastewater short circuiting through the tank. To our knowledge no studies have been conducted to test this hypothesis.

Impact of Salt on Septic Tank Microbiology

Septic tanks provide primary wastewater treatment through sedimentation and anaerobic digestion. The organic matter in the sludge layer undergoes facultative and anaerobic decomposition and is converted to more stable compounds and gases.

The biological conversion of organic matter under anaerobic conditions occurs in three steps: hydrolysis, acidogenesis and methanogenesis. In the hydrolysis step, a group of nonmethanogenic microorganisms break down high molecular weight organic compounds including proteins, starches and cellulose into simpler compounds such as monosaccharides and amino acids. In the acidogenesis step, a second group of nonmethanogenic microorganisms consisting of facultative and obligate anaerobic bacteria, referred to as *acidogens*, ferment the products to simple organic acids, the most common of which is acetic acid. Nonmethanogenic bacteria that have been isolated from anaerobic digesters include: *Clostridium* spp., *Peptococcus anaerobic, Bifidobacterium* spp., *Desulphovibrio* spp., *Corynebacterium* spp., *Lactobacillus, Actinomyces*, *Staphylococcus*, and *Escherichia coli*. In the methanogenesis step, methanogenic bacteria, referred to as *methanogens*, convert hydrogen and acetic acid formed by the *acidogens* into methane gas and carbon dioxide. Common methanogens include: *Methanobacterium, Methanobaciullus, Methanococcus*, and *Methanosarcina.* (Crites and Tchobanoglous, 1998)

Sodium is moderately inhibitory to anaerobic bacteria at 3.5 to 5.5 g/L and is highly inhibitory at 8 g/L (Robert Alley, 2000). In a study of sodium toxicity in mesophilic completely mixed anaerobic digesters it was found that methane production was reduced when sodium concentrations reached 6 to 9 g/L sodium addition; however, the addition of 200 mg/L calcium and 325 mg/L magnesium antagonized the sodium inhibition effect (Bashir and Matin, 2001). In a similar study on three different sludges, 50% inhibition was observed over a range of 3 to 16 g/L sodium with a strong antagonizing influence from the presence of other salts (Feijoo *et al*., 1995). In another study utilising an anaerobic granular biomass, sodium concentrations of 5, 10, and 14 g/L caused 10, 50 and 100% inhibition of methanogens, respectively, at neutral pH (Rinzema *et al*., 1988).

Kargi and Dincer (1999) found COD removal was inhibited in an rotating biological contactor (RBC) unit at NaCl concentrations greater than 20 g/L (2%), while Uygur and Kargi (2004) found decreasing COD, NH_4-N and PO_4-P removal with increasing NaCl concentration from 0 to 6 g/L using a lab scale anaerobic/aerobic sequencing batch reactor (SBR) system with a synthetic feed. In a study of a high NaCl wastewater treated by an anaerobic/anoxic/aerobic process, it found that COD removal declined from 97% to 60% and to 71% in non acclimatized and acclimatized brine solutions, respectively, as NaCl concentrations increased from 0 to 30 g/L (Panswad and Anan, 1999).

A study by the National Sanitation Foundation (NSF) (1978) on the impact of water softener brine on aerobic treatment units found no negative effects on the bacterial population. The literature review conducted by the Centre for Water Resources Studies

(Dalhousie University) reflects the same opinion, stating that salt addition to the septic tank slightly reduces the osmotic potential in the tank toward the optimum range for bacterial growth (CWRS, 2001). However, these findings were based upon NaCl concentrations measured at the septic tank outlet, as opposed to within the sludge itself where much of the digestion is occurring. Contradictory opinions were expressed in the Pipeline article (Moore, 2001) from two onsite wastewater experts who have observed trends of inadequate treatment from septic systems receiving water softener discharge including the non-digestion and carry-through of cellulose waste, as well as reduced scum layer development and carryover of solids and grease. These observations imply that the water softener discharge impacts the anaerobic bacterial metabolism as well as the settleability of solids in the tank, possibly due to density stratification and short circuiting through the tank.

Salt concentrations in septic tank effluent typically range from 40 to 100 mg/L chloride and 60 to 100 mg/L sodium excluding the addition from water softeners (Crites and Tchobanoglous, 1998). Sodium concentration in softened well water was 278±186 mg/L compared to 110±98 mg/L in municipal non-softened water in a Michigan study (Yarows *et al*, 1997). Backwash brine will increase chloride levels in septic tank effluent from 70 to 100 mg/L to 1500-2000 mg/L (CWRS, 2001).

In a study by Tyler *et al.* (1977), septic tank effluents (including systems with and without water softeners) were found to have salt concentrations from 7.3 to 21.8 meq/L (427 to 1644 mg/L NaCl) and sodium absorption ratios from 2.5 to 24.7. Sodium concentrations from septic tank effluent from households with a water softener (n=7) were 275 ±149 mg/L Na compared with 142±52 mg/L Na from households without a water softener. The osmotic potentials of septic tank effluents were determined to be between -0.21 and -0.77 bars, compared with reported optimal potential of -14 bars (~17,550 mg/L NaCl) for bacterial cell growth, suggesting that increasing salt content could actually improve the osmotic potential within a septic tank for bacterial life.

Hydraulic Conductivity of the Leaching Bed

Sodium can cause clay to swell, thereby reducing the hydraulic conductivity in the leaching bed. A study at the University of Wisconsin-Madison examined the effect of water softener discharge on the percolation rate of water in the leaching bed and found that there was no impact upon soil hydraulic conductivity (Corey *et al*., 1977). The researchers concluded that the calcium and magnesium in the regenerate waters counteracted the impact of the sodium, as divalent cations reduce swelling in clay soils. Soils with a clay content of 15% or more can experience swelling and a deterioration of hydraulic conductivity if the sodium adsorption ratio (SAR) is greater than 10, while the SAR value should be less than 20 for soils with lower clay content (Crites and Tchobanoglous, 1998). SAR is the ratio of sodium to calcium and magnesium ions in solution.

Corrosion of Concrete Tanks

Hydrogen sulphide gas (H_2S) is considered to be the primary cause of corrosion of concrete septic tanks. Sulphate in wastewater is biologically reduced under anaerobic conditions to sulphide which can combine with hydrogen to form hydrogen sulphide gas (H_2S) (Metcalfe and Eddy, 1991). Hydrogen sulphide gas accumulates in the void space above the liquid layer in the septic tank, where it can be oxidized biologically to sulphuric acid. The sulphuric acid leaches calcium from the concrete, reducing the tank's structural integrity and can lead to structural failure. As well, hydrogen sulphide can directly corrode exposed concrete reinforcement by reacting with iron to form iron sulphide (Perry and Green, 1997).

Chloride in known to act as a strong catalyst of corrosion of the iron bars in reinforced concrete (Litvan, 1984). Therefore, elevated chloride levels in septic tanks could accelerate concrete tank corrosion. However, we are not aware of any studies which have evaluated the relative role of elevated chloride concentrations from water softener backwash on the corrosion of concrete tanks.

Methodology

Field Data Collection

The study consists of the evaluation of 75 different residential septic tanks – 27 tanks with water softener backwash discharged to the tank and 48 without.

The field data was collected by René Goulet of Goulet Septic Tank Pumping. Mr. Goulet operates a septic pumping truck in Eastern Ontario, generally within the United Counties of Stormont, Dundas and Glengarry and the United Counties of Prescott and Russell (East of Ottawa between the Quebec and US borders). Ontario Rural Wastewater Centre (ORWC) researchers accompanied Mr. Goulet for the first several sample events in order to develop and document a standardised sampling methodology.

Each homeowner was asked to participate in the study as Mr. Goulet arrived to pump out the septic tank. Therefore, there was no possibility of bias from homeowners changing their practices on account of the study. Participating homeowners and individual data will remain confidential. A survey form was filled out by Mr. Goulet and each homeowner to gather the following information on each system: water softener type and amount of salt used, tank age, date of last pump-out, number of residents and bedrooms, type of septic system, soil type, and any history of bed failure or water quality problems. The survey form is presented in Appendix A.

The size, material and condition of each tank as well as any signs of leaching bed failure were documented by Mr. Goulet. The sludge and scum depths were measured using a "Sludge Judge"; a 2.5cm dia. clear plastic tube with a ball valve in the orifice. The tube is lowered into the tank and fills with a column of the tank liquid. When the tube is raised the ball closes the orifice and the depth of the sludge and scum layers can be measured. A photograph was taken of the outlet baffle when corrosion was evident.

A 2-L sludge sample was collected from the top 10 cm of sludge in the first compartment of each tank. The sludge sample was collected by taking a series of water column samples using the "Sludge Judge" and transferring the sludge component of the sample into a 2-L sample bottle. A 1-L sample was also collected from the outlet T of each tank. The "Sludge Judge" was used to collect this sample as well. Any scum was pushed aside prior to taking the sample and only sample collected from the level of the outlet T was transferred to the sample bottle. Samples were stored in a dedicated refrigerator in Mr. Goulet's garage prior to pick-up by ORWC staff and transfer to the Collège d'Alfred laboratory for analysis.

Laboratory Analyses

All samples were stored at 4ºC and all analytical methods follow Standard Methods for the Examination of Water and Wastewater (APHA/AWWA/WEF, 1998).

Each sludge sample was analysed for: Cl, Na, Ca, Mg, TSS, VSS, pH and total coliform. Each septic tank effluent sample was analysed for: Cl, Na, Ca, Mg, TSS, VSS, $CBOD_5$, COD, pH, total coliform, *E.coli* and heterotrophic plate count (HPC).

The Cl, TSS, VSS, $CBOD_5$, pH, total coliform, *E.coli* and HPC analyses were conducted in the ORWC Water Quality Laboratory at Collège d'Alfred, while the Ca, Mg, and Na analyses were conducted at Accutest Laboratories in Ottawa.

Statistical Analysis

The analytical results were divided into two groups: samples from tanks receiving water softener discharge and samples from tanks not receiving water softener discharge. Outliers were defined as being ± 3 standard deviations from the mean and were removed from the dataset. Data from the 2 groups were compared using a single factor ANOVA test for significance (P=0.05).

Results and Discussion

Raw data is presented in Appendix B.

Septic Tank Sample Group

The study sample consists of 75 septic tanks divided into two subgroups: 27 tanks receiving water softener backwash discharge (WS) and 48 tanks not receiving water softener backwash discharge (NWS). Table 1 compares the two experimental subgroups in terms of tank characteristics (volume, material, age) and use (number of inhabitants, years since the tank was last pumped out). As can be seen from Table 1, tank characteristics and use are similar between the two subgroups, suggesting that the impact of salt on tank performance can be compared between the two groups without an evident bias in the sample populations used.

Table 1. Septic Tank Sample Group

Parameter	Unit	Tanks Receiving Water Softener Backwash	Tanks Not Receiving Water Softener Backwash
		Median (Range)	Median (Range)
Number of Tanks	Number	27	48
Tank Volume	Litres	3600 (2700-5400)	3600 (1800-5400)
Tank Material		27 concrete	45 concrete - 2 steel – 1 plastic
Tank Age	Years	20 (5-40)	20 (2-40)
Number of Inhabitants	Persons	3 (1-5)	3 (1-6)
Years Since Last Pump-out	Years	5 (2-19)	4 (0.5-20)

Salt use to regenerate water softeners typically varied between 20-40 kg/month.

Effect of Water Softener Backwash on Tank Performance

Table 2 compares tanks receiving water softener backwash to tanks not receiving water softener backwash in terms of sodium and chloride concentrations and indicators of tank performance: Septic Tank Effluent (STE) COD, $CBOD_5$ and TSS concentrations and

E.Coli counts, solids accumulation within the tank, and bacteria populations within the tank. The sodium adsorption ratio (SAR) for the two groups is also compared, as this parameter could impact soil permeability in leaching beds with high clay content.

Table 2. Effect of Water Softener Backwash Discharge on Tank Performance

Parameter	**Unit**	**Tanks Receiving Water Softener Backwash (Mean ± 1 Standard Deviation)**	**n**	**Tanks Not Receiving Water Softener Backwash (Mean ± 1 Standard Deviation)**	**n**	**ANOVA P=0.05**
Cl^- (STE)	mg/L	686±773	21	90±69	35	0.00
Cl^- (sludge)	mg/L	1515±1329	15	146±67	21	0.00
Na (STE)	mg/L	604±801	19	121±76	36	0.00
Na (sludge)	mg/L	548±386	12	239±87	20	0.00
SAR (STE)		9.2±8.6	20	4.4±4.7	34	0.01
COD (STE)	mg/L	1004±1328	13	1611±2636	27	0.44
$CBOD_5$ (STE)	mg/L	340±203	18	396±281	33	0.46
TSS (STE)	mg/L	703±715	18	400±571	32	0.11
VSS (sludge)	g/L	33.5±20.7	16	30.3±13.3	21	0.57
TC (sludge)	cts/100 mL	1.87×10^6 (geometric mean)	16	4.46×10^6 (geometric mean)	18	0.44
HPC (STE)	cts/100 mL	2.83×10^6 (geometric mean)	11	3.86×10^6 (geometric mean)	25	0.54
E.coli (STE)	cts/100 mL	3.24×10^5 (geometric mean)	16	2.29×10^5 (geometric mean)	35	0.63
Sludge and Scum Accumulation Rate	L/person/year	118±78	23	117±57	39	0.95

NOTE: P<0.05 is considered to be a significant difference between means.

There were significant differences in both sodium and chloride concentrations (**P<0.05**) between tanks receiving water softener backwash and tanks not receiving water softener backwash (**P=0.00**). The chloride concentrations ($Cl_{(STE)}$ = 686±773 vs 90±69 mg/L) are similar to values reported in the literature: 1500 to 2000 mg/L in the STE of systems receiving water softener backwash and 70 to 100 mg/L in systems not receiving water softener backwash (CWRS, 2001). The two subgroups have significantly different sodium chloride concentrations; therefore, the impact of salt can be compared using indicators of septic tank performance.

Septic tank effluent quality was compared between the two subgroups in terms of COD, $CBOD_5$ and TSS; three common indicators of onsite wastewater system performance. As well, *E.coli* and HPC counts were compared to test whether salt impacts two common bacterial indicators. There were no significant differences (**P>0.05**) between $COD_{(STE)}$ (**P=0.44**), $CBOD_{5\,(STE)}$ (**P=0.46**), $TSS_{(STE)}$ (**P=0.11**), *E.coli* $_{(STE)}$ (**P=0.63**) and HPC (STE) (**P=0.54**) comparing tanks receiving water softener backwash to tanks not receiving water softener backwash.

Typical STE contains 150-250 mg/L BOD_5 and 40-140 mg/L TSS (Crites and Tchobanoglous, 1998). The average $CBOD_5$ and TSS values measured in this experiment ($CBOD_{5\,(STE)}$ = 377±255 mg/L; $TSS_{(STE)}$ = 509±636 mg/L) were higher than values reported in the literature. This suggests that high solids carryover into the leaching field may be a more significant problem than is suggested by the literature. The data from this study reinforces the importance of using septic tank effluent filters to prevent solids carryover into the leaching field and the importance of implementing management programs to have septic tanks periodically inspected and/or pumped out.

Bacterial degradation within the tank was measured indirectly using three indicators: volatile suspended solids (VSS), which is a common measure of bacteria biomass in aerobic and anaerobic digesters, total coliform, which is a common indicator of facultative bacteria, and the sludge and scum accumulation rate (Equation 1).

$$\text{Sludge and Scum Accumulation Rate} = \frac{\text{Depth of Sludge \& Scum x Tank Volume}}{\text{Liquid Depth x Persons x Years since last pump-out}} \quad \textbf{(Equation 1)}$$

There were no significant differences comparing tanks receiving water softener backwash to those not receiving water softener backwash for sludge VSS concentration (**P=57**), sludge total coliform counts (**P=0.44**) and sludge and scum accumulation rate (**P=0.95**). The lack of any observed impact from sodium concentrations on biological activity in the tank is consistent with the literature, which reports that sodium is only moderately inhibitory to anaerobic bacteria at concentrations of 3500-5500 mg/L and strongly inhibitory at 8000 mg/L (Roberts Alley, 2000); compared with an average sodium concentration observed in this study of only 550 mg/L. Only one sodium measurement was greater than the 3500 mg/L threshold.

There was a significant difference in Sodium Adsorption Ration (SAR) (**P=0.01**) comparing STE from tanks receiving water softener backwash to those not receiving water softener backwash. The tanks receiving water softener backwash had a median SAR of 7.9 and a range of 0.5-35.0, while the tanks not receiving water softener backwash has a median SAR of 1.6 and a range of 0.5-15.9. Thirteen of fifty eight STE samples had SAR values greater than 10; the limit at which swelling could occur in clay soils of greater than 15% clay content. Three of the thirteen systems with SAR>10 were in clay soils and none of the thirteen systems were showing signs of hydraulic failure. However, this study did not investigate the condition or permeability of the leaching field soils.

Tank Corrosion

The primary agent of concrete tank corrosion is sulphuric acid derived from hydrogen sulphide gas. However, high chloride concentrations from water softener backwash could play a role in accelerating the corrosion of reinforced concrete tanks by contributing to the corrosion of the reinforcing bars.

The condition of each tank in the study was recorded on the survey form and pictures were taken of systems which had experienced obvious corrosion. Table 3 describes the condition of the concrete tanks, while Figure 1 exhibits corroded outlet baffles from two of the tanks evaluated. As can be seen from Table 3, 38% of tanks receiving water softener backwash exhibited obvious corrosion of the outlet baffle, compared with 23% of tanks not receiving water softener discharge. It would appear that concrete tanks receiving water softener discharge are more likely to experience corrosion of the outlet baffle than tanks which are not receiving water softener discharge; however, the subjective and descriptive nature of the evaluation makes drawing a firm conclusion difficult. The impact of chloride from water softener backwash on corrosion of reinforced concrete tanks beyond that caused by hydrogen sulphide gas has not been evaluated in this study.

Table 3. Effect of Water Softener Brine on Tank Corrosion

Measure	**Units**	**Tanks Receiving Water Softener Backwash**	**Tanks not Receiving Water Softener Backwash**
Median Age (Range)	Years	20 (5-40)	20 (2-40)
Number of Tanks	Number	26	31
Number of Corroding Outlet Baffles	Number	10	7
Portion with Corroding Baffles	%	38	23

Figure 1. Corroded Outlet Baffles of two Tanks Receiving Water Softener Backwash – Does chloride accelerate the corrosion caused by H_2S gas?

Condition of the Leaching Bed

Twelve of seventy-five systems evaluated were experiencing hydraulic failure; where failure is defined as surface breakout (2 systems) or water level in the tank higher than the outlet (10 systems). Of the twelve leaching beds experiencing hydraulic failure, none were receiving water softener backwash; however, one home had a water softener which was not discharging the backwash to the septic system.

Importantly, 9 of the 12 systems were installed in clay soils, representing 41% of the systems installed in clay soils compared with just 3% failure of systems installed in other soil types. This data suggests that clay soils are a strong determinant of system failure.

The failed systems ranged in age from 10 to 40 years, with a median age of 27 years compared with a median age of 20 years for the rest of the systems, suggesting that system age is also a determinant of failure.

Solids Accumulation in the Tank

The solids (sludge and scum) accumulation rate was calculated to be 117±65 L/person/year (n=62). The literature and Ontario regulations typically suggest pumping out the septic tank when it has become 1/3 full of solids. Using this volume as the pump-out threshold, Table 4 provides a suggested tank pump-out frequency based upon the mean accumulation rate measured from 62 septic tanks. As well, the accumulated sludge data is presented as a function of time in Figure 2. As can be seen from Figure 2, few tanks required pumping before 3 years, while most required pumping after 5 years.

Table 4. Suggested Tank Pump-out Frequency (Years)

Tank Volume	Persons in the Home					
	1 Person	2 Persons	3 Persons	4 Persons	5 Persons	6 Persons
1800L	5	2	1	1	1	
2700L	7	3	2	1	1	1
3600L	10	5	3	2	2	1
4500L		6	4	3	2	2
5400L		7	5	3	3	2

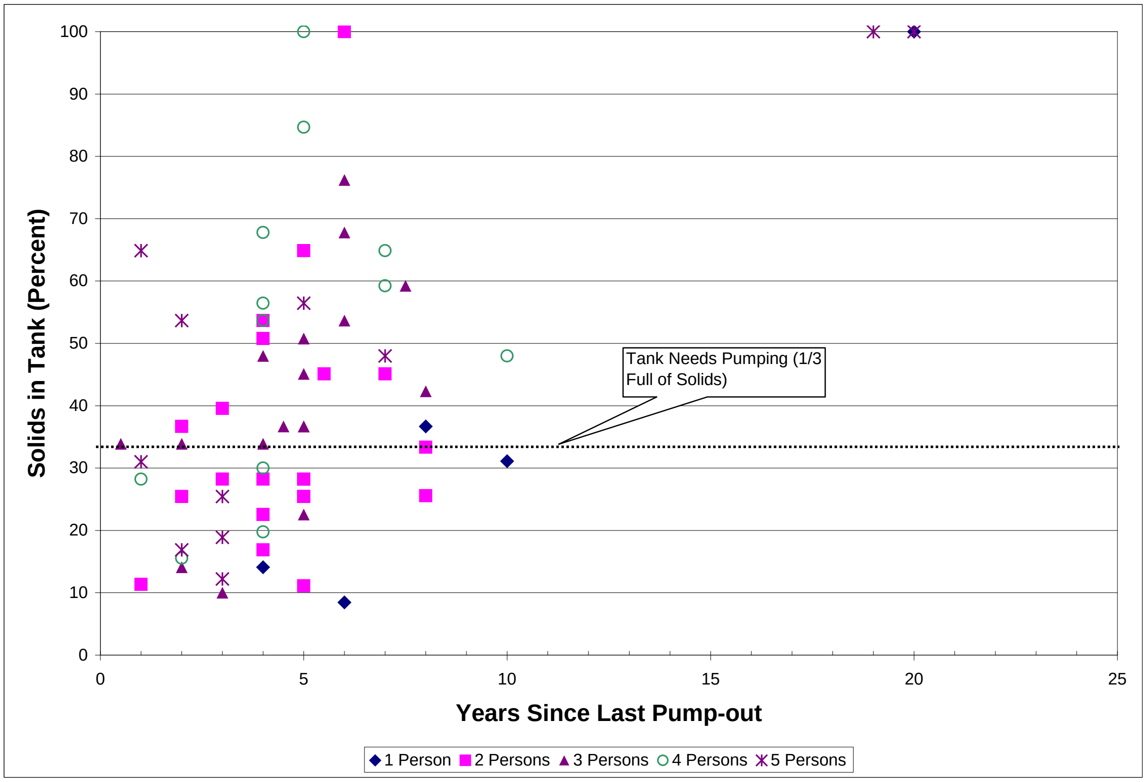

Figure 2. Sludge and Scum Accumulation with Time

Conclusions and Further Study

A number of septic systems receiving water softener backwash (n=27) and not receiving water softener backwash (n=48) were compared to determine whether water softener backwash impacts the functioning of the septic tank.

There were significant differences ($P<0.05$) in the sodium and chloride concentrations between tanks receiving and not receiving water softener backwash. Mean sludge chloride concentrations increased from 146 mg/L in tanks not receiving water softener backwash to 1515 mg/L in tanks receiving water softener backwash. Mean sludge sodium concentrations increased from 239 mg/L in tanks not receiving water softener backwash to 548 mg/L in tanks receiving water softener backwash. While the data shows an increase in salt concentration with the use of water softeners, sodium concentrations do not reach levels required to inhibit biological activity within the septic tanks.

There were no significant differences ($P>0.05$) between tanks receiving water softener backwash to tanks not receiving water softener backwash in terms of series of indicators of tank performance: $COD_{(STE)}$ (P=0.44), $CBOD_{5\ (STE)}$ (P=0.46), $TSS_{(STE)}$ (P=0.11), *E.coli* $_{(STE)}$ (P=0.63), $HPC_{(STE)}$ (P=0.54), $TC_{(sludge)}$ (P=0.44), $VSS_{(sludge)}$ (P=0.57) and sludge and scum accumulation rate (P=0.95).

Tanks receiving water softener backwash were more likely to exhibit obvious corrosion of the outlet baffle (38% versus 23%); however, the evaluation was subjective in nature. The potential impact of chloride on the corrosion of reinforced concrete tanks beyond that of H_2S gas has not been evaluated and bears further investigation.

Twelve of the seventy five systems evaluated were experiencing hydraulic failure. It appears that clay soils (9 out of 12 systems) and system age (median of 27 years) were the determinant factors of failure. None of the failed systems were receiving water softener backwash.

The results from this study indicate that water softener backwash discharged to septic tanks has no significant effect upon the biological or physical functioning of the septic tank with no significant differences observed in indicators of tank performance including the rate of solids accumulation and septic tank effluent quality.

Further Study

This field evaluation study considered the impact of water softener backwash on septic tanks. Further study is required to evaluate the impact of water softener backwash upon leaching field soils (particularly clay soils) and upon aerobic treatment units. A related issue which should be studied is the impact of calcium carbonate clogging of treatment unit orifices and media surfaces from hard water and from water softener backwash.

Technology Transfer

The results of the study were presented at a Special Symposium on the Impacts of Water Softeners on Onsite Wastewater Systems October 13th, 2005 in Cleveland, Ohio co-sponsored by the National Onsite Wastewater Recycling Association and the Water Quality Association. The paper presented at the Symposium will contribute to a "White Paper" being prepared on the topic.

The study results will be presented at the Annual Ontario Onsite Wastewater Association Conference in March 2006 in Kitchener, Ontario.

Study findings were published in an article in the fall 2005 edition of the Ontario Onsite Wastewater Association's "Onsite Wastewater News".

A summary of the study findings and the Final Report will be placed on the ORWC website in PDF format (www.orwc.uoguelph.ca).

References

American Public Health Association (APHA), American Water Works Association (AWWA), Water Environment Federation (WEF). (1998) Standard Methods for the Examination of Water and Wastewater, 20th Edit. Washington, APHA.

Bashir, B., Matin, A. (2001) "Combined Effect of Calcium and Magnesium on Sodium Toxicity in Anaerobic Treatment Processes". Electronic Journal of Environmental, Agricultural and Food Chemistry.

Centre for Water Resources Studies (CWRS), Dalhousie University. (2001). "The Effect of Water Softeners on Onsite Wastewater Systems". Available at: http://centreforwaterresourcesstudies.dal.ca/cwrs/onsite/phs4rpt.htm. Last Accessed: September 5, 2005.

Corey, R.B., Tyler, E.J., Olotu, M.U. (1977). "Effects of water softener use on the permeability of septic tank seepage fields" In *Proceedings of the Second National Home Sewage Treatment Symposium*. ASAE Publication 5-77. ASAE, St. Joseph, MI, pp. 226-235.

Crites, R., Tchobanoglous, G. (1998) Small and Decentralized Wastewater Management Systems. McGraw-Hill, Boston, MA.

Feijoo, G., Soto, M., Mendez, Ramon, m., Lema., J.M. (1995). "Sodium inhibition in the anaerobic digestion process: Antagonism and adaptation phenomena". Enzyme Microb. Technol., 17, 180-188.

Kargi, F, Dincer, A.R. (1999). "Salt inhibition in biological treatment of saline wastewater in RBC". Journal of Environmental Engineering, 125:10, 966-971.

Kargi, F, Dincer, A.R. (1996). " Effect of salt concentration on biological treatment of saline wastewater by fed-batch operation". Enzyme and Microbial Technology, 19:529-537.

Litvan, G. (1984). "Deterioration of Parking Garages" *In* Building Science Insight '84. Available at: http://irc.nrc-cnrc.gc.ca/bsi/84-4_E.html. Last Accessed: September 3, 2005.

Metcalfe and Eddy Inc. (1991). Wastewater Engineering Treatment, Disposal, and Reuse - Third Edition. McGraw-Hill. Toronto

Moore, M. (Edit.) (2001) "Water Softener Use Raises Questions for System Owners" Pipline 12:1. National Small Flows Clearinghouse.

National Sanitation Foundation. (1978). "The Effect of Home Water Softener Waste Regeneration Brines on Individual Aerobic Wastewater Treatment Plants". Report to the Water Quality Research Council.

Panswad, T., Anan, C. (1999). "Impact of high chloride wastewater on an anaerobic/anoxic/aerobic process with and without inoculation of chloride acclimated seeds". Wat. Res. 33:5, 1165-1172.

Perry, R.H., Green, D.W. (Edits.) (1997). Perry's Chemical Engineers' Handbook - Seventh Edition. McGraw-Hill. Toronto.

Rinzema, A., van Lier, J., Lettinga, G. (1988). "Sodium inhibition of acetoclastic methanogens in granular sludge from UASB reactor.". Enzyme Microb. Technol., 10, 24-32.

Roberts Alley, E. (2000) Water Quality Control Handbook. McGraw-Hill. Toronto.

Seigrist, R., Witt, M., Boyle, W.C. (1976). "Characteristics of Rural Household Wastewater". Journal of the Environmental Engineering Division, 102, 533-548.

Tyler, E.J., Corey, R.B., Osotu, M.U. (1977). "Potential Effects of Septic Tank Soil Absorption On-Site Waste Water Systems". Report to the Water Quality Research Council.

Uygur, A., Kargi, F. (2004). "Salt inhibition on biological nutrient removal from saline wastewater in a sequencing batch reactor". Enzyme Microbial Technology. 34, 313-318.

Yarows, S.A., Fusilier, W.E., Weder, A.B. (1997). "Sodium concentration of water from softeners". Arch Intern Med, 157, 218-222.

Appendix A – Homeowner Survey Form

Effect of Water Softeners on Septic Systems - Survey Form

Date	
Location Information	
Name	
Address	
Tank Information	
Tank Type	Concrete Plastic
Tank Size	
Tank Age	
Condition of tank *** take photo ***	
Date of last tank pump-out	
Sludge + scum depth (cm)	
Conductivity in first chamber (μS/cm)	Bottom ¼ Middle ¾ top
Outlet Sample (1L):	Temp (ºC): pH:
Sludge sample (2L) (top 10cm of sludge in first chamber):	Temp (ºC): pH:
Water Softener Information	
Is a water softener being used	Yes No
Is water softener being discharged to septic tank	Yes No
Type of salt	NaCl KCl
Amount of salt used (kg/month)	
Backwash Cycle (L/cycle, cycles/day)	
Water Use Information	
# of people in house	
# of bedrooms	
Drainage Field Information	
Type of system	Conventional Treatment System: Raised Mound
Age of system	
Signs of problems	mushy ground effluent breakout odours toilets backing up water level in tank higher than outlet water rushing back into tank after pumpout
Type of soil	
Well Information	
Well type (depth, m)	dug well drilled well
History of well water quality (Ecoli, fecal coliform, total coliform, nitrate): number of samples, dates, results	

Appendix B – Raw Data

	Tank Information					
#	Tank Type	Tank Size	Tank Age	Condition of Tank	Last Pump-out	Sludge + Scum Depth (cm)
1	Concrete	800 gal	23	1 compartment-Good. Replaced outlet baffle	Oct. 2004	10.2
2	Concrete	600 gal	37	1 compartment-Good. Baffle on.	2 yrs	22.9
3	Concrete	1000 gal	23	Rotting cover, around outlet pipe always at outlet baffle rotting	2 yrs	15.2
4	Concrete	1000 gal	35	1 compartment-Rotted outlet, baffle photos 1-2	1986	91.4
5	Concrete	1000 gal	40	2 compartments-good	2004	25.4
6	Concrete	1000 gal	40	Photos 3-4	1998	40.6
7	Concrete	1000 gal	5	good	never pum	25.4
8	Concrete	1000 gal	30	2 compartments-good at inlet could not see outlet	4 yrs	45.7
9	Concrete	800 gal	30	Photo 20	4 yrs	
10	Concrete	800 gal		Photo 21 - outlet end of tank starting to break down		45.7
11	Steel	400 gal		Poor but cannot really see as I had to pump through a pipe 2 years ago		68.6
12	Concrete	800 gal	15	good	1998	53.3
13	Steel - rotting	400 gal	40	rotting	never pum	91.4
14	Concrete	600 gal	23	Pumped through a pipe	2 yrs	48.3
15	Concrete	800 gal	30	Seems good, manhole over	4 yrs	48.3
16	Concrete	800 gal	10	Photo 20 - rotten cover	4 yrs	61
17	Concrete	800 gal	9	Photo 18-19	6 yrs	91.4
18	Concrete	800 gal	13	Tank is rotting - No.15	4 yrs	48.3
19	Concrete	800 gal	15	No. 15	4 yrs	50.8
20	Concrete	600 gal	35		6 months	30.5
21	Concrete	600 gal	35	good - 1 compartment	6 yrs	61
22	Concrete	800 gal	13	good - No. 13	6 yrs	68.6
23	Concrete	800 gal	25		5 yrs	25.4
24	Concrete	1200 gal	25	good	3 yrs	25.4
25	Concrete	800 gal	12	good	5 yrs	45.7
26	Concrete	800 gal	40	No. 12	3 yrs	35.6
27	Concrete	800 gal	8	No. 12	don't know new owner	
28	Concrete	800 gal	30	good	10 yrs ago	28
29	Concrete	800 gal	20		8 yrs ago	30
30	Concrete	800 gal	20	No.11	8 yrs ago	23
31	Concrete	600 gal	15	good	5 yrs ago	10
32	Concrete	1200 gal	9	good	4 yrs ago	27
33	Concrete	800 gal	25	good	3 yrs	9
34	Concrete	800 gal	28		2 yrs ago	14
35	Concrete	1000 gal	2	good (new)	never	30
36	Concrete	1200 gal	25	picture 5	3 yrs ago	17
37	Concrete	800 gal	25	good conditions	2 yrs ago	
38	Concrete	800 gal	25	No 8-9	3 yrs ago	11
39						
40	Concrete	800	20	good	8 yrs ago	38.1
41	Concrete	800	20	good	4.5 yrs ag	33
42	Concrete	800	20	good	4 yrs ago	25.4
43	Concrete	1000	5	good	5 years	50.8
44	Concrete	800	25	good	5.5 years	40.6
45	Concrete	1000	32	good (replaced outlet baffle)	7.5 years	53.3
46	Concrete	1000	25	Good	7 years	43.2
47	Concrete	800	20	Outlet end starting to break		20.3
48	Concrete	800	20	good	5 years	22.9
49	Concrete	800	15	good	4 years	12.7
50	Concrete	1200	17	good	5	40.6
51	Concrete	800	20	good	10	43.2
52	Concrete	800	30	good	4	20.3
53	Concrete	600	12	good	5	22.9
54	Concrete	800	15	Outlet end starting to break	5	58.4
55	Concrete	800	27	good (replaced outlet baffle)	4	43.2
56	Concrete	800	15	good	1	27.9
57	Plastic	850	2	good	2	33
58	Concrete	800	20	good	5	76.2
59	Concrete	800	30	good	4	30.5
60	Concrete	1200	17	deteriorating at outlet end	3	22.9
61	Concrete	1000	18	rotting outlet baffle		48.3
62	Concrete	800	17	good	1	58.4
63	Concrete	1000	18	good	2	12.7
64	Concrete	800	15	good	2	30.5
65	Concrete	800	7	Outlet end starting to break	7	58.4
66	Concrete	1000	20	good	5	full
67	Concrete	800	30	good	8	33
68	Concrete	1000	30	good	>15	91.4 (full)
69	Concrete	800	13	deteriorating at outlet end	4	17.8
70	Concrete	800	12	good	5	20.3
71						
72	Concrete	800	12	good	4	15.2
73	Concrete	800	10	cover rotting	5	33
74	Concrete	600	23	deteriorating at outlet end	5	33
75	Concrete	800	30	good		68.6
76	Concrete	800	15	good	6	7.6
77	Concrete	800	13	deteriorating at outlet end	6	48.3

#	Water Softener Information					Water Use Information	
	Water Softener Use	Water Softener to Septic System	Salt	Salt Amount (kg/mont	Backwash	# of People	# of Bedrooms
1	No	NO	N/A	N/A	N/A	2	3
2	No	No	N/A	N/A	N/A	2	2
3	Yes	Yes	NaCl	40 kg/month		5	6
4	Yes	Yes	KCl	Unknown	3 days	5	4
5	No	NO	N/A	N/A	N/A	4	4
6	Yes	No	NaCl	20 kg/mont	1/week	2	3
7	Yes	Yes	NaCl	25 kg per 4	1/week	2	2
8	Yes	Yes	NaCl	40 kg/mont	3 days	2	3
9	Yes	No	NaCl	40kg/2 mon	14 days	1	3
10	Yes	No - just since	NaCl	40kg/2 mon	10 days	2	3
11	No	No	N/A	N/A	N/A	4	3
12	No	No	N/A	N/A	N/A	4	3
13	No	No	N/A	N/A	N/A	1	3
14	No	No	N/A	N/A	N/A	5	4
15	Yes	Yes	NaCl	140 kg/mon	4 days	2	3
16	No	No	N/A	N/A	N/A	4	3
17	Yes	Yes	KCl	40 kg/mont	3 days	2	3
18	Yes	Yes		2 x 20 kg/m	Automatic	4	3
19	Yes	Yes	KCl	30 kg/mont	3-4 days	4	3
20	No	No	N/A	N/A	N/A	3	2
21	No	No	N/A	N/A	N/A	3	3
22	Yes	Yes	NaCl	20 kg/mont	automatic ev	3	3
23	No	No	N/A	N/A	N/A	2	3
24	Yes	No	NaCl	20 kg/mont	4 days	2	3
25	Yes	Yes	NaCl	30 kg	4 days	3	3
26	Yes	Yes	NaCl	30 kg/mont	4 days	2	3
27	No	No				3	3
28	Yes	Yes	KCl	20 kg/mont	4-5 days	1	3
29	Yes	Yes	KCl	30 kg/mont	4 days	2	3
30	No	No				2	3
31	Yes	Yes	KCl	20 kg/month		2	2
32	No	No				4	3
33	No	No				3	3
34	no	No				4	4
35	No	No				6	3
36	No	No				5	4
37	Yes	Yes				4	3
38	Yes	Yes	NaCl	40 kg/mont	3-4 days	5	4
39		No					
40	No	No				3	3
41	No	No				3	2
42	No	No				2.5	3
43	No	No				5	3
44	No	No				2	3
45	No	No				3.5	3
46	Yes	Yes	NaCl	40	3-4 days	5	3
47	Yes	Yes				3	3
48	No	No				2	3
49	No	No				1	2
50	No	No				3	4
51	No	No				4	3
52	No	No				2	3
53	No	No				2	3
54	No	No				2	3
55	No	No				3	3
56	No	No				5	3
57	No	No				2	1
58	No	No				4	3
59	No	No				3	3
60	Yes	Yes				5	4
61	Yes	Yes	KCl	3 bags/mon	3 days	5	4
62	Yes	No	KCl		3 days	5	3
63	No	No				3	3
64	Yes	No	KCl		3 days	3	3
65	Yes	Yes	NaCl	40kg/month	3 days	4	3
66	No	No				4	3
67	No	No				1	2
68	No	No				5	4
69	No	No				4	3
70	No	No				3	3
71							
72	No	No				2	3
73	Yes	Yes	KCl	40 kg/mont	automatic	3	3
74	Yes	Yes	NaCl	40 kg/2mon	4 days	3	2
75	Yes	Yes	NaCl	40 kg/mont	3-4 days	3	3
76	Yes	Yes	NaCl	40 kg/ 3 mo	automatic	1	3
77	Yes	Yes	KCl			3	3

#	Drainage Field Information			
	Type of System	Age of System	Problems	Soil Type
1	Conventional	1982	Water level in tank higher than outlet	Clay loam
2	Conventional		None	Grenville loam
3	Raised mound	1982	No. Mantle of gravel at end	Sand/stone fill on clay
4	Conventional	1	None	Eamers loam
5	Conventional	40 yrs	Water level in tank higher than outlet & water ru	Clay
6	Conventional		None	Clay loam
7	Raised mound	5 yrs	None	Sandy loam
8	Conventional	30 yrs	None	Clay loam
9	Conventional	30 yrs	None	Clay loam
10	Conventional	17 yrs	None	Sandy
11	Conventional (not a	30 yrs or	Water level in tank higher than outlet	Stony with clay fill, stone fenc
12	Conventional	27 yrs	None	Clay
13	Conventional	40 yrs	Water level in tank higher than outlet	Clay
14	Conventional (not approved)		Mushy ground and water level in tank higher tha	Clay loam
15	Conventional	30 yrs	None	Eamers loam
16	Raised mound		Very sludgy	Eamers loam
17	Conventional	9 yrs	No - past due for being pumped	Sandy
18	Conventional			
19	Raised mound	15 yrs	No	Sandy
20	Conventional	35-40 yrs	Toilets backing up; water level in tank higher tha	Clay
21	Conventional		Toilets backing up; blocked inlet pipe	Eamers loam
22	Raised mound	13 yrs	No	Sandy
23	Conventional	25 yrs	No	Eamers loam
24	Conventional		No	Sandy with gravel
25	Raised mound	12 yrs	No	Sandy
26	Conventional	40 yrs	No	Eamers loam
27	Raised mound		No problem except Outlo towd ot tank decomposing	
28	Conventional	30 yrs	No problem	Eamers loam
29	Conventional	20 yrs	No	Sandy
30	Conventional	20 yrs	water level in tank higher than outlet	Eamers loam
31	Conventional	15 yrs	No problem	Sandy Gravelly
32	Conventional		No problem	Eamers loam
33	Conventional	25 yrs	No problem	Stoney Hard pan
34	Conventional		No problem	Eamers loam
35	Raised mound		No problem	Sandy
36	Conventional	25 yrs	No problem	Stony Hard Ground
37	Conventional	25 yrs	No problem	Stony Hard Ground
38	Conventional		No problem	Hard Stoney
39				
40	Raised mound		No problem	Eamers loam
41	Conventional	20	No problem	Eamers loam
42	Conventional	20	No problem	Clayish soil
43	Conventional	5	No problem	Clay
44	Raised mound		No problem	Sandy
45	Conventional	32	No problem	Clay
46	Conventional		No problem	Clay
47	Raised mound		No	Eamers loam
48	Raised mound		No	Sandy
49	Conventional	15	Water level in tank higher than outlet	clay
50	Raised mound		No	sandy
51	Raised mound		No	Sandy
52	Conventional		Water level in tank higher than outlet	Clayish soil
53	Raised mound		No	Sandy
54	Conventional	15	No	clay
55	Raised mound	27	No	Sandy
56	Raised mound	15	No	Sandy
57	Raised mound		No	Sandy
58	Conventional	20	No	Clayish soil
59	Conventional	30	No	Clay
60	Raised mound	17	No	Sand
61	Raised mound	18	No	Sandy
62	Conventional	17	Water level in tank higher than outlet	Clay
63	Conventional	18	No	Sandy-clay
64	Raised mound	15	No	Sandy
65	Raised mound	7	No	Sandy
66	Conventional	20	No	Eamers loam
67	Conventional	30	No	Stoney Hard pan
68	Conventional	30	No	Eamers loam
69	Raised mound	13	No	Sandy
70	Raised mound	12	No	Sandy
71				
72	Raised mound	12	No	Sandy
73	Raised mound	10	No	Sandy
74	Raised mound	23	No	Sandy
75	Conventional	30	No	Clayish
76	Raised mound		No	Sandy
77	Raised mound		No	Sand

	Wastewater Parameters							
#	Effluent cBOD5 mg/L	Sludge COD mg/L	Effluent COD mg/L	Effluent pH mg/L	Sludge pH mg/L	Effluent TSS mg/L	Sludge TSS mg/L	Sludge TS mg/L
1				6.9			1300	42924
2		1830			6.63		3000	
3	488	3080	830	7.15		130	3400	8384
4					7.12		12300	69920
5	325			7.44	5.99	250	10150	6824
6	271			6.93	6.48	170	22600	14584
7					6.72		5850	17876
8	406			6.9	5.88	520	2000	28348
9	332			7.12	6.42	80	11850	56456
10	283			7.09	6.19	160	14800	3088
11					5.72		3900	
12					6.04		6600	8020
13				6.1			16250	
14					5.86		5300	
15					6.06		13400	15240
16	344			6.75	6.21	100	47400	51288
17	324			6.71	6.1	770	8550	71872
18	204		130	7.01	6.58	1000	14000	10256
19				7.09	6.2	2000	14000	56208
20					6.65		72000	3980
21							54000	
22	188		150	6.88	6.7	2000	26000	55688
23					6.48		88000	62880
24					6.72		40000	12636
25				6.74	6.59		20000	12980
26	412					33000	26000	20236
27	1005			6.745	6.66	2000	42000	7500
28					6.766		42000	14336
29					6.6		12000	23828
30	222.8			6.815	6.42	1000	12000	28936
31	269					10		
32	355					1000	33000	11996
33							5000	
34	4610					103000	78000	72936
35							14000	9216
36	2930					11333	4000	10568
37	380					1000	12667	9792
38	178					2000	109000	83936
39	183					2000	4000	4176
40	271		127			46		
41	340		135			20		
42	130		115			34		
43	977		645			292		
44	745		717			460		
45	473		512			176		
46	1357		4273			13100		
47	452		357			120		
48	443		327			62		
49	604		630			108		
50	223		407			160		
51	177		5248			8040		
52	42		125			108		
53	>8000		7573			30000		
54	1503		7148			1880		
55	1019		2573			780		
56	352		217			124		
57	1157		3973			5480		
58	172		667			520		
59	266		362			320		
60	235		205			70		
61	189		90			56		
62	562		562			164		
63	375		457			48		
64	245		320			104		
65	242		362			76		
66	2202		9423			6080		
67	248		152			60		
68	272		375			360		
69	236		240			98		
70	314		172			80		
71	84		262			44		
72	119		295			44		
73	862		2898			1260		
74	69		660			512		
75	185		182			172		
76	751		2423			880		
77	294		492			70		

#	Effluent Cl mg/L	Sludge Cl mg/L	Effluent Ca mg/L	Sludge Ca mg/L	Effluent Mg mg/L	Sludge Mg mg/L	Effluent K mg/L	Sludge K mg/L	Effluent Na mg/L	Sludge Na mg/L	SAR
	Salts										
1		66		911		75				163	
2		81		562		73				152	
3	252	1145	52	469	41	92	17		129	619	2.7
4		188		2840		219		268			
5	161	128	24	428	9	47	47		156	351	5.4
6	150	150	13	768	4	38	12		228	360	11.0
7		1091		2050		16				673	
8	71	188	46	581	8	118	17		137	234	3.7
9	59	203	12	1570	5	110	15		201	351	9.7
10	86	116	58	351	10	47	26		162	310	3.9
11		86		1450		87				213	
12		100		349		135				341	
13		150		1220		139				280	
14		77		677		139				405	
15		989									
16	183	289	119	1730	32	192	29		120	207	1.9
17	6140	11694	877	1770	82	120	26	44	2820		17.8
18	1203	2525	236	2310	74	110	36		716	1040	8.1
19	775	1884	68	918	13	139	9	70	367		8.0
20		210		1780		86				274	
21				2570		158				189	
22	1535	1263	253	2940	25	104	18		707	847	8.3
23		284		4060		115				206	
24		100		2600		132				191	
25		5051		976		78				1290	
26	2652	2652	353	509	43	185	1830		49	121	0.5
27	44	147	104	1500	34	96	26	55	51		0.9
28		775		1990		218				598	
29		814									
30	90	236	149	1700	35	105	26		84	181	1.2
31	41			58		34				242	
32	142	150	505	3400	64	181			1870	190	15.4
33		72		167		47		22			
34	95	171	1400	2340	315	437			197	128	0.9
35		95		568		22				158	
36	292	188	807	90	60	40			147	129	1.0
37	2181	3070	275	21	56	53			1110	129	12.0
38	525	897	226	3440	29	175			353	654	4.3
39	74	111	72	165	102	141			146	120	2.3
40	262		19		7				247		9.7
41	27		115		10				41		0.7
42	67		117		11				42		0.7
43	89		128		18				91		1.5
44	70		99		19				34		0.6
45	52		101		20				35		0.6
46	772		624		214				5090		35.0
47	214		19		6				426		16.9
48	27		100		16				31		0.6
49	49		121		17				29		0.5
50	162		44		7				264		7.3
51	118		198		27				80		1.0
52	51		34		11				122		3.6
53	846		263		60				130		1.4
54	262		169		40				104		1.4
55	222		165		39				104		1.4
56	32		6		3				189		12.6
57	45		13		4				216		10.4
58	11		15		2				174		8.3
59	40		83		29				74		1.4
60	543		78		27				551		10.7
61	209		91		30		18		162		2.9
62	22		9		1		19		143		8.9
63	18		6		1				154		11.5
64	70		18		4		246		57		2.4
65	191		14		3				302		14.5
66	23		82		25				38		0.7
67	27		79		27				48		0.9
68	37		101		31				50		0.9
69	100		36		11				56		1.6
70	180		12		3				312		15.9
71	33		87		31				48		0.9
72	567		57		21				131		3.0
73	1920		469		121		65		2660		21.7
74	663		141		59				397		5.6
75	245		53		23				339		7.8
76	39		51		21				51		1.2
77	44		45		21		20		50		1.2

		Bacteria			
	STE *E.coli*	STE Total Coliform	Sludge Total Coliform	STE HPC	VSS of Sludge
#	cts/100mL	cts/mL	cts/mL	cts/100 mL	g/L
1			12900		30.725
2			12000		24.28
3		8500	1000		26.965
4			59000		53.315
5	700	3300			10.165
6	110	31	5600		35.71
7					27.59
8	73000	8200	9000		6.86
9		9000	22000		39.17
10	5200	21100	1200		11.66
11					22.215
12			37000		35.135
13			2380		31.34
14					21.865
15			1520		18.905
16	11000	119	116000		34.935
17	700	7	520		43.17
18	190000		12000		30.805
19			2000		43.835
20			100		37.04
21			3800		
22		5500	120000		30.61
23					50.48
24			6000		35.95
25			1200		16.085
26			1000		52.825
27			28000		43.345
28			48000		87.615
29			1900		34.355
30	40000	290	31000		38.215
31			23110		
32	2870000	1890000	11700000		26.41
33			3535000		11.16
34	500000	97000	2095000		56.95
35			28000000		33.605
36	1360000	45000	4400000		8.005
37	41000		9930000		11.3
38	72000	13300	1700000		42.97
39	231500	94381	430000		5.06
40	1890000			8000000	
41	3300000			4000000	
42	200000			62000000	
43	320000			17000000	
44	640000			2000000	
45	100000			11300000	
46	6200000			12000000	
47	6800000			19000000	
48	400000			5700000	
49	600000			6100000	
50	200000				
51	1500000				
52	100000			300000	
53	900000			3900000	
54	200000			700000	
55	600000			1800000	
56	200000			4000000	
57	14900000			5000000	
58	200000			15000000	
59	6400000			3000000	
60	1200000			1500000	
61	1300000			7100000	
62	27600000			76000000	
63	700000			30000000	
64	300000			900000	
65	100000			1800000	
66	100000			600000	
67	200000			1100000	
68	40000			700000	
69	100000			900000	
70	100000			12000000	
71	200000			1300000	
72	200000			1300000	
73	100000			600000	
74	300000			1800000	
75	900000			4200000	
76	2100000			4000000	
77	1000000			900000	