at Nimbus Centre, CIT

A Partnership between CIT, Cork City Council and Cork County Council

Process Test Report
for
Sludge Drying Beds Ltd

September 2014

Revision Control Table

Rev	Date	Description	Written	Reviewed
0	28/08/2014	Draft Issue	Aoife Kyne	Kevin Fitzgibbon
1	03/09/2014	Final Draft	Aoife Kyne	Kevin Fitzgibbon
2	03/09/2014	Final	Aoife Kyne	Kevin Fitzgibbon

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Executive Summary

The Sludge Drying Beds Ltd (SDB) process is an innovative and sustainable sewage treatment technology. SDB received a €5000 Innovation Voucher from Enterprise Ireland in May 2014 to evaluate the performance of the system. The Water Systems and Services Centre (WSSIC) based at Cork Institute of Technology was selected by SDB as the most appropriate Knowledge Provider to undertake this project.

WSSIC carried out a 5 week process-proving project to test, and validate the process. The SDB process takes secondary sewage sludge with a concentration in the range of 0.8-1% dry solids (% d.s.) and dewaters it to concentrations in the range of 7-10% d.s. Results from the process proving period were very positive, with 90% sludge volume reduction being achieved, with no energy input and no chemical addition. This volume reduction results in significantly reduced sludge tankering costs for transporting sludge to Roscrea, North Tipperary's central sludge processing facility.

1. Introduction

Sludge Drying Beds Ltd. (SDB), based in Co. Tipperary, has developed an innovative approach to dewatering municipal wastewater sludge that involves minimal/no energy consumption, and no added chemicals. The process typically treats secondary sludge from a municipal Wastewater Treatment Plant (WWTP) with a sludge concentration of 0.8-1% d.s.; it dewaters sludge to concentrations in the range of 7-10% d.s.

SDB received funding (€5k Innovation Voucher) from Enterprise Ireland to evaluate the performance of the system in a structured manner. The Water Systems and Services Innovation Centre (based at the Nimbus Centre, Cork Institute of Technology) was commissioned by SDB to design and undertake the necessary testing programme. This Report presents the findings of the programme.

2. Sludge Drying Beds Technology

2.1 Description

A single SBD unit consists of:

- A concrete tank: unit dimensions 1m in depth, 3m in width and 8m in length.

- A membrane roof of woven black geotextile material on a lightweight hinged aluminium frame
- An outlet in one short wall, which is closed by 3 or more baffle plates, manually operated
- An open sump outside the outlet, to receive decanted water
- A decant water return pump in a dedicated closed manhole/sump
- Sludge inlet pipework mounted on the wall opposite the outlet

The floor of each unit or bed is constructed in a shallow V-shape to the Centre and is sloped towards the outlet at one side of the tank. The decant control consist of 3 or 4 stainless steel baffle plates (depending on the mode of operation).

- One baffle plate is used as an internal blank when filling the bed;
- Two plates are fabricated with a precise series of slots, to details developed by SDB, so as to release the decant effluent;
- And the final baffle can be an outer blank with an inbuilt valve fitting for greater decant control.

An interesting design feature of the Sludge Drying Bed is the membrane roof which reportedly helps keep the surface of the sludge moist. SDB consider this element to be one of the key factors in the success of the overall system, in terms of avoiding odour generation and excessive caking of the sludge surface, as well as eliminating rainfall ingress. However, the performance and impact of this element of the system, i.e. the roof, falls outside the scope of the current testing programme.

Figure 1: Sludge Drying Beds at Twomileborris WWTP.

2.2 Operation

The SDB system can be described as a passive multi-stage batchwise dewatering process. The influent is typically raw sludge from a WWTP secondary stage settlement tank; however, sludge from an initial thickener such as a picket-fence thickener can also be treated by the SBD. The process is as follows:

1. Fill SDB unit with raw sludge at <1.0% d.s. – by gravity or pump
2. Allow detention time – usually not less than 48 hrs; it can be more
3. Decant 1 – Insert slotted plate nr 1 to outlet slot and remove the inner blank plate
4. Decant 2 – Insert slotted plate nr 2 to outlet slot and remove slotted plate nr 1
5. Close – insert the internal blank plate at the end of the decanting process
6. Holding period – which varies by plant, since the determining factor is the time taken by the WWTP to generate surplus sludge requiring removal from the aeration basin
7. Repeat Steps 1 – 6 for as many cycles as the capacity of the bed and/or the density of the sludge will allow
8. Remove dewatered sludge – normally at c. 8 – 9% d.s.; using standard suction tanker equipment
9. Wash down the unit to remove old sludge remnants; with wash water returned to the head of the works; generally by sludge transport contractor
10. Repeat from Step 1

The SDB units can be installed singly or in multiple units, in parallel configuration.

2.3 Test Installation

At time of writing there are three purpose-built SBD installations in operation in North Tipperary, located at Borrisoleigh, Templetouhy and Twomileborris WWTPs. The beds were installed by SBD in partnership with North Tipperary County Council with the aim of reducing operational costs associated with sludge treatment and transportation. (In other locations, existing drying beds were reconfigured to trial the SDB system; refer to Appendix D below).

The Twomileborris WWTP was selected as the most appropriate plant to carry out process proving of the SDB technology; the plant is located c. 7.5km from Thurles town in Co. Tipperary. It is estimated that Twomileborris WWTP caters for c. 1000 PE. The treatment train at the plant consists of a Bar Screen, Step Screen, Oxidation Ditch, Final Settlement Clarifier, Sludge Holding Tank, and Sludge Drying Beds.

This SDB installation at Twomileborris is a ‘double’ tank, effectively 2 SDB units constructed side-by-side without a dividing wall. The sludge beds have been operating on this site since 2012.

3. Process Proving Methodology

The process proving phase lasted for 5 weeks from 30/06/2014 to 30/07/2014. Prior to the first fill, the tanks were desludged and thoroughly cleaned to ensure no old/septic sludge remained, which could inhibit the dewatering process. During the 5-week testing period ten fill/decant cycles were carried out, following the steps listed above.

Various items of data were gathered during the test period to monitor the performance and operating conditions of both the WWTP and the sludge beds. These included:

- Inlet Flow to the Wastewater Treatment plant
- Sludge Height in Bed before Fill cycle
- Sludge Height in Bed after Decant cycle

3.1 Flows

Inflow to WWTP

Influent flows to the WWTP (as recorded by the WWTP flow meter at the inlet) are not reliable due to the particular details of the meter installation at the plant. The operator reports that readings are heavily distorted if blockages occur at the inlet, for example. The data for inflows is not reported here.

Inflow to Sludge Beds

During the process proving phase the height of the sludge surface in the SDBs was measured and recorded. Figure 2 below shows the height variance during the process proving period.

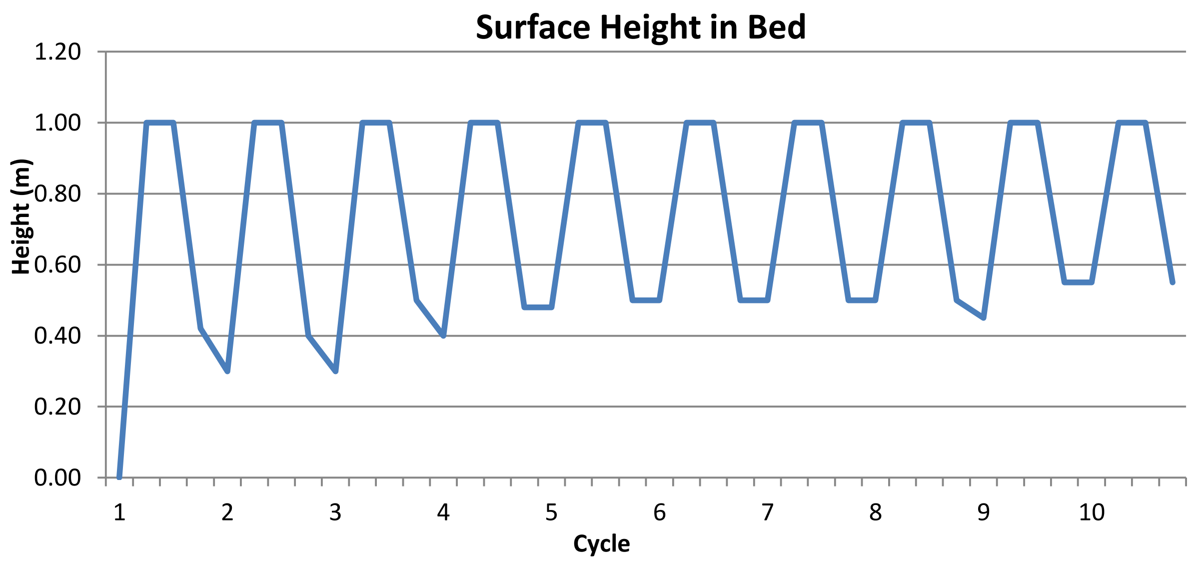

Figure 2: Height measurements during the process proving phase.

The rises in the graph correspond to filling of sludge into the beds; and the falls to decanting of separated water from the beds. In some cases the decant operation continued for 2 days, with the second day showing a slower drop in surface level, as might be expected.

3.2 Measuring, Sampling & Analysis

During the process proving period samples were taken by the WWTP operator and stored in the on-site fridge at 4^0C. Laboratory analysis was carried out at Cork Institute of Technology's Environmental Laboratory. Samples were collected and transported by SDB Ltd. to Cork Institute of Technology's Environmental Laboratory. The frequency of sample collection, transportation and laboratory analysis are summarized in the Table 1 below.

Table 1: Sampling schedule during process proving period

Date	Cycle Stage	Sample	Stored/transported	Analysis
30/06/2014	Fill	Influent & Effluent discharge	Stored at 4^0C	COD, pH, Suspended Solids
01/07/2014	Decant	Decant effluent & Sludge in bed	Transported to CIT	COD, pH, % Dry Solids
02/07/2014	Fill	Influent & Effluent discharge	Stored at 4^0C	COD, pH, Suspended Solids
03/07/2014	Decant & Fill	Decant effluent & Sludge in bed	Transported to CIT	COD, pH, % Dry Solids
07/07/2014	Decant	Decant effluent & Sludge in bed	Transported to CIT	COD, pH, % Dry Solids
08/07/2014	Fill	Influent & Effluent discharge	Stored at 4^0C	COD, pH, Suspended Solids
09/07/2014	Decant	Decant effluent & Sludge in bed	Transported to CIT	COD, pH, % Dry Solids
11/07/2014	Fill	Influent & Effluent discharge	Stored at 4^0C	COD, pH, Suspended Solids
13/07/2014	Decant (self-triggered)	Decant effluent & Sludge in bed	Transported to CIT	COD, pH, % Dry Solids
14/07/2014	Fill	Influent & Effluent discharge	Stored at 4^0C	COD, pH, Suspended Solids
16/07/2014	Decant	Decant effluent & Sludge in bed	Transported to CIT	COD, pH, % Dry Solids
18/07/2014	Fill	Influent & Effluent discharge	Stored at 4^0C	COD, pH, Suspended Solids
20/07/2014	Decant	Decant effluent & Sludge in bed	Transported to CIT	COD, pH, % Dry Solids
21/07/2014	Fill	Influent & Effluent discharge	Transported to CIT	COD, pH, Suspended Solids

Date	Cycle Stage	Sample	Stored/transported	Analysis
23/07/2014	Decant	Decant effluent & Sludge in bed	Transported to CIT	COD, pH, % Dry Solids
25/07/2014	Fill	Influent & Effluent discharge	Stored at 4^0C	COD, pH, Suspended Solids
27/07/2014	Decant	Decant effluent & Sludge in bed	Stored at 4^0C	COD, pH, % Dry Solids
28/07/2014	Fill	Decant effluent & Sludge in bed	Transported to CIT	COD, pH, Suspended Solids
30/07/2014	Decant	Decant effluent & Sludge in bed	Transported to CIT	COD, pH, % Dry Solids

4. Results

4.1 Sludge Volumes

Using the height measurements taken from the beds, influent sludge, decant effluent and post-decant sludge volumes were calculated. Figure 3 below shows the inflow into and decant flow out of the beds. As the graph illustrates, by Cycle 5 the inflow and outflow were approximately constant at c. 21-25 m3 per cycle. This indicates a steady rate of dewatering for the latter half of the period, with corresponding increases in solids concentration.

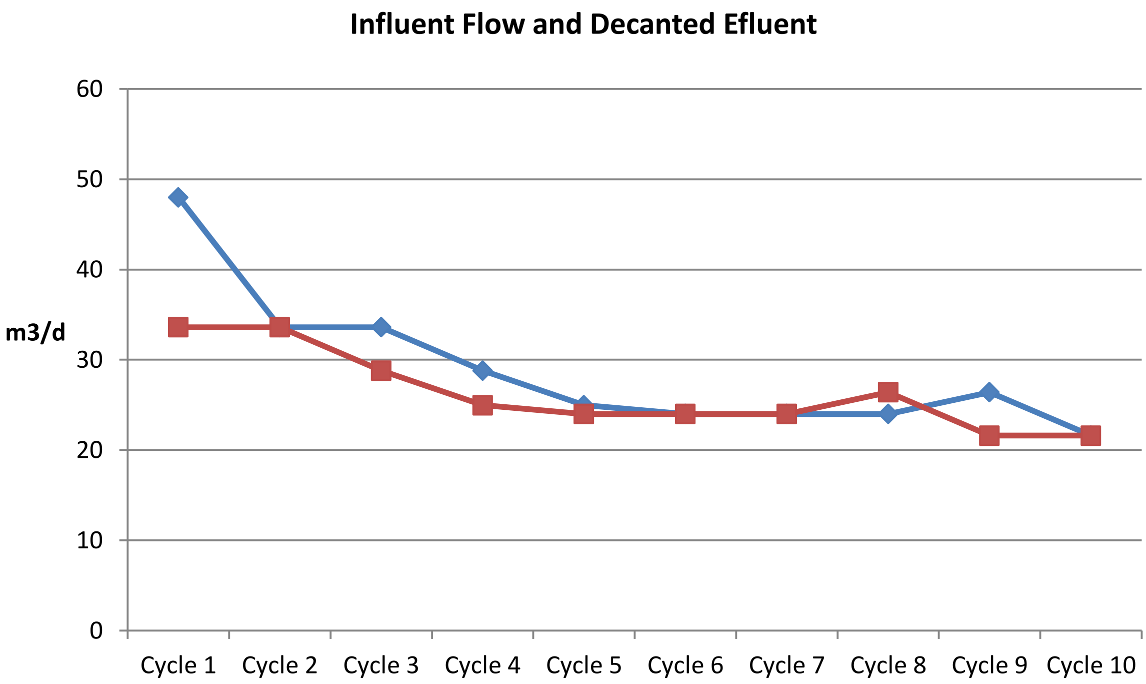

Figure 3: Influent Flow to and Decanted Effluent from Sludge Drying Beds

The cumulative and total volumes of influent, decant effluent and final wet sludge product, for the entire process proving period, were calculated and are illustrated in Figures 4 & 5. At the end of the test period the depth of sludge in the tank was 0.55m, which equates to approximately half the available tank volume. The total sludge inflow was calculated at 289 m3; total decanted water was 263 m3; and total remaining wet sludge at the end of the testing period was 26.4 m3. This equates to 9.14% of the influent volume.

Therefore, the results show a sludge volumetric reduction of over 90% over the test period, which is significant considering no chemical addition or energy for dewatering was required.

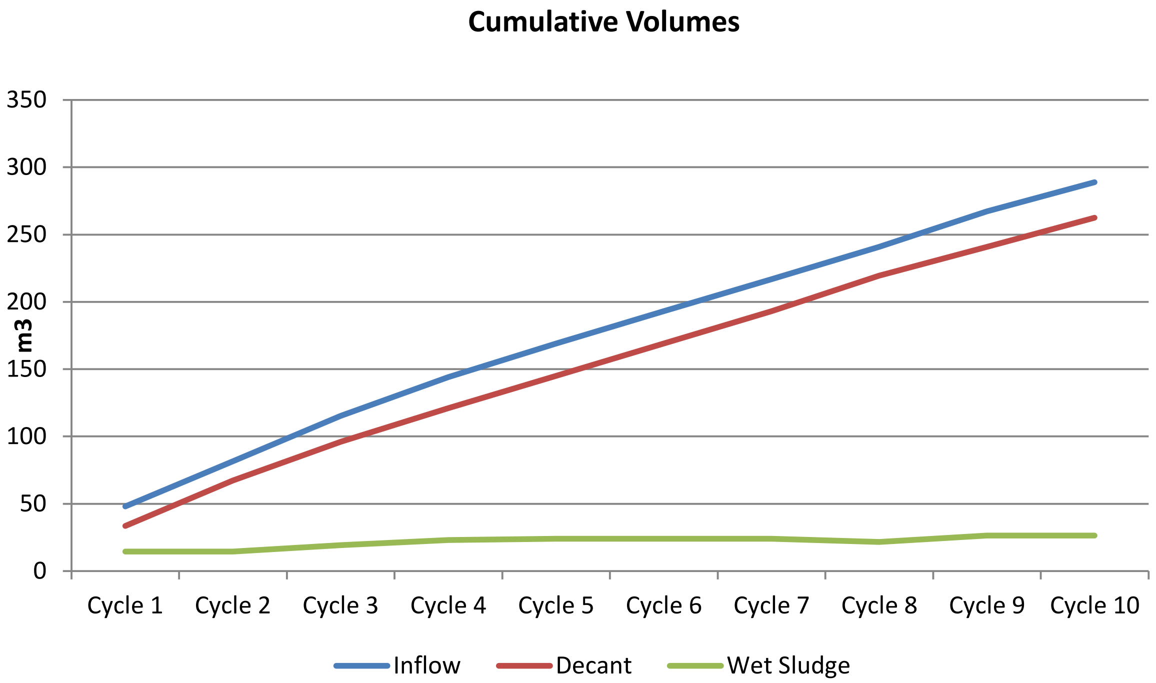

Figure 4: Cumulative Inflow, Decant & Wet Sludge Volumes for test period

4.2 Dry Solids

During the testing period the % d.s. of the influent sludge and of the sludge product were measured, at each cycle. The influent was sampled midway through the filling stage; while the sludge was sampled as a single grab sample from approximately the same location in the tank each time, immediately prior to filling.

Figure 6 below illustrates the % d.s. for each cycle. The incoming sludge samples varied from 0.55% to 1.34% d.s. However, the retained sludge in the beds increased in concentration up to a measured maximum of 10.2% after the final cycle, based on the laboratory analysis of grab samples.

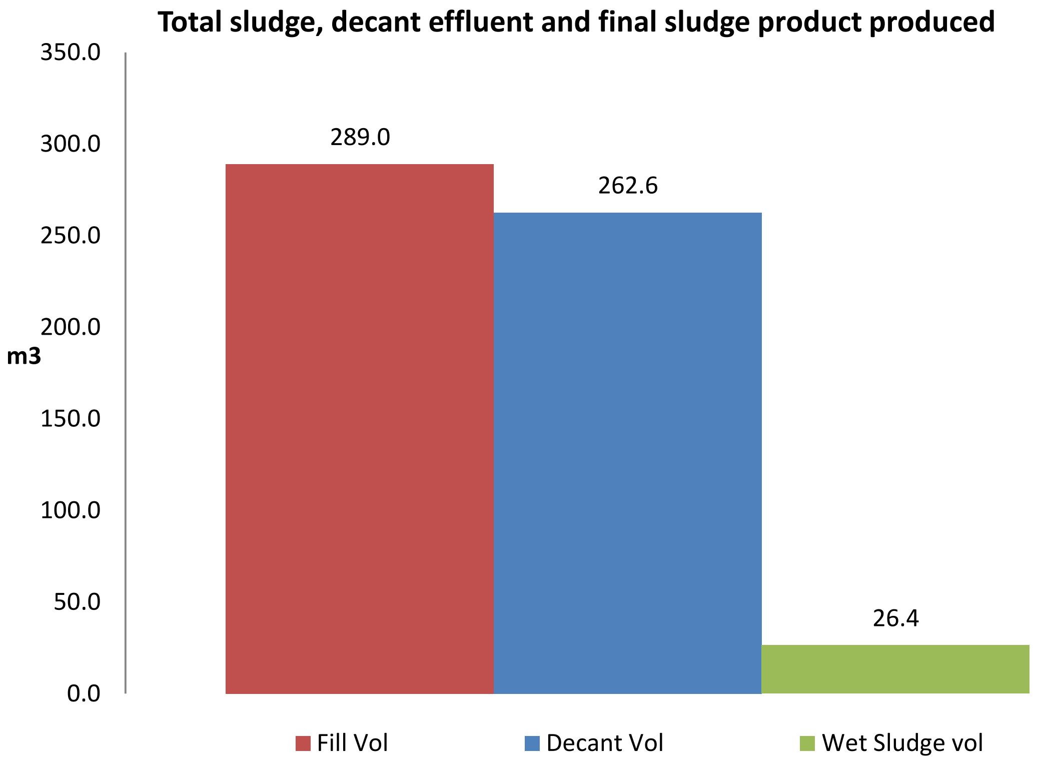

Figure 5: Total sludge, decant effluent and final sludge product produced during the process proving phase.

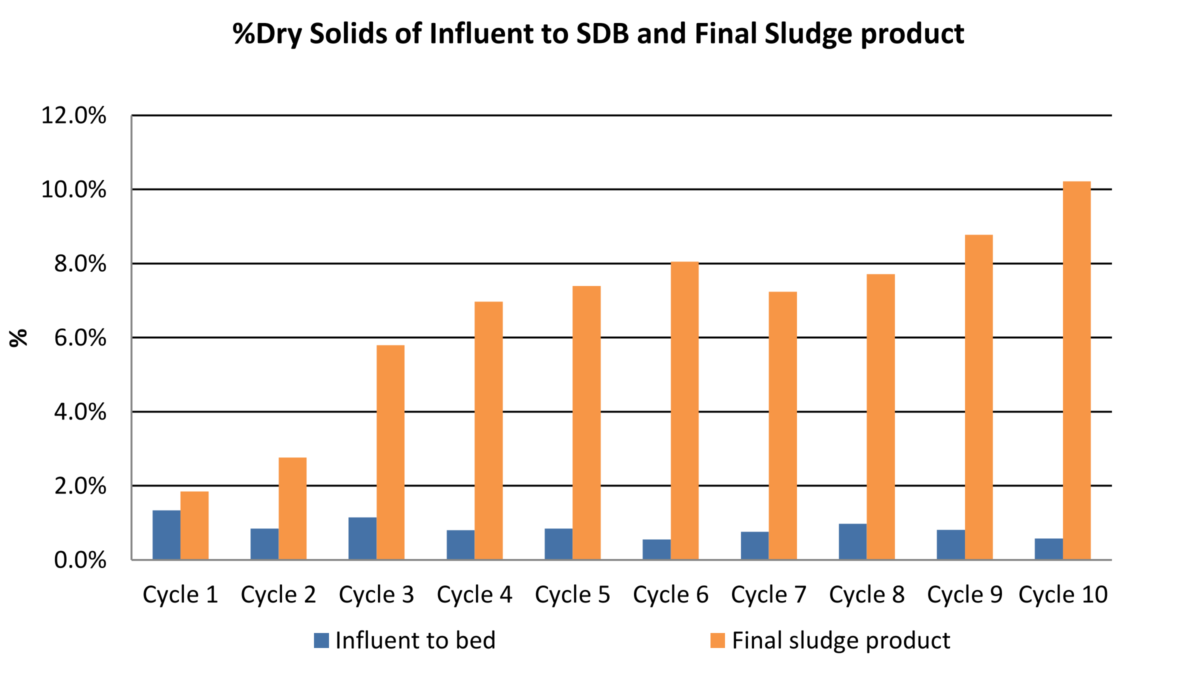

Figure 6: % Dry Solids of Influent to SDB and of final sludge product from samples

Figure 7 below presents 2 different estimates of dry solids in the beds, based on

1. Measured levels in the bed and influent % dry solids; and
2. Samples of settled sludge as tested in the laboratory

The overlaid graphs do not coincide exactly, which probably reflects the fact that only single grab samples of sludge were taken for analysis. Also, the influent was sampled only once per fill cycle, and the solids concentration in the influent could be expected to vary slightly. However, despite the minor uncertainty that might attach to individual figures, the final overall concentration by the 2 methods is in close agreement at 10.0 – 10.2% d.s.

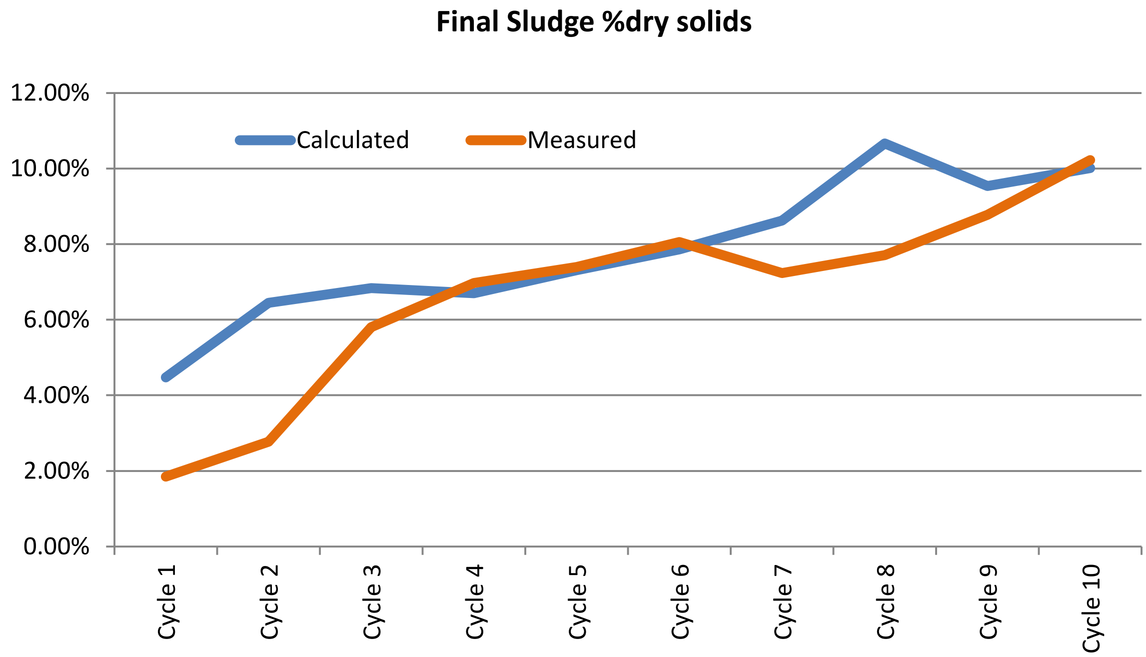

Figure 7: Dry solids % by Calculation and by Testing

4.3 Effluent Quality

Process proving also involved investigating the quality of both the decant effluent and the final effluent being discharged to the watercourse. Discussions with Tipperary County Council operator staff have suggested that the installation of the SDB process has improved the quality of the final effluent. Figures 8 and 9 below show Total Suspended Solids and Chemical Oxygen Demand concentrations in the decant effluent and final effluent over the process proving period.

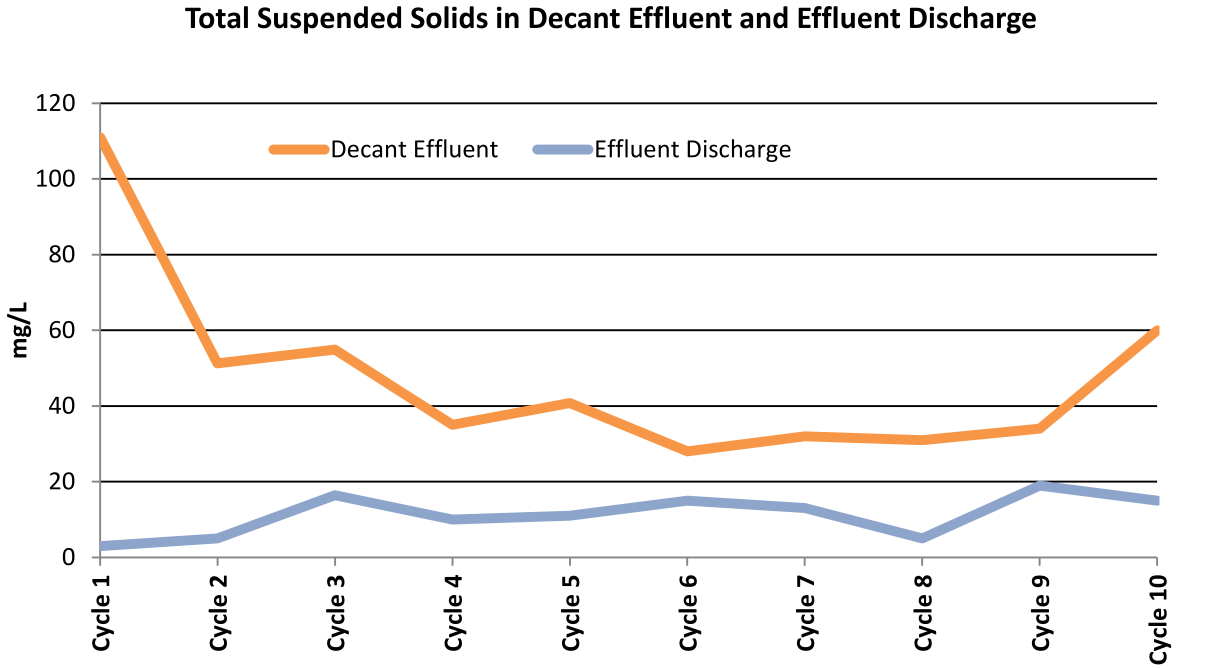

Figure 8: Total Suspended Solids in the Decant effluent and effluent discharge

Figure 8 shows the concentration of suspended solids in the decant effluent is relatively low, with an average concentration of 47.8 mg/L. Suspended solids in the final effluent is also low, with an average concentration of 11.2 mg/L over the testing period.

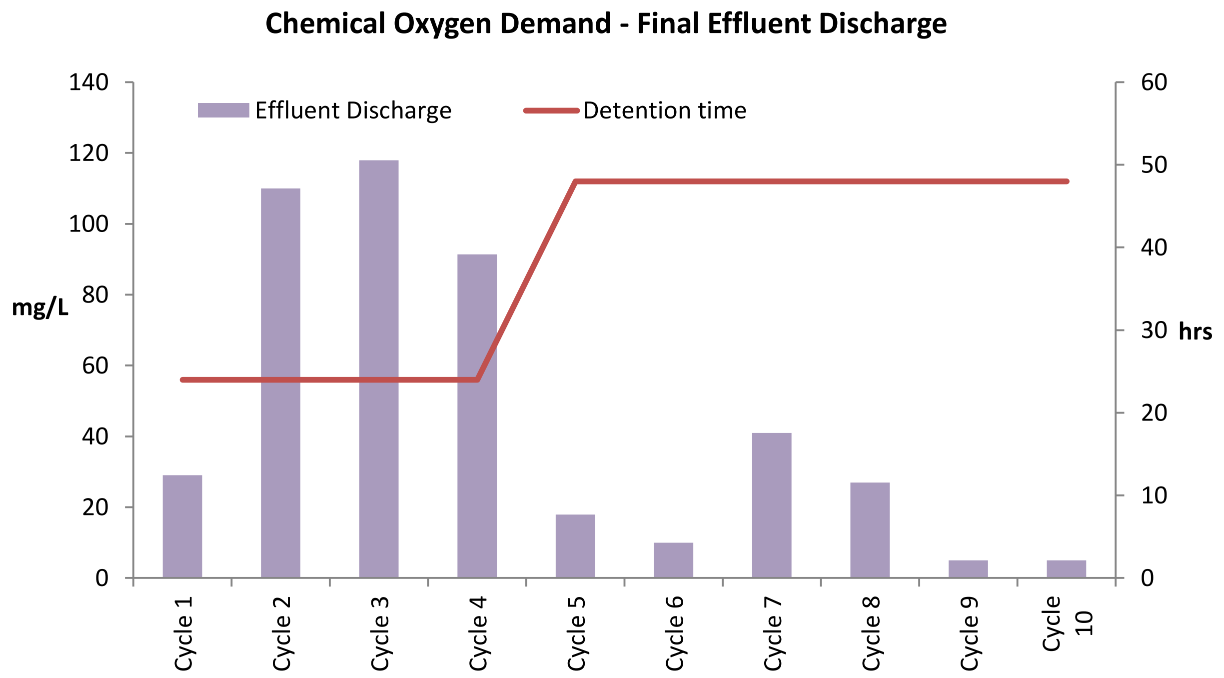

Figure 9: Chemical Oxygen Demand in the Decant effluent and effluent discharge

Figure 9 reveals an interesting anomaly in the results. The period before first decant varied during the process proving programme. Initially the first decant was carried out after 24 hours; rising to 48 hours in Cycle 5. Coincidentally, the COD in the WWTP final effluent showed elevated levels in the range 90-120mg/l over Cycles 2 – 4 inclusive; whereas the COD fell to generally less than 20mg/l over Cycles 5 – 10 incl. There may be no direct link between these results – the effluent from the SDBs is returned to the Oxidation Ditch, not discharged to the outfall – but this coincidence may bear further investigation.

From the point of view of the SDB performance, the optimum retention time per cycle appears to be 48 hours or more before decanting; whenever decanting was carried out after only 24 hours, effluent continued to discharge for at least a further 24 hours i.e. until the next fill.

Data was received from Tipperary County Council in order to compare test results; the Council's final effluent analysis results are shown in Figure 10 below.

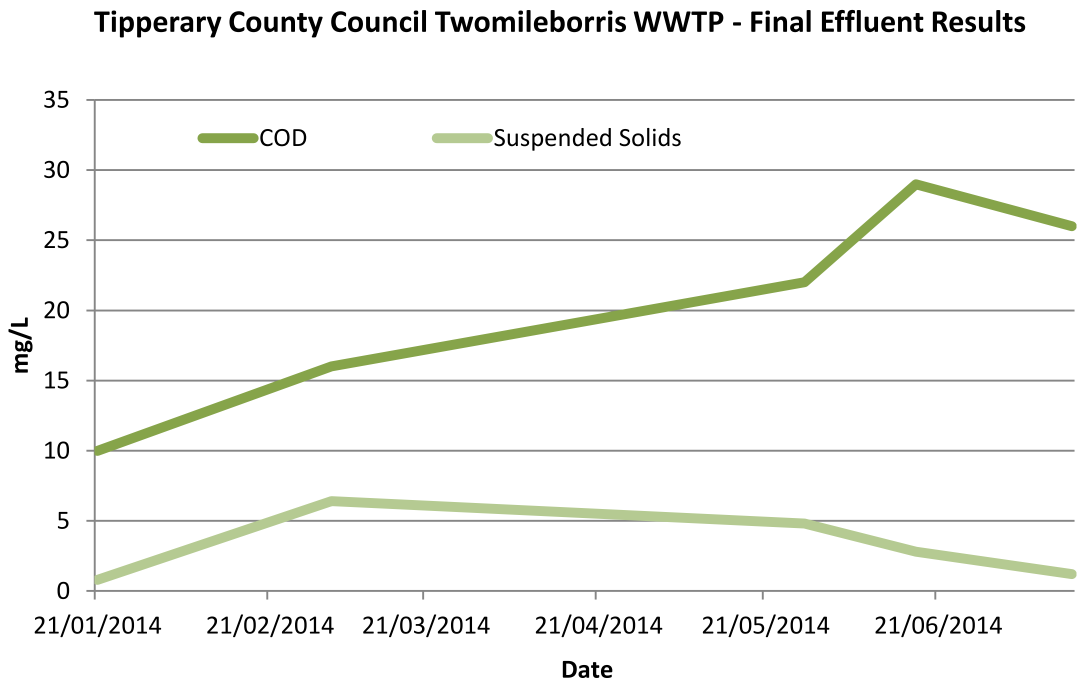

Figure 10: Tipperary County Council Final Effluent Results for Twomileborris WWTP.

Figure 10 shows results of the WWTP final effluent analysis taken during 2014. Suspended solids concentrations were very low, with average concentrations at 3 mg/L. COD also proved to be very low with an average of 21 mg/L.

5. Discussion

Summary of Results

This project focused on assessing the SDB process over a suitable period to demonstrate its capabilities. The results have shown that the process can achieve significant dewatering of sludge, up to 90% volumetric reduction, without energy or chemical addition; and without excessive caking of the sludge surface. The end product is suitable for removal by suction tanker which is the usual method for sludge installations of this scale. At solids concentrations of c. 9-10%, compared to c. 2-4% from a picket fence thickener, this could be expected to result in significant savings in terms of tankering costs. This has been borne out by the experience of North Tipperary County Council since the trial beds were installed – see below.

Process Implications

Regarding process implications, the SDB was decanted approximately 1-3 times per week with the decant effluent being returned directly to the Oxidation Ditch. It is suggested that the decant effluent could be expected to contain high levels of soluble volatile fatty acids. Soluble volatile fatty acids (VFAs) are produced from the hydrolysis/fermentation of extracellular polymeric substances (EPS) of sludge microorganism cells. The build-up of soluble VFAs in the SDB would seem to be avoided as they are probably removed in the decant effluent. Soluble VFAs are substrates for anaerobic microorganisms and tend to release strong odour. The (likely) removal of soluble VFAs from the sludge using the SDB process would explain why there was no offensive odour from the final sludge product, throughout the process proving period. This factor would presumably be a strong positive in favour of the process.

As a result of hydrolysis of EPS in the sludge flocs, the surface charge of the cells change, which encourages the sludge flocs to agglomerate to form denser flocs, thereby releasing a proportion of free water contained in the sludge cells. It is postulated that layers of water and sludge form throughout the depth of the tank, during the settling period after filling. This is consistent with the observed discharge of effluent from varying heights of slots in the baffle plates.

North Tipperary County Council: East Area Sludge Infrastructure Improvements

Regarding financial savings, in recent years Tipperary County Council undertook an Improvement of Sludge Infrastructure project in the East Area of the county. Prior to the project, sludge concentrations being removed from satellite WWTPs ranged between 0.45 to 2.73% dry solids (ref Appendix D from Project Lead Engineer Patrick Moran). The aim of this project was to reduce sludge treatment and disposal costs from satellite WWTPs.

The project consisted of the construction of 3 installations of new SDB tanks, with fitted louver plate doors, and breathable membrane roofs; as well as the retrofitting of existing drying beds at 3 further WWTPs (1 bed at each location) with some of the features per the SDB system i.e. louvre plates and membrane roofs. (However other features were not retrofitted e.g. floor slopes, and consequently the retrofitted units reportedly did not perform as well as the new SDB installations). Other improvements included optimising polymer dosing in other plants. In total, improvement works were carried out at eight WWTPs throughout the East Area (Thurlus, Roscrea, Borrisoleigh, Holycross, Littelton, Templetouhy, Toomevara and Twomileborris).

Reported operational financial savings for the East Area over a 12 month period (2011-2012) amounted to €206,036.43 (ref Appendix D). The cost of infrastructure works (i.e. installing new SDBs and retrofitting existing beds per the SDB system) equated to €100,000, resulting in a net saving of €106,036.43 in year 1. However, it is important to note that the new beds were installed by SDB Ltd at a significantly subsidized rate, in order to establish demonstration facilities for their process.

In overall terms, it could be expected that operational savings would arise under a number of headings, namely:

- reduced charges from the sludge transportation contractor;
- reduced processing costs (presumably);
- reduced polymer dosing; and
- reduced operator hours, particularly if the SDBs were to be fully automated.

The precise apportionment of the savings reported by North Tipperary Co. Co. under these different headings was not detailed in the correspondence with the Council; it would appear that the savings relate primarily to transport cost reductions. Further clarification on these issues is recommended.

However, regarding just transport costs, based on the figures provided by the Council, i.e. average transport costs of €9.22/te of sludge removed from satellite WWTPs to Roscrea (average of €7.84 - €10.60/te), and a reference base-case range of 0.45% - 2.73% d.s. prior to the improvement work being carried out (Appendix D), the following transport cost savings appear to be realisable, for sludge being tankered from satellite WWTPs to Roscrea:

- For every 100 te of raw sludge at 0.8% d.s., treated by and removed from the SDBs at 8% d.s.: saving of €369, compared to removal from e.g. a picket fence thickener at 1.6% d.s. (the average of the base-case range reported by North Tipperary Co. Co.).

- For every 100 te of raw sludge at 0.8% d.s., treated by and removed from the SDB at 8% d.s.: saving of €830 compared to removal of raw sludge (i.e. at 0.8% d.s.) from the plant.

- Note that the total raw sludge treated during the testing period (from first fill to emptying of beds) was 289m³ between the 2 beds i.e. approximately 289te.

These savings increase as the influent concentration decreases; in particular it is noteworthy that the minimum reported concentration of tankered sludge was 0.45% d.s.

Further investigation is required to identify the benefit to the sludge processing at Roscrea arising from the greater concentration of dry solids in the incoming sludge; the effect of polymer dosing optimization; and the labour cost savings that may be possible using the SDB system.

6. Conclusions & Next Steps

The SDB process has demonstrated it is a viable and sustainable sewage treatment technology, particularly considering no energy or chemical dosing were required to achieve sludge concentrations in the region of 10% d.s.

The SDB system has resulted in operational cost savings to North Tipperary County Council arising from reduced tankering costs for the more concentrated sludge produced, compared to sludge from a picket fence thickener for example.

In terms of process investigation, next steps could include focusing on monitoring soluble fatty acids concentrations throughout the process to determine removal rates. It would also be beneficial to analyse Total Nitrogen and Total Phosphorus concentrations at various stages throughout the process to determine removal efficiencies.

The project to reduce sludge handling costs in North Tipperary East Area involved retrofitting of only a portion of the existing beds (3 out of a total of 14 reported – see Appendix D) (in addition to the new beds at 3 locations). It would appear that retrofitting the remaining 11 of the existing beds would result in commensurate savings, and would be an obvious next step.

Another important next step would be to automate the SDB process and improve the operational features of the design, i.e. automating the changeover of the louver plate doors and automating the decanting process. This could be expected to reduce the labour costs involved.

The unitised operational savings estimated above could be further examined so as to allow the potential cost benefits of deploying the SDB system on a wider scale to be verified.

Finally, the operational savings and process benefits for the sludge processing facility at Roscrea could be further examined, in order to complete the overall cost-benefit analysis of the Sludge Drying Beds system.

Appendices

Appendix A	**Site Measurements**
Appendix B	**Analysis Results**
Appendix C	**Tipperary County Council Analysis Results**
Appendix D	**Tipperary County Council Financial E-mail**

Appendix A Site Measurements

Cycle stage	Date	Influent meter reading	Influent Flow to WWTP	Height in Bed before Fill Cycle	Height in bed after	Sample taken
		m3/d	m3/d	m	m	
Fill	30/06/2014	346979		0	1	Fill + Effluent Discharge
Decant	01/07/2014	347050	71	1	0.42	Decant effluent + Sludge
Fill	02/07/2014	347114	64	0.3	1	Fill + Effluent Discharge
Fill	03/07/2014	347205	91	1	0.4	Decant effluent + Sludge
Decant	07/07/2014	347429	224	0.3	1	Fill + Effluent Discharge
Fill	08/07/2014	347636	207	1	0.5	Decant effluent + Sludge
Decant	09/07/2014	347709	73	0.4	1	Fill + Effluent Discharge
Fill	10/07/2014	347745	36	1	0.48	Decant effluent + Sludge
Fill	11/07/2014	347810	65	0.48	1	Fill + Effluent Discharge
Decant	13/07/2014	347909	99	1	0.5	No Effluent, Sludge
Fill	14/07/2014	347999	90	0.5	1	Fill + Effluent Discharge
Decant	16/07/2014	348257	258	1	0.5	Decant effluent + Sludge
Fill	18/07/2014	348448	191	0.5	1	Fill + Effluent Discharge
Decant	20/07/2014	348854	406	1	0.5	Decant effluent + Sludge
Fill	21/07/2014	348995	141	0.5	1	Fill + Effluent Discharge
Decant	23/07/2014	349206	211	1	0.5	Decant effluent + Sludge
Fill	25/07/2014	349385	179	0.45	1	Fill + Effluent Discharge
Decant	27/07/2014	349554	169	1	0.55	Decant effluent + Sludge
Fill	28/07/2014	349781	67	0.55	1	Fill + Effluent Discharge
Decant	30/07/2014	349781	160	1	0.55	Decant effluent + Sludge

Appendix B Analysis Results

Suspended Solids & Total Solids								Chemical oxygen demand	Notes	pH
02/07/2014	**Before (mg)**	**After**	**Volume of water filtered (ml)**	**Weight container plus wet**	**SS (mg/L)**	**% DS**	**mg/L**	**mg/L**		
Decant Effluent	204.8	215.9	100		111			64		7.15
Effluent Discharge	200.4	200.7	100		3			29		7.73
Influent to bed	2.2024	2.9784	60	60		1.3	13,000	12,880		7.12
Sludge from bed	2.201	3.1776	60	55		1.8	18,000	14,990	01:10	7.01
04/07/2014	**Before**	**After**		**Weight container plus wet**	**SS (mg/L)**	**% DS**		**mg/L**		
Decant Effluent	201.57	206.7	100		51.3			146		7.26
Effluent Discharge	205.3	205.8	100		5			110		8.15
Influent to bed	2.2037	2.283	10	11.6		0.8	8,000	12,700		7.08
Sludge from bed	2.1912	2.5541	10	15.3		3	30,000	18,720	1:5 then 1:10	6.97
08/07/2014	**Before**	**After**		**Weight container plus wet**	**SS (mg/L)**	**% DS**		**mg/L**		
Decant Effluent	205.01	210.5	100		54.9			222		
Effluent Discharge	200.78	202.42	100		16.4			118		
Influent to bed	2.2037	2.769		51.5		1.1	11,467	18,510	1:5 then 1:10	
Sludge from bed	2.1912	4.6227		43.8		5.8	58,437			
10/07/2014	**Before**	**After**		**Weight container plus wet**	**SS (mg/L)**	**% DS**		**mg/L**	Decant & Filled	
Decant Effluent	191.3	194.8	100		35			340		7.15
Effluent Discharge	185.8	186.8	100		10			91.4		7.81
Influent to bed	2.192	2.336		20		0.8	8,000	6,240		7.23

Sludge from bed	2.1939	3.436		20		6.98	69,757			7.08
14/07/2014	**Before**	**After**		**Weight container plus wet**	**SS (mg/L)**	**% DS**		**mg/L**		
Decant Effluent	**No decant sample today**									
Effluent Discharge	189.5	190.6	100		11			17.9		
Influent to bed	2.1874	2.5922		50		0.8	8,466	10,280		
Sludge from bed	2.191	5.725		50		7.4	73,919	15,330	1:5 then 1:10	
16/07/2014	**Before**	**After**		**Weight container plus wet**	**SS (mg/L)**	**% DS**		**mg/L**	Decant not filled till Friday to allow time for sludge to accumulate in the system	
Decant Effluent	185.9	188.7	100		28			111		7.55
Effluent Discharge	189.1	190.6	100		15			10		8.14
Influent to bed	2.1889	2.4526		50		0.6	5,515	5,410		7.1
Sludge from bed	2.0195	5.884		50		8.1	80,543	18,300	1:5 then 1:10	7.04
21/07/2014	**Before**	**After**		**Weight container plus wet**	**SS (mg/L)**	**% DS**		**mg/L**		
Decant Effluent	200.7	203.9	100		32			190		
Effluent Discharge	202.8	204.1	100		13			41		
Influent to bed	2.1906	2.555		50		0.8	7,622	7,460		
Sludge from bed	2.1866	5.647		50		7.2	72,365	17,740		
23/07/2014	**Before**	**After**		**Weight container plus wet**	**SS (mg/L)**	**% DS**		**mg/L**		
Decant Effluent	201.7	204.8	100		31			104		7.33
Effluent Discharge	205.5	195.5	100		5			27	SS <10mg/L	7.81
Influent to bed	2.1946	2.66		50		1.0	9,735	7,440		6.82
Sludge from bed	2.1935	5.880		50		7.7	77,117	26,070		6.71

27/07/2014	Before	After		Weight container plus wet	SS (mg/L)	% DS		mg/L		
Decant Effluent	203.5	206.9	100		34			147		7.52
Effluent Discharge	203.6	205.5	100		19			5		6.91
Influent to bed	2.1894	2.5766		50		0.8	8,099	10,580		6.7
Sludge from bed	2.1865	6.383		50		8.8	87,772	14,480	1:5 then 1:10	6.96
30/07/2014	**Before**	**After**		**Weight container plus wet**	**SS (mg/L)**	**% DS**		**mg/L**		
Decant Effluent	203	209	100		60			187		7.06
Effluent Discharge	199.9	201.4	100		15			5		7.96
Influent to bed	2.1846	2.4609		50		0.6	5,778	7,280		7.01
Sludge from bed	2.1805	7.069		50		10.2	102,228	21,000	1:5 then 1:10	8.08

Appendix C Tipperary County Council Analytical Results

Station Name	Sample Date	BOD	COD	Suspended Solids	Ammonia (N)	Chloride	Nitrates (N)	Nitrites (N)	Ortho-P (P)	pH	Sulphate	Temperature	Total Oxidised Nitrogen	Total Phosphorus
Twomileborris STP **influent**	21/01/2014	117	250	111	16.99	104.5	2.81	0.197	2.01	7.91	28.77	6.7	3.01	3.2
Twomileborris STP influent	04/03/2014	57	115	46	7.66	62.09	3.62	0.133	0.934	7.77	26.49	5.7	3.75	1.72
Twomileborris STP influent	28/05/2014	359	802	314	48.2	166.7	0.06	0.034	5.55	8.57	28.63	14.1	0.09	8.9
Twomileborris STP influent	17/06/2014	394	740	135	52.44	202.7	0.06	0.022	5.97	8.41	28.75	16.2	0.08	9.35
Twomileborris STP influent	15/07/2014	293	620	316	44.66	288.2	0.35	<0.01	4.87	8.32	7.25	16.2	0.35	8.2
Twomileborris STP final **effluent**	21/01/2010	4	20	7.6	2.39	109.5	9.05	0.15	1.72	7.65	37.66	8.1	9.2	1.96
Twomileborris STP final effluent	02/03/2010	6	30	10	6.65	194.2	12.53	0.18	3.458	7.77	51.06	6.5	12.71	3.72
Twomileborris STP final effluent	06/05/2010	6	43	7.2	0.055	217.9	37.62	0.19	3.75	7.78	51.29	12.9	37.81	4
Twomileborris STP final effluent	22/07/2010	3	18	7.6	<0.01	144.01	16.64	0.02	3.28	7.69	37.18	15.4	16.66	3.48
Twomileborris STP final effluent	12/08/2010	3	17	19.2	0.044	197.6	26.63	BLD	4.03	7.95	49.3	15.6	26.64	4.28
Twomileborris STP final effluent	30/11/2010	4	5	10.4	0.051	151.2	25.94	0.12	2.429	7.69	51.2	5.8	26.06	2.52
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Twomileborris STP final effluent	13/01/2011	3	15	8	0.1	131	11.24	0.28	2.2	7.59	31	8.9	11.51	2.2
Twomileborris STP final effluent	24/02/2011	6	29	7	5.1	106	6.39	0.92	1.0	7.68	37	9.4	7.31	1.3
Twomileborris STP final effluent	12/04/2011	5	49	8	12.2	216	0.55	1.07	5.1	7.97	47	12.5	1.63	5.4
Twomileborris STP final effluent	26/07/2011	3	29	9	0.3	236	0.92	0.245	4.0	7.89	43	17	1.17	4.7
Twomileborris STP final effluent	17/08/2011	3	21	10	0.0	206	5.48	0.028	3.3	7.77	43	14.6	5.51	3.7
Twomileborris STP final effluent	04/10/2011	3	24	4	2.4	162	1.08	0.05	3.1	7.77	35	14.3	1.13	3.3
Twomileborris STP final effluent	10/01/2012	4	25	10	0.8	122	5.72	0.282	1.8	7.76	42	10	6.01	2.1
Twomileborris STP final effluent	21/02/2012	5	28	10	2.8	211	4.9	0.275	4.2	7.7	51	9.5	5.17	4.3
Twomileborris STP final effluent	29/05/2012	3	33	6	16.0	256	0.13	0.372	4.7	7.89	52	16.8	0.51	4.9
Twomileborris STP final effluent	03/07/2012	2	9	2	1.3	98	0.4	0.183	1.8	7.7	30	15.9	0.58	2.0
Twomileborris STP final effluent	21/08/2012	2	13	6	4.5	86	0.5	0.352	0.7	7.79	36	16.1	0.85	1.1
Twomileborris STP final effluent	18/10/2012	2	7	5	3.1	63	0.45	0.344	0.3	7.41	16	12.1	0.79	0.4
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Twomileborris STP final effluent	22/01/2013	4	15	9	4.8	99	0.29	0.416	0.0	7.81	32	6.7	0.71	0.2
Twomileborris STP final effluent	07/03/2013	7	40	13	30.6	228	0.02	<0.01	0.2	7.98	43	8.6	0.02	0.5
Twomileborris STP final effluent	23/04/2013	23	62	26	30.2	171	0.05	<0.01	15.6	7.81	33	11.4	0.05	16.5
Twomileborris STP final effluent	09/05/2013	20	73	16	32.4	167	<0.01	<0.01	4.7	7.91	33	11.4	<0.01	5.2
Twomileborris STP final effluent	04/06/2013	18	67	19	46.3	201	0.08	<0.01	12.9	7.95	45	17.7	0.09	14.0
Twomileborris STP final effluent	10/09/2013	5	34	10	12.3	281	0.44	2.32	5.5	7.88	54	14.3	2.75	6.0
Twomileborris STP final effluent	21/11/2013	9	46	12	33.1	249	0.13	0.238	0.2	7.95	46	7.5	0.37	0.5
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Twomileborris STP final effluent	21/01/2014	3	10	1	0.1	135	6.76	0.157	1.6	7.79	39	8.7	6.92	1.6
Twomileborris STP final effluent	04/03/2014	3	16	6	0.0	86	6.01	0.089	0.8	7.71	29	8.5	6.1	0.9
Twomileborris STP final effluent	28/05/2014	3	22	5	0.0	213	2.44	0.039	3.2	7.85	46	15.7	2.47	12.5
Twomileborris STP final effluent	17/06/2014	4	29	3	0.1	259	0.77	0.132	2.5	7.85	51	17.8	0.9	2.9
Twomileborris STP final effluent	15/07/2014	2	26	1	0.0	258	4.99	0.066	6.6	7.75	49	18.1	5.06	6.7

Appendix D Tipperary County Council Financials Email

Sent: 14 August 2013 16:51
To: Jim McGuire
Cc: Eddie Loughnane
Subject: east area improvements sludge infrastructure resulting in financial savings

In late December 2011 Roscrea became the central hub for sludge from the smaller plants in the East area in addition to Cloughjordan and Silvermines in the West area & the Seven villages plants.

The Reason Roscrea was selected as a hub above Thurles was largely because it had a sludge digester which could harness the gas from the sludge satellite plants identified by volatile solid lab tests. (see attached volatile solid results)

Following negotiations in mid December 2011 a rate of €175-€200 per load was offered by letter (13/12/11) by H & L for the removal of sludge from our satellite plants based on the vehicle used which was governed by accessibility. This translated to a cost of between €7.84/t- €10.60/T for the sludge from the various sites to be brought into Roscrea.

In another letter (12/12/11) from H & L arising from negotiations they offered rate of €60/m3 for sludge removal from all the larger sites in the county from Jan 2012 reducing to €55/m3 by July 2012.

In relation to the East area these were the rates applied for removal of sludge from Thurles, Roscrea,

Temple more (separate arrangement DBO)

It was confirmed following lab analysis in Roscrea in October-November 2011(see attached results) that the dry solid from the satellite plants being transported off site & processed by H&L at €40/t , **ranged between 0.45 to 2.73% dry solids**

It was felt that with infrastructural improvement and a high level of focused commitment from caretakers that the process could be greatly improved to produced sludge's with much higher dry solids, and thus a dramatic reduction of sludge to be transported off site resulting in major cost saving.

All the sites were visited, the infrastructure inspected with each caretaker and a plan devised to optimise the removal of cent rate from the sludge, so as to increase its dry solid content

The results following improvement works occurred in 2012- early 2013:

Thurles wwtp optimisation of poly dose

Roscrea wwtp optimisation of poly dose + decanting centrate from sludge holding tank

Borrisoleigh wwtp construction of sludge drying beds with louver plate doors for decanting water & breathable covers.

Holycross wwtp recommissioning sludge beds having fitted louver plate doors and drainage pipework & trial breathable cover on one of four beds

Littleton WWTP recommissioning sludge beds having fitted louver plate doors and drainage pipework & trial breathable cover on one of eight beds.

Templetouhy WTWP construction of sludge drying beds with louver plate doors for decanting water & breathable covers & recommissioning existing sludge beds having fitted louver plate doors.

Toomevara WWTP recommissioning sludge beds having fitted louver plate doors and drainage pipework & trial breathable cover on one of two beds.

Twomileborris wwtp construction of sludge drawing beds with louver plate doors for decanting water & breathable covers.

See attached sludge dry solids results showing:

Holycross in July 2012 with dry solids in covered trial bed at 4.42% & uncovered beds at 3.44%

Littleton at 5.39% & uncovered beds at 2.76%

The cost of sludge removal from Holycross for 2011 –v- 2012 went from €16,000 to €5,000

Improvements to louver plate doors and drainage pipework were carried out subsequently and a result of 8% was recorded by an independent lab for the covered beds.

The Most recent sludge is excellent quality in terms of dry solid and we have sent a sample away to independent lab for testing.

Visually when pushing a shovel into the beds the sludge appears homogenised and thicker with no water pockets. Caretakers have noted that sludge is removed from site on average every seven weeks as against every week to fortnightly previously.

These observations are support by substantial reduction of sludge tonnages removed by H & L and their complaints of it being too thick, confirmed by the attached sheets from agresso which show the following in relation to **2011-v-2012 removal costs**

Thurles WWTP a reduction in sludge removal cost from €64,489.83 to €48,107.65 (part related to improvements) saving €16,382.18

Roscrea a reduction in sludge removal cost from €114,813 to €81,312.31 when the total removal cost of the satellite sites and Roscrea for 2011 was €270,966.56, with the resultant saving of €189,654.25

Over all sludge saving East area 2011 –v- 2012 = €206,036.43 (-) €100,000 spent to achieve the infrastructure improvements

Net Saving was €106,036.43

Savings attributable to reduced charges from H&L and improvements to sludge infrastructure