TE MAUNGA WWTP SLUDGE DEWATERING – PILOT TRIALS TO FULL SCALE

Gareth Hall, Jessica Daly (CH2M Beca Ltd) and Wally Potts (Tauranga City Council)

ABSTRACT (500 WORDS MAXIMUM)

Since the Te Maunga WWTP was commissioned in 1997, waste activated sludge (WAS) has been pumped to an adjacent sludge holding pond for partial stabilisation, with desludging required about every five years. A resource consent condition in the latest consents for the WWTP required the pond to be decommissioned as a sludge pond. Consequently, an options study was undertaken to select sludge thickening and dewatering equipment to be installed at the WWTP.

In conjunction with the Tauranga City Council (TCC) operations team, gravity belt thickeners (GBTs) and screw presses were chosen as the preferred thickening and dewatering equipment respectively. GBTs were well known to TCC, being used at their Chapel Street WWTP in a similar duty. Screw presses were preferred over traditional dewatering machines such as centrifuges due to much lower power consumption, operating speeds and maintenance requirements. As screw presses were a relatively new technology in New Zealand wastewater treatment plants and WAS without any primary sludge is more difficult to dewater, it was considered prudent to undertake WAS dewatering trials.

Innovative Filtration Solutions (IFS) was able to provide a screw press pilot trial unit. WAS was pumped directly from the activated sludge bioreactor to tanks to simulate sludge thickening prior to being fed through the screw press pilot plant. This paper describes the pilot plant trials including the key parameters that impacted on performance of the screw press being sludge feed % solids, age, VSS:TSS ratio, and use of coagulant.

Best dewatering performance was achieved with sludge feed solids between 1.5% and 3% and higher sludge age with a resultant VSS:TSS ratio which is less than 82%. The lower than expected optimum solids feed resulted in a re-think of the sludge thickening process to be adopted. Gravity tank picket fence thickeners (PFTs) were selected to provide better control of the thickened sludge solids % based on residence time in the tanks. Large thickened WAS tanks have been included in the design to provide a buffer for the screw press feed, with further destruction of volatiles to decrease the VSS:TSS ratio possible. To achieve the 20% dewatered solids target, a coagulation injection system was implemented as part of the sludge conditioning process prior to dewatering.

The Te Maunga sludge thickening and dewatering plant was commissioned in late March 2019. The results from the full-scale operation to date are presented in this paper.

KEYWORDS

waste activated sludge, thickening, dewatering, picket fence thickener, screw press

PRESENTER PROFILE

Gareth Hall is a Chartered Professional Engineer and Senior Associate Project Manager at CH2M Beca. His training and background is in wastewater treatment process design. He currently manages a wide range of three waters and infrastructure projects mainly for Local Government Clients.

Wally Potts is the team leader for wastewater and stormwater at Tauranga City Council. He has developed and implemented long-term strategies for the two activities. Providing for growth is a focus for the development of treatment plants and associated assets. Wally is a past President and Board Member of Water New Zealand.

1 INTRODUCTION

Tauranga City Council (TCC) operates two wastewater treatment plants (WWTPs). Chapel Street, near central Tauranga, and Te Maunga on the Mount Maunganui side of the harbour. TCC has the unique ability to divert wastewater flows and loads from the western side of the city to either plant through a pump station located at Memorial Park.

With very close neighbours and site space constraints, the ability to expand the Chapel Street WWTP is very limited. Therefore, the major WWTP capacity upgrades are planned for the Te Maunga plant. With rapid population increase, more wastewater will be diverted to Te Maunga via the Memorial Park pump station and southern pipeline under the harbour.

An overview of the TCC wastewater system is shown in Figure 1 below.

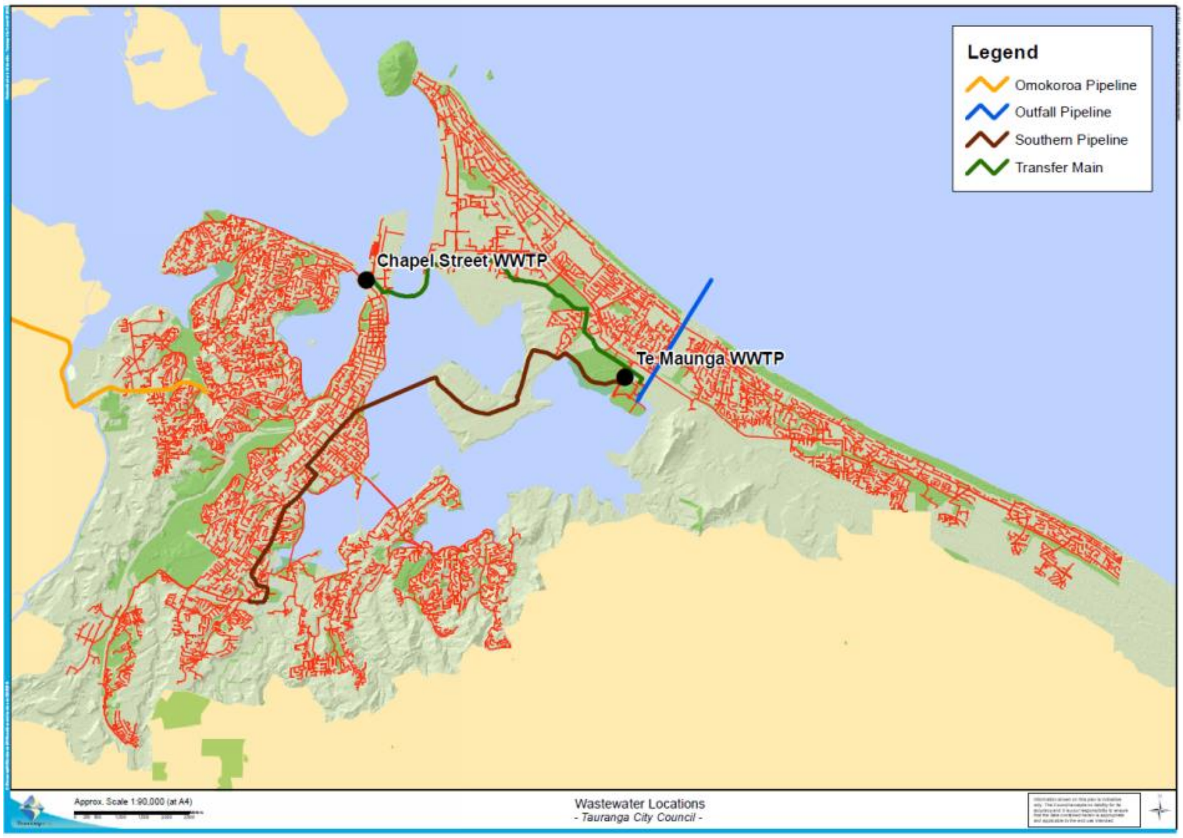

Figure 1: Tauranga City Wastewater System Overview

Digested sludge and WAS produced from the Chapel St WWTP is thickened and dewatered through gravity belt thickeners (GBTs) and centrifuges. The dewatered sludge is trucked to Hampton Downs for application to land.

Since the Te Maunga extended aeration bioreactor plant was commissioned in 1997, waste activated sludge (WAS) has been pumped directly from the bioreactor to Pond 1, which was one of the original oxidation ponds. The sludge is partially stabilised before the pond is de-sludged approximately every five years. Portable centrifuges have been used for sludge dewatering, with the dewatered sludge being placed in the closed landfill at the Te Maunga site. TCC has consent for disposal of sludge in the landfill until 2024.

The last round of resource consents were issued for the Te Maunga WWTP in 2005/2006. A subclause in the air discharge consent required that Pond 1 be decommissioned as a sludge pond by 2012. Being such an innocuous subclause in the air discharge consent, the need to cease WAS discharge to Pond 1 was not recognised until a comprehensive consent review was undertaken in 2014. This emphasises the importance of reviewing all consent condition details and planning to implement those requirements.

Consequently, some urgency was placed on ceasing the WAS discharge to Pond 1. A new sludge thickening and dewatering plant needed to be constructed before pumping WAS to Pond 1 could be discontinued.

At the same time, TCC's biosolids strategy was under review. The ultimate goal adopted is to transform the waste sludge into a useful product to be beneficially used as a fertiliser or fuel replacement instead of landfilling. Design of the thickening and dewatering plant needed to consider this aspiration.

2 INITIAL EQUIPMENT SELECTION

A comprehensive options study was undertaken to determine the preferred sludge thickening and dewatering technologies, that would achieve a dewatered cake with a dry solids (DS) content of at least 20%. This target of 20%DS was adopted due to the requirements of the landfill, which will be the destination for the dewatered biosolids until subsequent phases of TCC's biosolids strategy are implemented (currently programmed in their Long Term Plan for the period 2022-2025). The outcomes of the options assessment are summarised below.

2.1 THICKENING

The sludge thickening technologies considered were:

- Centrifuge
- Gravity Tank
- Gravity Belt
- Drum/Screw Thickener

Although gravity thickening tanks are well proven and had the lowest NPV costs following eight years of operation, gravity belt thickeners were ultimately selected due to TCC Operations staff familiarity with these units at the Chapel St WWTP.

2.2 DEWATERING

The sludge dewatering technologies considered were:

- Centrifuge
- Belt Filter Press
- Vacuum drum filter
- Plate Filter Press
- Rotary Press
- Screw Press
- Piston Press

The belt filter press, rotary press and screw press were short listed mainly due to low operating speeds, lower power consumption and maintenance requirements. NPV costs for the three options were similar.

Screw presses were selected as the preferred technology for the reasons described above and Ishigaki (now IFS) were able to offer a screw press pilot plant to specifically test dewatering of the Te Maunga WAS. This was considered especially important as WAS alone is more difficulty to dewater than if it is mixed with primary/digested sludge.

Dewatering with a screw press begins with flocculated sludge being pumped into a cylindrical screen basket containing a slowly rotating helical screw as shown in Figure 2. Towards the end of the basket the screw shaft diameter increases and the gap between its flights decreases. The volume between the basket, shaft and flights continuously decreases, thus the pressure increases as the sludge is moved through the basket. The screw pushes the increasingly thicker sludge towards the annular clearance, defined by a circular opening and an adjustable discharge cone. The cone is pressed against the opening by pneumatic cylinders to maintain a defined sludge pressure at the discharge end. A brush on the flights cleans the rotating screen from the inside and a spray bar backwashes it periodically from the outside.

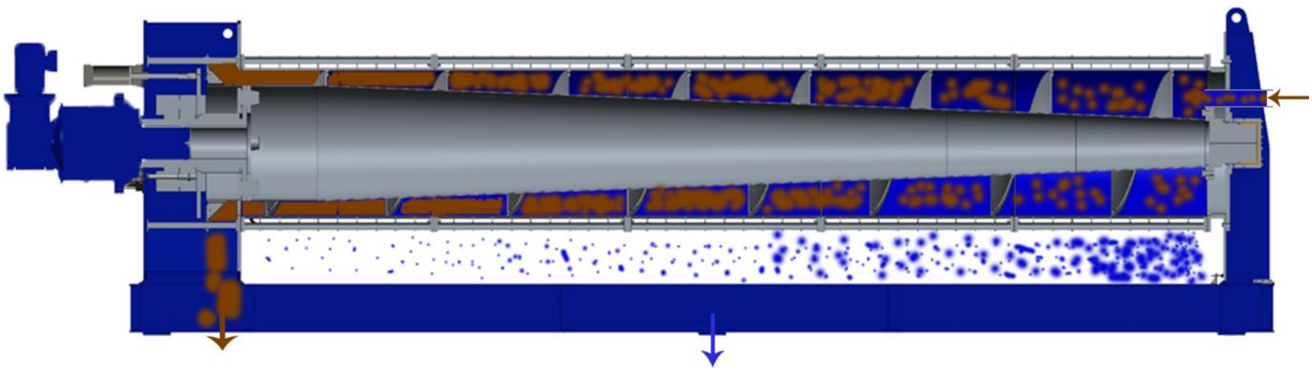

Figure 2: Screw Press Schematic (courtesy of IFS) – Solids move from right to left

The remainder of this paper outlines the screw press pilot plant trials, and how the trial results influenced the process design and construction of the Te Maunga sludge thickening and dewatering plant.

3 WAS DEWATERING PILOT PLANT TRIALS

3.1 TRIAL SET UP

For the screw press pilot plant trials, mixed liquor was pumped directly from the bioreactor into either a standard PE tank or stainless steel hopper bottom tank so different sludge thicknesses could be achieved. Surface wasting is currently implemented at Te Maunga to minimise scum and for ease of sludge age control. As such, trials were initially conducted on WAS from the bioreactor rather than the clarifiers. The thickened sludge was then batch pumped into the screw press trial unit at controlled feed rates. Photographs 1, 2, and 3 demonstrates various aspects of the sludge pilot plant trial set up and operation.

Photograph 1: Pilot Trial Sludge Thickening Tanks

Photograph 2: Screw Press Pilot Plant Unit

Photograph 3: Screw Press Operation

Circled in red in Photograph 3 is 'worm type formation', which indicates that the sludge cake is as dry as possible through the physical squeezing process.

For each batch run through the screw press pilot plant the following sludge feed and polymer data was measured and recorded:

- Feed solids concentration and flowrate
- Cake solids
- Filtrate solids
- Polymer type and dose rate

Dewatered sludge cake percentage solids, and the filtrate suspended solids were sampled from the screw press solids and liquid outlets respectively. As well as the target dewatered cake solids content of 20%, a solids capture rate of at least 95% is necessary so that excessive solids load is not recycled back to the head of the WWTP.

3.2 TRIAL RESULTS

3.2.1 SLUDGE FEED CONCENTRATION

Sludges of different feed concentrations were trialled to investigate the effect of this on dewatering performance. This was achieved by trialling sludge fed directly from the bioreactor (0.25-0.3%DS), gravity thickened sludge (1-2.5%DS) and GBT thickened sludge (3-7%DS) from the Chapel Street site. The results from this series of trialling is shown in Figure 3 below.

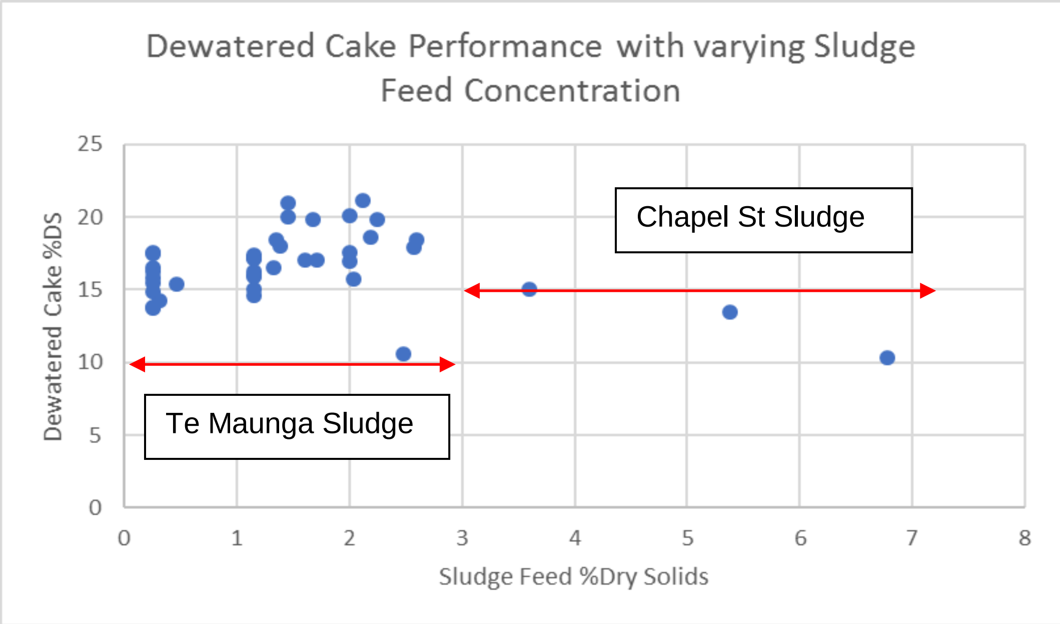

Figure 3: Dewatered Cake Performance with varying Sludge Feed Concentration

It was difficult to get good mixing between the polymer and sludge (>4%DS) when trialling the GBT thickened Chapel Street sludge. This was because it was difficult to uniformly disperse the polymer into sludge of this thickness.

Best dewatered cake performance was achieved when the sludge feed concentration was in the range of 1.5-2.5%DS.

3.2.2 CHEMICAL CONDITIONING

Different powder and emulsion polymers were trialled. Whilst both powder and emulsion polymers initially gave similar dewatered cake results, the strength of the floc was observed to be better with the emulsion polymers. This resulted in a better capture rate being achieved with emulsion polymer for similar dose rates of powder polymer (Figure 4).

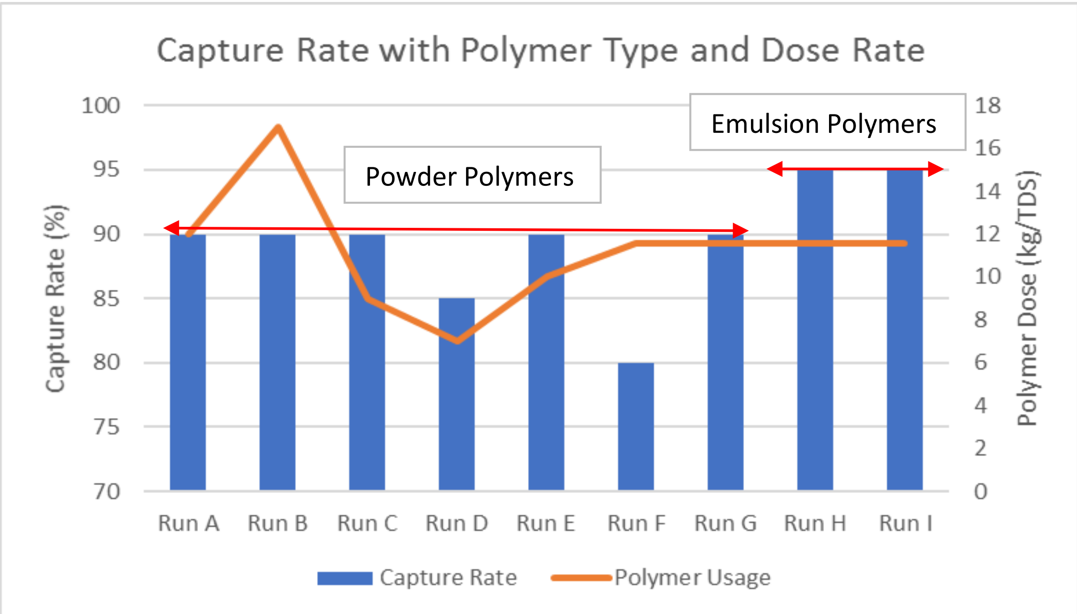

Figure 4: Capture Rate for different polymers trialled 2nd and 3rd November 2016

In addition to polymer, different coagulants were trialled. The use of coagulant improved dewatered cake performance by approximately 1-2%DS.

3.2.3 VSS:TSS RATIO AND SLUDGE AGE

During the trials, IFS indicated that the volatile suspended solids (VSS) to total suspended solids (TSS) ratio and sludge age can have an impact on dewatering performance. Sludge with a high ratio and therefore high volatile solids content can be indicative of a high biological content in the sludge compared to inert material. This means that there is potentially a higher content of water trapped within the biomass (intracellular water) which makes the sludge more difficult to dewater. WAS from a plant with a higher sludge age tends to have a lower VSS:TSS ratio than plants with a lower sludge age.

The VSS to TSS ratio was measured to be 82% on average and sludge age was approximately 12-14 days throughout the trials.

4 PROCESS DESIGN IMPLICATIONS

The pilot trials resulted in changes to the process design for the new plant. The biggest change was instigated by the poor results from the GBT thickened sludge trials causing a rethink of the best thickening process to be adopted. Picket fence thickeners were selected as the thickening process as they would deliver the optimal feed concentration for screw press performance without the need to add polymer.

Other changes to the design included:

- Addition of a coagulant dosing system
- Microscreens added to the filtrate process stream from the screw presses. This was required to improve capture rate to 95%.
- Addition of a static and dynamic mixer upstream of the screw press to promote good mixing of the polymer and sludge.
- Addition of "cutting type" macerators ahead of the screw press feed pumps to prevent hair and rags clogging the mixers.
- Provision was made in the pipework to allow for a second static and dynamic mixer should these be required during commissioning.

5 FULL SCALE CONSTRUCTION AND COMMISSIONING

5.1 PLANT CONSTRUCTION

Plant construction began in February 2018 with the first sludge cake being produced in late March 2019.

Photos (4, 5, 6) of the fully constructed plant are shown below.

Photograph 4: Full scale screw presses

Photograph 5: PFTs, Dewatering Building and Loadout Silo

Photograph 6: Dewatered Sludge Cake Loadout

5.2 PLANT COMMISSIONING

5.2.1 FULL-SCALE RESULTS

The full-scale screw presses were commissioned in late March 2019. The dewatered cake %DS for the first three months of operation are shown in Figure 5 below.

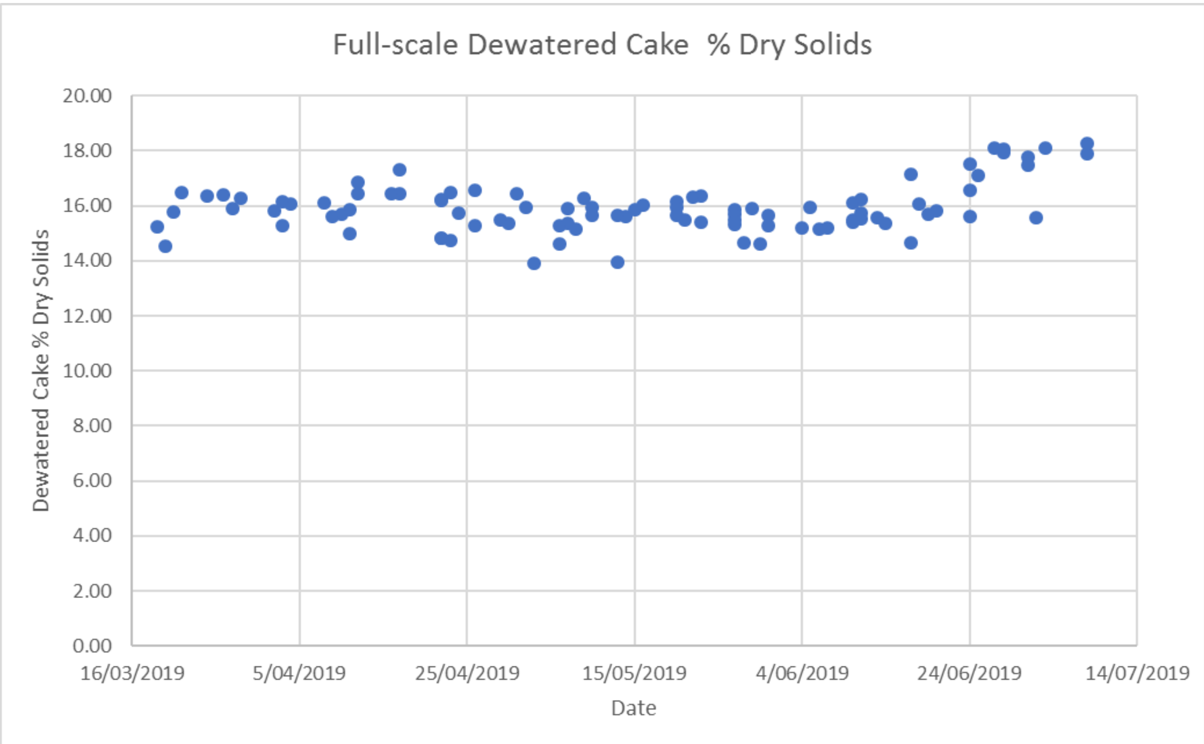

Figure 5: Full-scale screw press dewatered cake %DS results

The full-scale results achieved to date are similar to those achieved in the pilot trials with dewatered cake of 14-18%DS being consistently achieved compared to 15-20%DS in the trials. A change in polymer implemented in late June has seen an improvement in cake solids from 14-15% to 16-18%DS. Anecdotally, the change in polymer has also resulted in an improvement in capture rate. Capture rate has not been formally measured to date, but will be as part of the final performance testing regime. Polymer dose rate has been similar to that in the trials at approximately 10kg/T DS.

5.2.2 FINAL PERFORMANCE TESTING

The Te Maunga plant is currently running under higher than normal loading. This is because the recently completed Southern Pipeline has allowed the transfer of wastewater flows from Tauranga City catchments to be treated at the Te Maunga plant. The completion of the pipeline has also allowed the critical maintenance activity of relining the sewer from the Memorial Park Pumpstation to Chapel Street to occur. The flows through this sewer have been diverted away from Chapel Street resulting in a larger proportion of wastewater flows than usual to be transferred to Te Maunga.

The higher loading at the Te Maunga plant has caused the sludge age to drop to around 8 days which is lower than the 12-14 day sludge age during the trials. Similarly, the VSS:TSS ratio in the sludge has been 88% compared to 82% during the trials. Once the sewer relining to Chapel Street is complete, the loads to Te Maunga will be able to be reduced and hence an increase in sludge age and corresponding drop in VSS:TSS ratio is expected. The increase in sludge age and drop in VSS:TSS ratio is expected to improve dewaterability of the sludge and hence final performance tests have been delayed until the Te Maunga plant can be run at a more optimal sludge age. If available, the results from the final performance tests will be included in the conference presentation.

6 CONCLUSIONS

The sludge thickening and dewatering plant has met TCC’s primary objective of ceasing the discharge of WAS to Pond 1 at the Te Maunga WWTP. Commissioning of the plant has completed the first step of TCC’s biosolids strategy, ultimately aimed at beneficial use as opposed to landfill disposal of sludge. The design of the plant access and loadout hopper facilitates transport of sludge either off site or across to proposed solar drying halls at Te Maunga, which are included in the Council Long Term Plan.

The importance of sludge dewatering pilot plant trials, particularly with WAS has been clearly demonstrated. Sludge feed rate, percentage solids, age, VSS:TSS ratio as well as polymer and coagulant dosing rates all affect dewatering performance. The Te Maunga WAS pilot plant trials allowed necessary changes to be made to the sludge thickening and conditioning process prior to detailed design. The implications of having to make such changes following construction of a full-scale plant are significant and potentially extremely expensive.

Pilot trialling also allowed a “hands on” demonstration of a technology that had not been previously used locally. This was useful for owners, operators and designers to get a greater understanding of the screw presses.

In spite of the VSS:TSS ratio being much higher than that during the trials, the screw presses are consistently achieving 16-18%DS giving us confidence that when the ratio is returned to a normal range the results from the pilot trials will be replicated. It is intended that the final screw press performance testing results will be presented at the Water NZ conference in September 2019.

ACKNOWLEDGEMENTS

We wish to acknowledge and thank the TCC operations team and IFS for their assistance.

REFERENCES

Tauranga Te Maunga Screw Press Test Reports – Ishigaki Oceania Pty Ltd (Test Dates 3rd – 7th October 2016, 2nd – 3rd November 2016, 28th November – 8th December 2016, 27th February – 2nd March 2017).