PUTTING THE SQUEEZE ON SLUDGE – THE ADOPTION OF SCREW PRESS TECHNOLOGY FOR MUNCIPAL SLUDGE DEWATERING AT NEW PLYMOUTH WWTP

Chris French (CH2M Beca Ltd), David Taylor (New Plymouth District Council), Alun James (Opus International Consultants), and David Grace (CH2M Beca Ltd).

ABSTRACT

New Plymouth District Council have undertaken a major upgrade of their sludge thickening and dewatering facilities to substantially improve the dry solids content of dewatered sludge. The key drivers of the upgrades are; to reduce energy use in the existing downstream thermal dryer process, improve the operational reliability of the existing dewatering process by replacing the ageing direct coupled Gravity Belt Thickener (GBT) and Belt Press process; and increase redundancy by producing a dewatered sludge that can be landfilled directly if required (>20%DS). Screw presses were selected as the preferred technology based on early trials and evaluation of a range of technologies.

A screw press essentially squeezes the feed material (in this case thickened waste activated sludge) against a screen, utilising a slowly rotating screw. The "pressate" (liquid stream) is drained by gravity from the underside of the machine, and the dewatered sludge is conveyed out of the end of the machine. The "squeezing process" is regulated by an automatically adjusting backing plate which moves back and forth to maintain a constant "squeeze" pressure inside the machine.

This paper presents the project from master planning to commissioning, including the outcomes of early operation. A number of considerations and lessons learnt that influenced the design, construction and early operation of this project, which have also been discussed in this paper.

KEYWORDS

Sludge Dewatering, Screw Press

PRESENTER PROFILE

Chris French is an Associate in Beca's Water team has over 15 years' experience in the design and project management of municipal wastewater treatment plants. Chris was the design project manager for the initial design phases of the New Plymouth WWTP upgrades, and has provided ongoing technical and commissioning and advisory services.

David Taylor has over 11 years' experience in civil and environment engineering and project management, and is a Senior Infrastructure Project Manager at New Plymouth District Council. David was initially Project Manager, and has since become Project Director, for the recent New Plymouth WWTP Upgrades projects.

David Grace is a Senior Mechanical Engineer at Beca, who has over 8 years of experience in design, project management, construction management, and technical review of mechanical systems including significant industrial and water / wastewater treatment projects. David was the lead Mechanical Engineer for the recent New Plymouth WWTP Upgrades.

1 INTRODUCTION

1.1 BACKGROUND INFORMATION

The New Plymouth Wastewater Treatment Plant (WWTP) provides tertiary treatment of municipal wastewater for the city of New Plymouth and the satellite communities of Inglewood, Waitara and Oakura, serving a total population equivalent of approximately 104,000. This includes a trade waste component, predominantly from chicken processing, which contributes approximately 18 – 20% to the total average daily flow.

The original plant, constructed in the early 1980's, provides preliminary treatment including fine screening and grit removal; secondary treatment using extended aeration activated sludge "carousels" together with secondary clarifiers; and chlorine disinfection. Several upgrades have been undertaken to the plant to address growth and asset life cycle demands, most notably including the introduction of a thermal rotary (drum) dryer process in 1999, to dry waste activated sludge (WAS) that has been thickened (through the picket fence thickener process) and dewatered by the direct coupled gravity belt thickener and belt presses.

A Master Plan for the New Plymouth WWTP was produced in 2010 which defined future work to be undertaken at New Plymouth WWTP for a design horizon to the year 2040. The principal driver for commissioning the plan was to allow for the predicted increase in loads to the plant. Several upgrades were identified, including:

(i) A significant upgrade of the extended aeration activated sludge process, which was undertaken in 2013 to convert the existing carousels to a nutrient removal plug flow configuration (known as the "Bioreactors").

(ii) An upgrade to the inlet works system and flow balancing facility to address issues of flow and hydraulic capacity, and replace ageing assets.

(iii) An upgrade of the existing sludge dewatering process, to improve the dewatering performance and replace ageing assets (as detailed further below).

In addition, an upgrade of the thermal drying facility (TDF) be undertaken over the next two years. The TDF receives and dries the dewatered sludge to generate a commercial fertilizer project known as Bioboost®.

1.2 THE NEED FOR THE DEWATERING UPGRADE

NPDC identified that the old sludge dewatering plant, consisting of three direct coupled gravity belt thickeners with belt presses, required a significant refurbishment. The extent of the refurbishment, and the relatively low dry solids content of the dewatered sludge from the belt presses at New Plymouth WWTP, meant that it was worth considering alternative dewatering technologies.

Therefore, the major drivers for upgrade were:

1. The whole of life cost for replacement of the belt presses with an alternative dewatering technology (that could produce a substantially dryer dewatered sludge) was lower than for the option of retaining and operating the belt presses. This was

largely due to the reduction in natural gas use that would result from the dryer feed sludge.

2. Typically, sludge cake of less than 20% dry solids content is not accepted at landfills because it cannot be suitably worked by tracked equipment. The belt presses typically produced dewatered sludge in the order of 14 – 15% dry solids. Should the TDF break down and be unable to be reinstated quickly, NPDC required an alternative sludge disposal route. In these situations, transport and disposal costs were also reduced.

1.3 REVIEW AND SELECTION OF SLUDGE DEWATERING TECHNOLOGY

1.3.1 INITIAL DEWATERING TRIALS

Recognising the need for the upgrades, and to inform the master planning process for sludge dewatering, NPDC undertook pilot testing of centrifuge and screw press technologies in 2014, using mobile test units. The performance of dewatering technology is usually very specific to the sludge characteristics of the particular sludge feed, which in turn will be related to the biological and/or physical wastewater treatment processes that have been used to generate the sludge in the first place. Therefore, undertaking the pilot trials to confirm the effectiveness of the proposed sludge dewatering technologies became an important step in determining the preferred technology for New Plymouth WWTP.

The trials indicated that, while similar polymer consumption rates would be required for each technology, a higher dry solids content (of 22 – 24% DS) could be achieved in the dewatered sludge for the particular sludge type and characteristics at New Plymouth WWTP.

1.3.2 FURTHER ASSESSMENT AND SELECTION OF SLUDGE DEWATERING TECHNOLOGY

In 2014, New Plymouth District Council (NPDC) commissioned a review of sludge dewatering technologies. The review presented a number of options that were shortlisted based on process performance (to produce the desired dry solids content in the dewatered cake), footprint, power consumption, likely polymer consumption, odour risk and operations/maintenance inputs.

Following further assessment of the shortlisted options based on whole of life costs, previous trials of the technology at the treatment plant, and other operational considerations, screw presses were found to be the most favourable technology for sludge dewatering, on the basis that:

- They presented the lowest whole of life cost option.
- The screw presses were the only option that could achieve a dewatered sludge cake with greater than 20% dry solids content, thus enabling landfilling as a back-up disposal option.
- Screw presses produce relatively low noise emissions.
- Screw presses have lower rotational speeds and less moving parts than other dewatering technologies, which is expected to reduce maintenance burden.

2 OVERVIEW OF SLUDGE DEWATERING PROCESS

2.1 SLUDGE THICKENING

The original New Plymouth WWTP included two picket fence thickeners (PFTs) that were designed to operate in parallel to thicken waste activated sludge (WAS) from the secondary treatment process ahead of sludge dewatering. The primary purpose of the PFTs is to separate the supernatant from the WAS and allow it to settle and thicken under gravity, providing a more compacted sludge blanket. The PFTs also provided limited WAS flow moderation (buffering) between the secondary treatment and sludge dewatering processes.

Figure 1: Aerial View of Two Picket Fence Thickeners at New Plymouth WWTP, Prior to Upgrade.

During the preliminary design phase of the sludge dewatering upgrades, a re-evaluation was undertaken of the need to upgrade the sludge thickening and buffering operations to enable better performance and less complex operation of the sludge processing train. The primary objectives of the sludge thickening upgrade included:

- To improve the amount of sludge buffer capacity in the sludge process train prior to sludge dewatering.
- Improve the consistency of the dry solids content of the sludge feed to the screw presses, noting that a stable (or only gradually varying) flow and solids load is an important element of screw press (and other sludge dewatering) operations. Ultimately, this improves sludge dewatering performance and reduces operator input.

The upgrade of the sludge thickening system was completed in 2016. A process diagram incorporating the upgraded sludge thickening process is provided in Figure 2 overleaf.

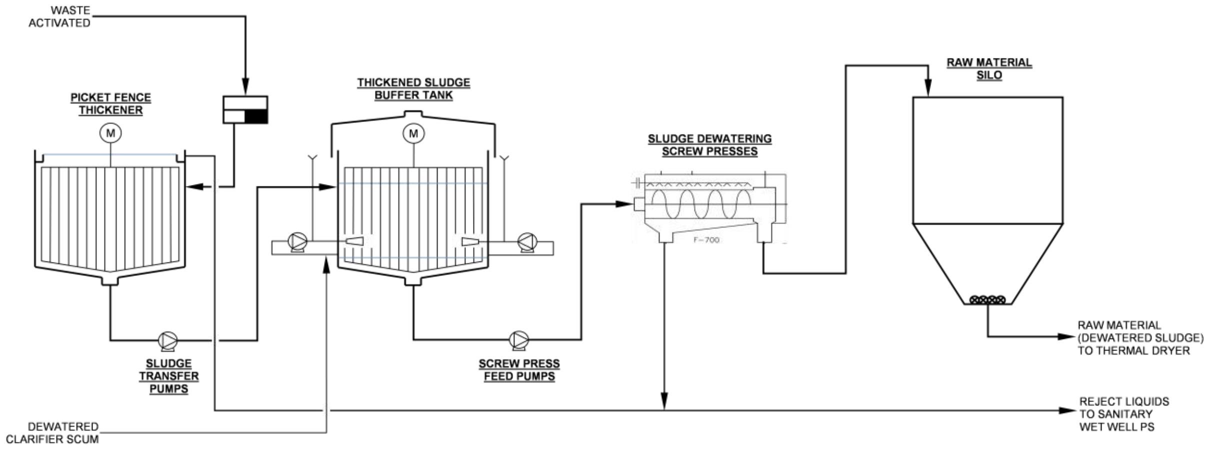


Figure 2: Process Schematic of Sludge Thickening and Dewatering process (After Upgrade) at New Plymouth WWTP.

Under the upgraded plant configuration, waste activated sludge (WAS) is discharged to one PFT, which has been refurbished and upgraded with improved sludge blanket control systems. This ultimately improves the timing and extent of sludge withdrawal (using a thickened sludge transfer pumping system) from the PFT and therefore enables a more consistent thickened sludge stream to be produced.

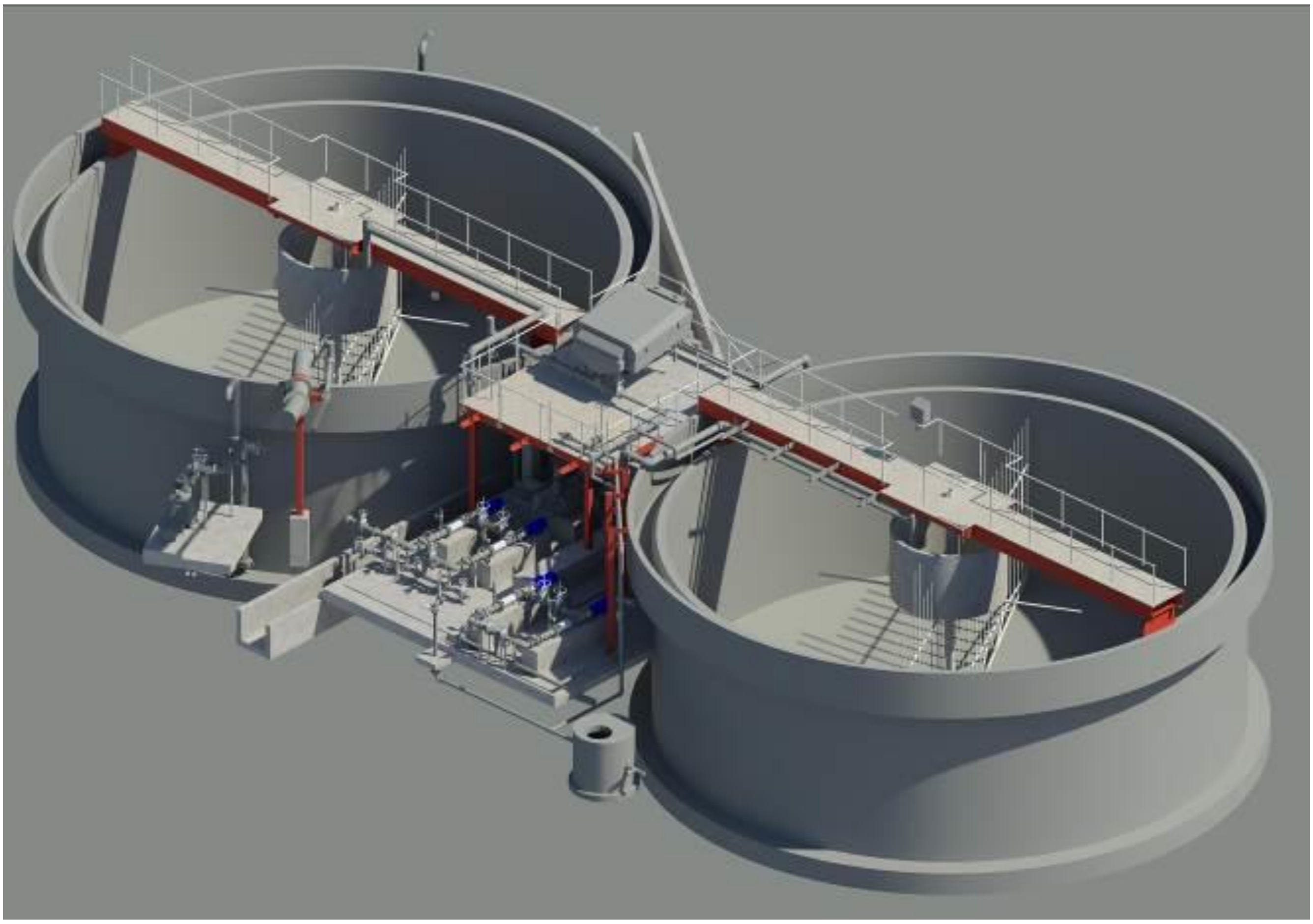
Thickened sludge is introduced into a sludge buffer tank, which has been converted from one of the two original PFTs. This has required significant modification of the PFT, including:

- The installation of a mixing system, which consists of externally mounted pumps that withdraw sludge from the bottom of the tank and re-introduce it via specially orientated nozzles at higher level within the tank. Air is introduced into the mixed sludge stream via a venturi system on the discharge side of the mixing pumps. This is intended to provided limited aeration to the sludge, thereby reducing potential for odour emissions in the storage of the thickened WAS.

- To further manage odour emissions, the buffer tank has been covered. A geomembrane cover was installed, supported by epoxy coated mild steel ribs retrofitted over the tank, as shown in Figure 3. Note that when considering options to cover the existing tank, the use of this type of cover system provided cost advantages for supply and construction over other options.

In addition, a new filtration process, known as a “Baleen Filter”, has been installed to remove the “carrier water” entrained in the scum from the secondary clarifiers. This has removed approximately 40 – 50 m^3 water from the sludge feed to the PFT, resulting in at least a one half of a percent increase in the thickened solids feed to dewatering. Under the new process, flocculent is added to the scum, before it is filtered over a 130 micron filter table within the Baleen Filter unit. The resulting dewatered scum stream is fed into the thickened sludge buffer tank.

Figure 3 provides an overview of the 3D design model of the plant and photographs of the installed plant.



(a)

(b)

Figure 3: (a) Design Model Render of Sludge Thickening Upgrade at New Plymouth WWTP, including PFT (to the Right) and Sludge Buffer Tank (to the left of picture). (b) Photograph of Upgraded Plant, showing Sludge Buffer Tank with Geomembrane Cover Fitted (left of picture)

2.2 THE SCREW PRESS PROCESS

2.2.1 THE SCREW PRESS

A screw press works on the principle of straining available free water from sludge by "squeezing" the sludge against a perforated screen, through which the strained water drains under gravity. Figure 4 provides a schematic of a screw press including key components.

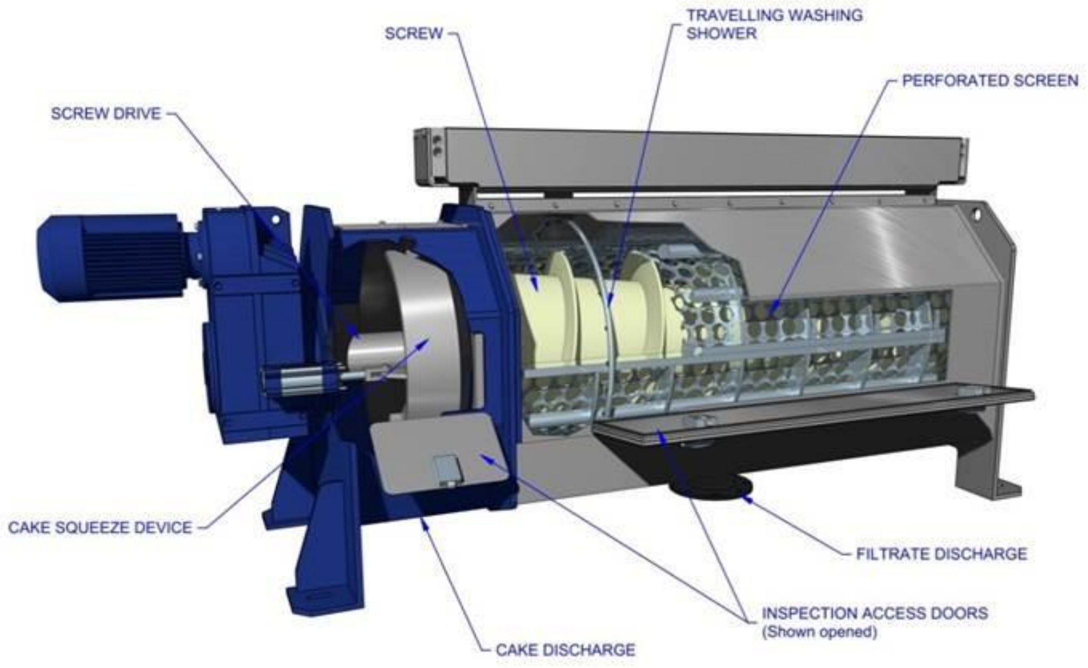


Figure 4: Cross-section Schematic of a Screw Press. Courtesy of Ishigaki Oceania Ltd.

The main screw, which is typically installed in either a tapered or variable pitch configuration, is usually installed between two bearing housings within the main frame of the screw press, and is (typically) driven by a (typically) direct coupled gearbox and associated drive motor. A cylindrical basket or screen is provided between the screw and the press frame. Wedgewire or perforated plate screen configurations are common, with some screw press designs incorporating variable aperture perforations or slots. The screw press screen can be mounted in either a horizontal (as shown in Figure 4) or inclined alignment, depending on vendor preferences.

Prior to entering the screw press, and after mixing with polymer, the sludge will enter a flocculation vessel to enhance floc formation prior to dewatering. The sludge is then introduced into the screw press, between the screw and the screen via the inlet port(s). Free water from the sludge drains through the perforated screen and is collected by the drip tray. The remaining solid matter is separated from the filtrate water and is captured along the internal face of the screen/basket. As this material is being captured, the screw slowly squeezes the material while continuously moving the dewatered solids towards the discharge end of the press. At the discharge end of the press, a pressing cone is situated to provide additional back pressure, usually driven and controlled by a set of pneumatic cylinders.

The efficiency of the dewatering is determined by the degree of flocculation, the speed of the screw and ultimately the pressure on the pressor at the end of the screw press.

A wash ring, which includes several washing nozzles, is contained in the enclosure to rinse the filter screen and the inside of the cover regularly, or on demand. The washing nozzles are installed on a circular tube which moves horizontally over the full length of the filter screen by means of a linear drive (which is pneumatically actuated). During the washing of the filter screen, the dewatering process is not interrupted.

2.2.2 ADDITIONAL PROCESS ENHANCEMENTS

One of the key performance requirements of the sludge dewatering upgrade was to achieve a solids capture of greater than 95% (measured as the total dry solids mass flow rate at the screw press outlet divided by the total dry solids mass flow rate of the sludge feed). This was to prevent excess accumulation of solids in the wastewater process which could lead to operational issues in the biological treatment and sludge thickening processes.

To meet these requirements, it was recognized that additional processing of the filtrate may need to be undertaken. This has been achieved at New Plymouth WWTP by the addition of a "Microscreen". The Microscreen is equipped with a fine barrel screen/drum which captures the solids in the filtrate from the screw presses. During normal filtering operation, the screen remains static. Solids are collected on the screen and washed off. Once washed off, the solids are discharged into a separate solids recovery tank, and then pumped back to be incorporated with the thickened sludge (which is then fed back into the screw presses).

2.3 SLUDGE LOAD-OUT AND DOWNSTREAM PROCESSING

Once the sludge has been dewatered, it is discharged via gravity. At New Plymouth WWTP, the sludge is conveyed via a series of shaftless screw conveyors to a "raw material storage silo".

3 KEY PROCESS DESIGN CONSIDERATIONS

3.1 SLUDGE CHARACTERISTICS

The sludge flow and load to the proposed screw press system was based on a mass balance developed for the New Plymouth WWTP as part of the preliminary design process, which was in turn "calibrated" by comparison to current average daily Waste Activated Sludge (WAS) production. One of the key challenges of building the mass balance was to account for the suspended solids removed in the preliminary treatment (screens and grit removal) process, which could only be accounted for, in practical terms, by building a discontinuity into the mass balance model. WAS production was projected to year 2040 utilising sludge yield factors based on influent Biochemical Oxygen Demand (BOD_5) in the Bioreactor influent, and growth factors to project future BOD_5 loads,. The resultant mass balance is provided in Figure 5.

Ultimately, the mass balance provided key duty points that provided a "starting condition" for the purposes of sizing the new sludge dewatering system. While total WAS production was one important factor, process redundancy and the capacity of storage were other very (if not more) important factors in system sizing, as described further below.

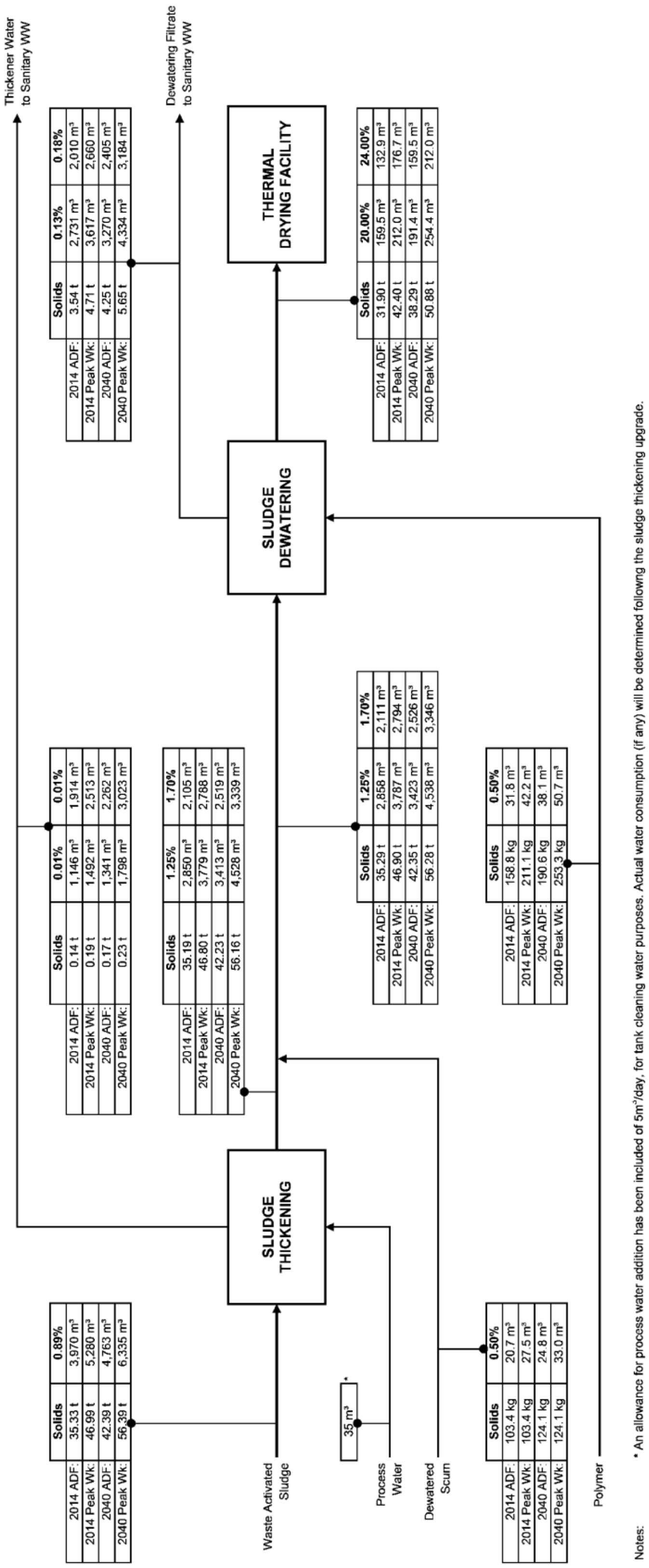


Figure 5: Summary Schematic of Mass Balance for Upgraded Sludge Process Train at New Plymouth WWTP (figures shown are total weekly rates).

3.2 SCREWPRESS REDUNDANCY AND PERFORMANCE REQUIREMENTS

When sizing the screw press equipment, an important relationship was identified between redundancy provisions and sludge dewatering performance (dry solids content in the dewatered sludge). For example, if two screw presses are installed to each provide the full duty capacity of the plant and are designed to simply operate in duty/standby configuration, a lower dewatering performance (lower dry sols content in the dewatered sludge) can be expected from the single operating machine can be expected. However, if the screw presses are operated in duty/assist mode at the same total throughput (i.e. with turn down), a higher dry solids output from can be expected. This creates a trade-off between cost (of installing more screw presses), reduced process reliability and dewatering performance.

The relationship between redundancy and dewatering performance is represented in a simple form in Figure 6 below, and will be in practice be more complicated, based on specific variables of any given sludge dewatering operation. However, as has been found at New Plymouth WWPT, it is an important factor that requires early consideration in determining the design basis.

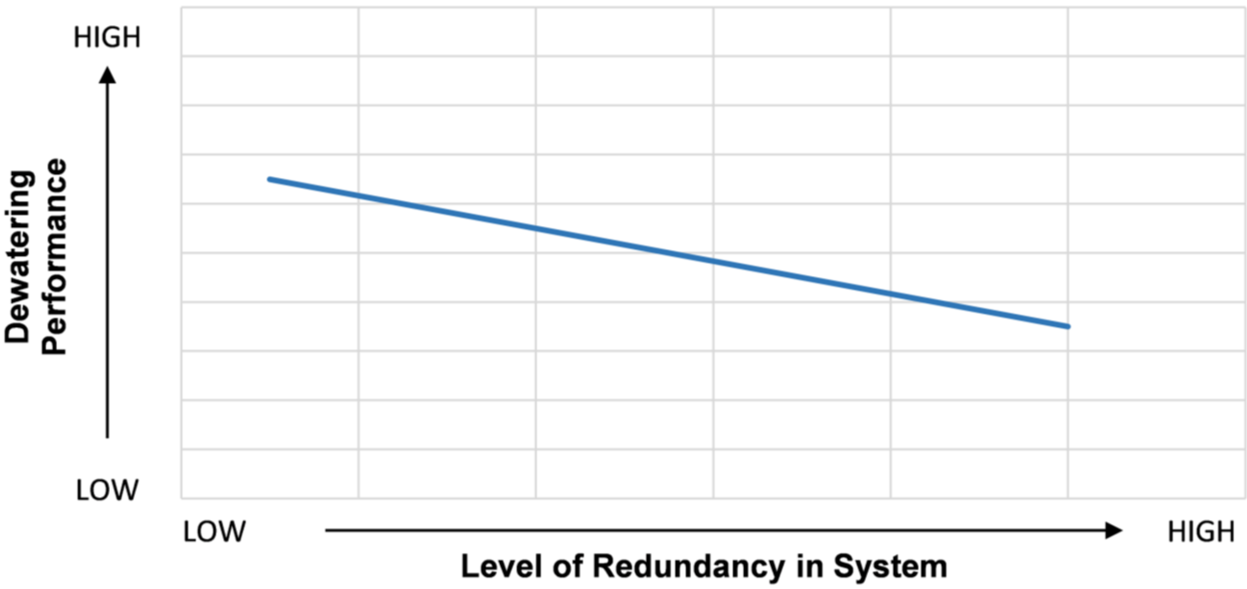


Figure 6: Schematic Indicating trade-off / Relationship between Dewatering Performance and Level of Redundancy Provided in a Screw Press System.

At New Plymouth WWTP, a minimum requirement was established to provide:

- Duty/standby capacity, provided by two screw press units; and
- Sufficient hydraulic and solids throughput in each screw press that a minimum dewatered cake of 20% dry solids is achieved when operating in duty/standby configuration.

The opportunity has also been taken, through process equipment selection and configuration, to be able to operate the screw presses in duty/assist configuration to achieve higher dry solids content in the dewatered sludge output. This particularly impacted the design of the sludge feed system, so formed an important part of the design basis.

3.3 UPSTREAM AND DOWNSTREAM PROCESS INTEGRATION

During the process design development or he sludge dewatering system, consideration was given to integration with the upstream (sludge thickening) and downstream (sludge drying) processes.

In terms of the upstream side, the key factor here was providing sufficient buffer storage to enable differences in the operating regime of each part of the sludge process train (wasting, thickening, dewatering and drying) to be accounted for, within the limits of available existing infrastructure. In addition, buffer storage provisions needed to account for the desire to operate the screw presses as turned down as is practical to achieve higher dry solids content in the dewatered sludge.

This required an analysis of storage provisions afforded by existing infrastructure at New Plymouth WWTP, and any additional sludge buffering that could be provided, particularly on the upstream side of the process. The analysis included the development of a process model to determine, in practice, how the thickened sludge buffering and dewatered sludge storage would operate based on varying thickened sludge production rates, varied screw press feed rates, and a fixed raw material feed into the thermal dryer. The process model was deemed necessary to take account of these multiple variables, and provided invaluable input into validating screw press sizing.

On the downstream side, the most important consideration was how changes in the sludge dewatering would impact the thermal drying facility (TDF) operation. During the design process, attempts were made to understand these impacts but with mixed success. Very recent (more extensive) investigations have been undertaken since the sludge dewatering upgrade was completed, which indicate that the dryness of the dewatered sludge will have an impact on the formation of sludge pallets inside the drum dryer. This in turn impacts the characteristics of the product from the thermal dryer, in terms of shape, size, hardness and dust content, which are all important considerations for NPDC who must meet market requirements for their Bioboost® dried sludge product. In hindsight, the knowledge gained from these investigations may have influenced (or at least enhanced) the design development process of the sludge dewatering system.

4 PROCUREMENT

The screw presses, including the associated polymer system and microscreen, were purchased by an equipment supply tender process. The design was then completed by NPDC's nominated designer and installed under a separate installation contract. This strategy was chosen as it gave NPDC better control over process equipment selection, and enabled a full detailed design to be developed around a specific screw press model with full integration with existing upstream and downstream equipment, and within the existing sludge dewatering building – particularly important in a brownfields upgrade.

The sludge dewatering equipment contract contained several key feature requirements, including the way that performance requirements were specified; the management of testing and commissioning; and the approach to health and safety management.

4.1.1 PERFORMANCE SPECIFICATION OF SLUDGE DEWATERING EQUIPMENT

It is typical when specifying process equipment to nominate specific duty points that form process requirements and may form performance guarantees for the equipment. As previously noted, the design and operation of the equipment in this case is dictated by a significant number of operating condition parameters, with a significant potential for variation of these operating parameters. Added to this, the different sizes of available equipment will impact the preferred combination of equipment size and number.

It was also desirable (where possible) to provide flexibility to vendors, when tendering for equipment supply, so that they could bring innovation to the design process and submit a number of options that would enable NPDC to consider opportunities to reduce whole of life cost, and/or increase operational flexibility.

To manage all of these considerations through the procurement process, and evaluate the performance of the screw press equipment tendered across the wide range of possible operating points, all tenderers were required to submit performance curves for three important performance factors. These included:

- Performance curves sludge dewaterability (dry solids output) versus hydraulic throughput, across a range of sludge feed dry solids conditions capacity.
- Performance curves of solids capture ratio versus hydraulic throughput, across a range of sludge feed dry solids conditions.
- Performance curves of polymer consumption versus hydraulic throughput, across a range of sludge feed dry solids conditions.

The intention of the performance curves was to enable performance envelopes for each tendered equipment option to be compared using basic statistical analysis, so that NPDC could consider the performance and flexibility in operation provided by each option. In addition, Net Present Value calculations could be made at various operating points within these performance envelopes as part of the tender evaluation process.

While these performance curves were provided with the tenders received from plant vendors, vendors were generally unwilling to guarantee the performance of the plant according to these curves. This limited the validity of this approach, and with this knowledge, may have impacted the procurement process, in terms of the structure of the procurement process and the way that performance guarantees were developed.

4.1.2 TESTING AND COMMISSIONING REQUIREMENTS

One of the key risks identified at the initial project risk workshop was the potential for short or long term plant performance issues as a result of poor installation, commissioning or testing. This risk may become exacerbated when multiple parties are involved in the project lifecycle, including the design, plant supply, installation and commissioning process.

To address this and associated risks, specific delineations were made between testing and commissioning stages, with specific pass criteria for each stage, associated certification requirements, and milestone payments tied to this. In addition, the contract featured:

- The screw press equipment supplier was nominated as the lead commissioning party, even for plant and equipment not supplied by them. This recognized that the plant not supplied by the screw press vendor has a significant impact on the screw presses themselves, and their ability to achieve performance requirements.
- An extended trial operation period was included, in which continuous uninterrupted and correct operation of the screw press and all associated supplied systems without defect is required. This was to increase the screw press supplier’s vested interest in the commissioning process to confirm that the plant is operating correctly and to the expected performance before the trial operation commences.

- "Defects", as defined in the contract, included performance issues and overuse of utilities / consumables.

4.1.3 PROMOTION OF PROACTIVE SAFETY MANAGEMENT

The sludge dewatering upgrade was undertaken in a brownfields environment, in an existing building containing live plant that needed to be kept operating throughout the physical works. The very nature and location of the works therefore created significant interfaces with existing plant operations, as well as requiring the inputs of multiple contractors, sub-contractors, the Principal (NPDC) and its representatives.

In addition, execution of the physical works (construction) occurred shortly after the introduction of the Health and Safety at Work Act 2015 came into force. The provisions of this place new and additional requirements for health and safety management, including but not limited to the installers of plant, substances and structures. This includes duties of care on all parties to undertake significant consultation, cooperation and coordination of resources and activities; and higher levels of worker-to-worker communication in the workplace.

To assist in the management of this risk, a Health and Safety Management Framework was developed for the project to outline the key responsibilities of each stakeholder party in the implementation of the physical works stages, and the minimum expected Health and Safety requirements for all employers and their personnel engaged to undertake work. In essence, the Framework sought to achieve a consistent and coordinated approach to health and safety management across all parties. Key features of the Framework included:

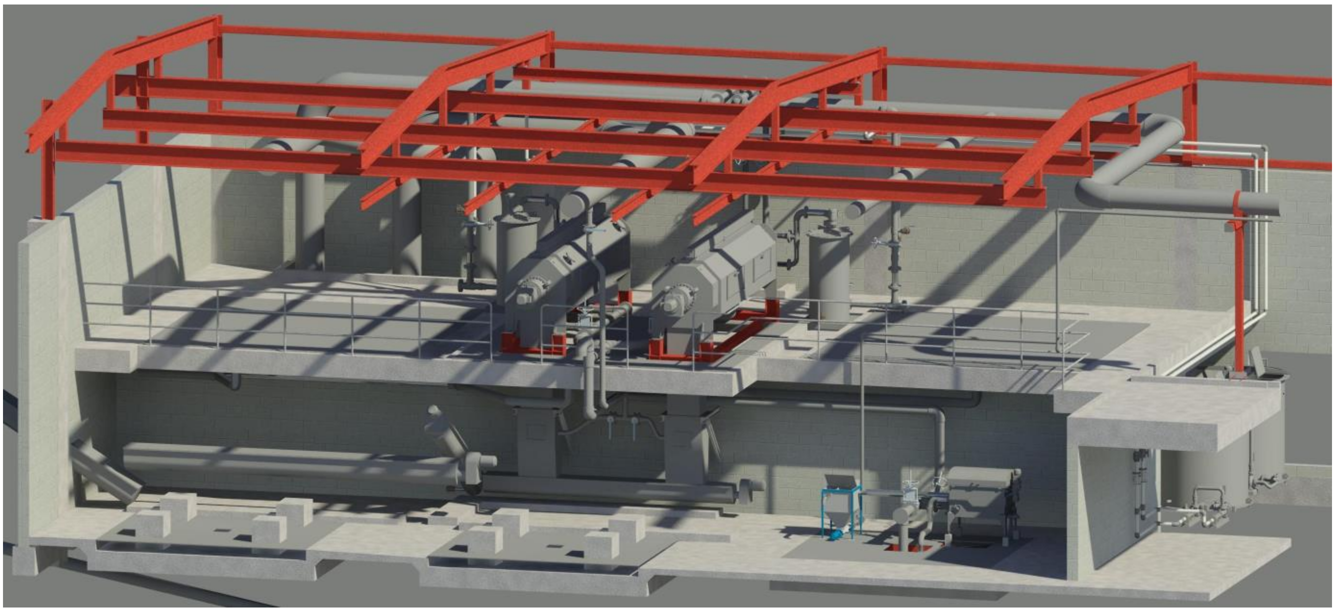
- Defining in detail the responsibilities for planning and management by "minor" and "major" contractors, and how the planning contributions of one contractor would feed into another's health and safety management considerations.

- The use of tiered hazard management, requiring contractors to participate in hazard identification and management activities at various times in a staged approach. This was tied to the natural rolling task planning process for the physical works, requiring detailed planning for the foreseen future and higher level planning for the longer term of the physical works.

5 PLANT LAYOUT CONSIDERATIONS

The design of the plant arrangement for the upgrade was undertaken to make use of the existing sludge dewatering building at New Plymouth WWTP, which presented both some significant opportunities and constraints.

The building features a mezzanine floor on which the original gravity belt thickener sections of the existing sludge dewatering equipment were located, above the belt presses. The mezzanine floor provided an opportunity, at relatively insignificant cost, to locate the new screw presses at elevation. Doing so provides the benefit of pumping the wet sludge to an elevated level and allowing the separated materials from the dewatering process – solids and liquids – to discharge under gravity. This is particularly advantageous for conveyance of the solids stream, where keeping transfer by mechanical handling to a minimum reduces complexity and can increase process reliability. Re-use of the mezzanine floor to accommodate the screw presses therefore become an important aspect of the design development.



(a)

(b)

Figure 7: (a) Design Model Render of Sludge Dewatering Upgrade at New Plymouth WWTP. The screw presses can be seen in the centre of the picture, and the microscreen is shown in the bottom right of the picture.

(b) Photograph of Sludge Dewatering Plant during Construction, showing Screw presses and Polymer Dosing Equipment (in foreground).

One of the key advantages of screw presses is the relatively small footprint relative to the original belt presses. This has maximized the opportunity to re-use the existing building space, and bunded areas to manage filtrate flows, chemical containment and the like.

This has also enabled the sludge dewatering upgrade to be undertaken while maintaining operation of one of the existing belt presses. Retaining operation of one belt press heavily influenced the location of the screw presses, feed piping designs, and integration with the existing dewatered sludge conveyor system. Tying in with the existing sludge conveyor system and the constraints this placed on screw press set-out, as well as construction, has proven to be one of the most significant challenges of the design and construction.

One of the key features of the plant control system is the use of a suspended solids meter to measure (online) the solids content of the sludge feed, which in turn enables automatic fine tuning of the screw presses during operation to accommodate changes in sludge feed consistency. NPDC had undertaken trials of suspended solids meter technologies, which had determined that an inline sensor using microwave technology provided more consistent and reliable results than an infrared type sensor. This is because the infrared sensor required re-calibration if the sludge was stored for any length of time and became anaerobic.

The microwave sensor technology required installation in a location that enabled it to operate under pressure. This heavily dictated the location of the instrument and the consequential sludge feed pipework design, because a significant vertical section of pipe was required to provide sufficient pressure for the instrument. Instrument location is not normally a matter of key consideration in fundamental plant layout, but did require early consideration in this case.

6 EARLY PERFORMANCE AND OPTIMISATION

The sludge dewatering upgrade was initially commissioned in June 2017. The pre-commissioning and early commissioning phases presented no substantial issues or challenges that could be considered beyond the "normal" commissioning process of plant testing and start-up.

However, following the initial commissioning stages, when the plant was able to automatically operate, two key operational issues were identified:

- The static mixing system, which is used to mix the polymer solution with the sludge feed prior to the flocculation vessel, has clogged repeatedly with fibrous material, including predominately hair, even though a macerator is installed upstream of the mixers. The issue may be exacerbated by the need for small mixers to create sufficient mixing energy for effective flocculation.

  This has required frequent clearing of the mixers, and highlighted the importance of the ease of removal and re-installation of the mixers in the sludge feed pipework (which had been designed into the process). At the time of writing this paper, further investigations are being undertaken to confirm whether an alternative maceration technology, alternative mixing system, or other technical solutions can resolve this issue, in addition to undertaking regular cleaning of the mixers themselves. The key impact of this is that it is likely to lead to reduced and variable sludge dewatering performance due to improper mixing of polymer with the sludge and reduced throughput due to clogging.

- The volatile suspended solids (VSS) in the sludge feed is currently higher than was expected based on limited historic data. This significantly impacts the "dewaterability" of the sludge, and has led to not achieving the expected plant performance. At the time of writing this paper, process changes are being implemented to resolve this, noting that given the sludge in the Bioreactors is approximately 20 days, changes in the performance of the plant will be somewhat delayed. This is an important lesson for this project, as described further below.

7 CONSLUSIONS AND LESSONS LEARNT

At the time of writing this paper, the success of this project in terms of meeting all of NPDC's drivers for the upgrade, has not yet been determined. The new plant is providing a simpler, less maintenance intensive and "cleaner" dewatering plant than was used previously, but the performance of the plant in long term stable operation is yet to be proved. This plant represents one of the first large scale implementations of screw press technology for municipal sludge dewatering in New Zealand. This provides a significant opportunity to identify key learnings for future implementation of the technology at other New Zealand wastewater treatment plants.

In summary, the key lessons learnt are:

- A comprehensive sampling programme is critical to process design development, procurement of the plant and preparedness for commissioning and handover. Of particular note, understanding the volatile suspended solids to total suspended solids ratio of the sludge, among other key characteristics, by undertaking regular sampling and testing to build up a large distribution of data over time, is imperative. Sampling and testing programmes are often seen as expensive tasks but represent a small proportion of total project cost, especially in consideration of the significant project risks that they may address.

  A key lesson is that this sampling programme should be re-initiated at least 2 – 3 months in advance of the commissioning period, to best enable the Principal to meet the requirements of the sludge feed characteristics as required by performance guarantees.

- There is a strong relationship between process redundancy and dewatering performance for screw press systems, which needs to be understood and then used to determine the process basis of design. This will impact the number and size of screw press units, based on whether the asset operator is willing to trade off process reliability with improved performance (base do specific owner drivers).

- The downstream processes for the dewatered sludge, and the disposal route of the biosolids, are very important in developing the process design basis. These should be considered before the new sludge dewatering plant is specified – i.e. requiring the design team to work "backwards" from the downstream process and disposal route to the sludge dewatering plant.

- Significant effort was put into understanding and developing performance guarantees for the sludge dewatering plant, prior to developing procurement documentation. During the procurement process, changes were still required to the performance guarantees in terms of the actual guarantees and the ways these would be measured. Additional interaction with suppliers, potentially through a formal interactive pre-tender or tender process, may have facilitated this process more effectively. One of the key constraints in New Zealand is the limited availability of trial units, which may be invaluable in proving the performance of a dewatering technology, and should not be considered lightly when undertaking a project of this kind.

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REFERENCES

French, C. & Grace, D. (2015) *options for Location of Proposed Scum Separating/Dewatering System at New Plymouth WWTP.* Opus International Consultants Limited, New Zealand.

French, C. & Grace, D. (2015) *Preliminary Design Report – Sludge Thickening and Dewatering for Wai Taatari Phase 2: New Plymouth WWTP Upgrade.* Opus International Consultants Limited, New Zealand.