OPTIMISING WATER TREATMENT PLANT COMMISSIONING: STRATEGIES FOR SUCCESSFUL INTEGRATION

Pearson, S (Beca) & Lewis, C (Marshall Projects Limited)

ABSTRACT

Tauranga's water supply was under pressure and the construction and commissioning of the recently completed Waiāri Water Treatment Plant (WTP) needed to be brought forward prior to the 2022/2023 summer water demand peak.

The WTP, with a 30 ML/d capacity and a future design capacity of 60 ML/d using coagulation, clarification, membrane filtration and disinfection (sodium hypochlorite), and zero liquid discharge facility first produced water to supply in December 2022, made possible from an integrated commissioning approach.

In June 2022 Tauranga City Council explored options to bring forward the production of water to supply through either:

- decoupling construction items from practical completion to allow commissioning to progress, or
- to integrate commissioning into the construction programme, with commissioning occurring prior to practical completion.

After careful consultation and engagement with the key stakeholders, including client, engineer to contact, principal contractor and sub-contractors, it was concluded and instructed to proceed with an integrated commissioning approach, where parts of the process / plant were commissioned in parallel with construction activities on less critical / non process related works.

The overall Waiari Project delivery team was fairly complex, including; TCC's project team and wider stakeholders, the plant operations team, health and safety specialists, the intake construction contractor, the WTP construction contractor, the membrane design build contractor, the trunk main contractor, plant designers, software engineers, commissioning agents, the communications team, and multiple contract administration teams. This required a significant amount of collaboration and trust between all parties for the commissioning process to be successful.

This paper discusses / explores the key factors for the success of this integrated approach, including, but not limited to;

- Why the Integrated Commissioning Approach?
- The contractual considerations to manage change and reduce liabilities in the form of damages, extension of time and further potential project delay.
- Construction adaptation to manage health and safety for construction and commissioning occurring concurrently.
- The Health and Safety approach and protocols needed to allow works to progress safely.
- The requirements for commissioning to start, and effect on contractual elements.
- Being able to plan and then adapt that plan as things inevitably change.
- Still retaining some programme float.
- Clear communication pathways during commissioning.
- Creating a commissioning environment which allowed people to be their best and for the approach to succeed.

The result of this was a successfully commissioned plant, allowing water to enter supply in December 2022, in time to manage the summer peak without the need for significant water restrictions, while reducing the risks to the overall water supply scheme.

This paper also discusses elements of this approach that can be applied to other projects including sharing of knowledge, transfer of skills, and the ability to make changes quickly, efficiently and safely.

KEYWORDS

Commissioning, Water treatment, Collaboration, Programme management, Health and Safety, Risk Mitigation

PRESENTER PROFILE

Scott has worked in operations, planning and consulting in the water industry. Scott was the process lead for Waiāri and brought a wealth of skills and experience in both process design and treatment operations. Scott was also the technical commissioning lead, ensuring safe water was provided to the community.

Claude has over 15 years' engineering and project management experience. Claude was recently the mechanical and electrical works package manager for the Waiāri Water Treatment plant, and is now the mechanical engineering manager at Marshall Projects who led the membrane installation for Waiāri.

INTRODUCTION

Over the 2021/2022 summer, Tauranga City's water supply was under pressure, with water restrictions in place and limited operational headroom for any outages.

The Waiāri WTP was under construction, had suffered delays during the COVID pandemic and was at risk of not being completed prior to the summer water demand peak. That would have meant that Tauranga City would require their 'at capacity' existing infrastructure to manage through another summer.

The Waiāri WTP has a 30 ML/d capacity and a future design capacity of 60 ML/d; using coagulation, clarification, membrane filtration and disinfection (sodium hypochlorite) as the main process. The WTP is a zero liquid discharge facility requiring backwash clarification, sludge thickening and dewatering processes with a complete recycle or removal from site of all waste streams (liquids and solids).

The WTP design and construction was split across multiple parties:

- Designer for WTP and Intake – Beca Ltd.
- Intake construction contractor - HEB
- Balance of plant contractor – Fulton Hogan
- Membrane design build contractor – Pall Marshall Water Consortium

Other groups involved in the project included TCC's project team and wider stakeholders, the TCC operations team, health and safety specialists, software engineers, commissioning agents, the communications team, and multiple contract administration teams.

This structure meant that the software development and process commissioning was not part of the main construction contracts and thus originally, practical completion of the physical works was used as a gate to start process commissioning. Thus, site ownership and site health and safety requirements were clearly defined.

To alleviate the delay risk to TCC, the construction and commissioning of the Waiāri WTP thus needed to be brought forward prior to the 2022/2023 summer water demand peak.

The process followed was to complete a programme and risk review, identify approaches to bring forward the operation to supply, assess the required approaches and agree on a final approach.

PROGRAMME AND RISK REVIEW

PROGRAMME REVIEW

The first step was to review the individual programmes across the multiple contracts to identify opportunities to reduce risk or programme float. The following key items were identified:

- **Duplicate tasks:** Reservoir disinfection was included in both the construction and commissioning programmes. Completion of this with commissioning would allow for timely disinfection and a saving of 5 working days.
- **Completing works early:** Bringing forward the commissioning of the intake pump station removes this process from the critical path – reducing the risk of potential delays
- **Items missing:** Software I/O testing was not included in any programme and there was an opportunity to complete this in conjunction with contractor point to point testing
- **Remove non-critical elements from the critical path:** Activities for the initial commissioning such as installation of lamella plates in the clarifier and completion of the dewatering building could be completed in parallel with commissioning
- **Adjusting sequences of works:** Moving the reservoir drop test to before the reservoir membrane roof leakage test reduces the risk on the reservoir commissioning process. Another example was the focus of resources on earlier process commissioning areas / processes as opposed to splitting resources over a wide range of activities. This was the case for the dewatering building, where resources were re-focused on completion of the process and membrane hall as well as the analyser room.
- **Deferring non-process related activities / tasks or works:** Building services works, such as HVAC, fire, security and access control were assessed in terms of resources constraints. If a process task or activity could be completed earlier by deferring a building services activity, this was discussed with the principal and engineer to the contact for implementation.

COMMISSIONING PROCESS REQUIREMENTS

The following WTP elements were needed to confirm the commissioning sequence and pre-requisites required for each stage.

COMMISSIONING FLOW PATHS

Commissioning flow paths needed to be understood to identify which areas of the works were required to enable each stage of the process commissioning. This was completed graphically for the liquid and waste management streams as shown in Figure 1 and Figure 2 below.

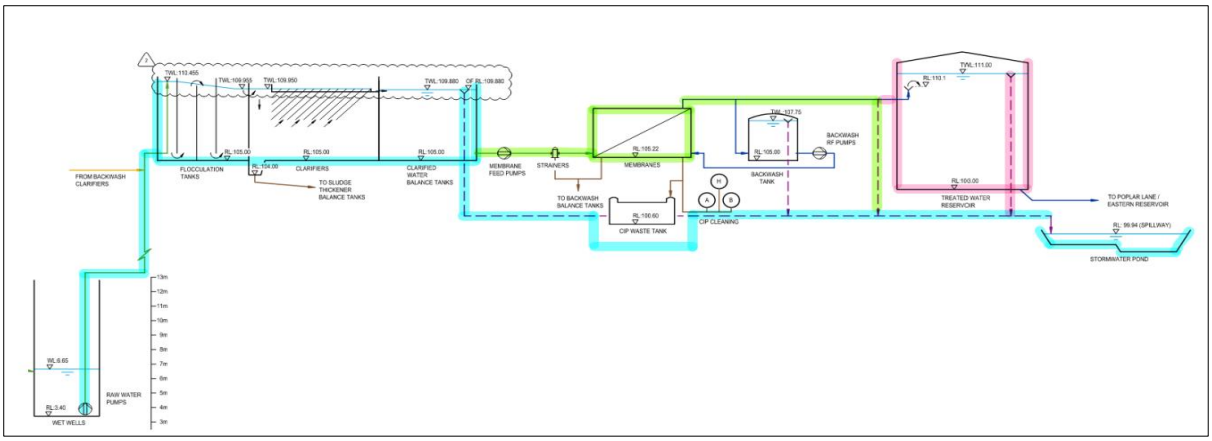


Figure 1 – Commissioning Flow Paths 1

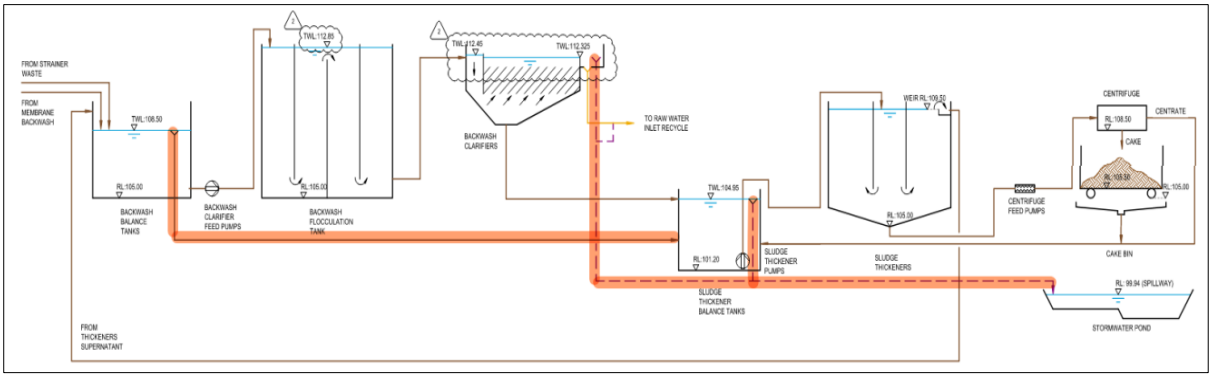


Figure 2 – Commissioning Flow Paths 2

KEY PRE-REQUISITES FOR COMMISSIONING OF EACH STAGE

Each process area was then considered to determine what the minimum viable completed product would be to allow for commissioning of main flow paths (to open other commissioning stages), what the minimum instrumentation would be for flow control, and then the requirements for process control. This created a wider understanding of a logical sequence for commissioning and identified areas where temporary works would be required. Examples included the supply of temporary service water for safety showers and washdown to allow for chemical deliveries (the permanent service water supply was to come from downstream of the reservoir), and managing security for hazardous substances compliance prior to the site being fully secured.

CONSTRUCTION PROGRAMME RISKS

Construction programme risks were identified and contingencies considered for risk items relating to the delivery of some mechanical equipment, control system equipment and instrumentation. Contingencies included commissioning without redundancy, future isolations to install some equipment, and the use of some instrumentation from other plant areas or other TCC spares inventory.

APPROACHES CONSIDERED

The following approaches were considered to bring the operation to supply date forward:

- Altering the construction programme and adjusting practical completion requirements for each separable portion by moving specific items to another separable portion. The purpose of this would be to bring forward practical completion for the critical works and allow commissioning to start earlier (and ultimately the operation to supply date).
- Integrating process commissioning to start as areas within the WTP have been constructed and handed over to the commissioning team to bring forward the operation to supply date.

ALTERING THE CONSTRUCTION PROGRAMME

Altering the construction programme to bring forward the commissioning start date by giving practical completion on all items required for the plant operation. This meant deferring items that aren't required for the start of process commissioning from project practical completion of the relevant separable portion.

For Waiāri, this meant no significant change to the contractual agreements with the issuing of Practical Completion as completion of pre and cold commissioning on individual equipment prior to process commissioning (by process stream then the overall WTP).

This option is more easily accommodated by the contractor, as work areas could be isolated with fewer interdependencies. This approach also offered potential contractual management savings with less risk for contractual implications and H&S issues with clear demarcation and ownership of the site.

The significant risk is that it still requires sufficient plant to be available prior to process commissioning taking place, with any delay or risk eventuating from one of multiple workstreams delaying the start of process commissioning.

The initial assessment of this approach indicated a saving of up to 20 working days by the removal of the dewatering building and access elements.

INTEGRATED PROCESS COMMISSIONING

This option allows the start of commissioning to occur prior to practical completion, with individual flow paths and process areas 'handed over' for commissioning as they are available. The initial premise of this was that the commissioning process would work around the documented construction programme.

The following key points were considered when assessing this option:

- Commissioning is able start on the completion of the first flow path, rather than the majority of the WTP. In order to complete a flow path, the flow

path needed to be isolated from the rest of the plant to ensure health and safety is maintained.
- There is an ability for commissioning to continue to occur around specific delays, with focus moving to other areas.
- Additional resources may be required to manage the works and assist the process commissioning team.
- Occupancy prior to Practical Completion (PC), i.e. beneficial use of the plant is allowable, however any delays or additional costs incurred by the contractor would be considered a variation under NZS3910:2015.
- Integrated commissioning would require trades to share areas and coordinate works around others, leading to additional management and coordination efforts, potential increased health and safety risk as well as potential time and cost increases.
- Early occupancy and beneficial use could impact warranties for pumps and plant items, as individual equipment warranties usually start from PC, or a certain time period from delivery to site. With various start dates for warranty periods depending on when the respective plant / equipment goes into use, instead of a single PC date, it could complicate contractual matters. Extension of warranties would be considered on an individual equipment basis in consultation with the client.
- The contractors would want to protect themselves from liquidated damages (LDs) if anything limits their ability to secure PC.
- There is a risk of programme slip on non-critical works to maintain critical path works.
- Decreased productivity through the prioritisation of process commissioning, where workers are required to complete multiple roles.
- Managing health and safety where commissioning is being undertaken by a multi-party team on a construction site under the control of a seperate Contractor, with potential implications to liabilities and insurances.
- Additional management to manage handover of each process area, requiring additional resources.
- A risk of decreased productivity on work areas adjacent to or affected by commissioning

The initial assessment indicated a saving of 31 working days, with an additional contingency of 10 working days for handover, documentation and health and safety included in this period.

SELECTED APPROACH

The fundamental decision was a compromise between the following:

- Simplified contract management and accepting risks to programme, or
- A greater ability to adapt to risks and changes in a tight construction programme with increased management effort.

TCC made the decision that an integrated approach to commissioning provided the best flexibility and risk mitigation for their primary objective in having water to supply prior to the 2022/23 summer peak demand period.

The intention of this approach was not to modify the construction programme but to work around it. However, with multiple work fronts and limited staff, delays or disruptions in one area could then roll over into other areas of the works

The following key areas were further developed to enable this approach.

CONTRACTUAL AGREEMENTS

For Waiāri, the integration of process commissioning ahead of completion of the planned works would constitute a contractual change. Separating required areas into separable portions would be time-consuming and onerous, so, it was agreed, and instructed through the existing / standing contract that the integrated commissioning approach would be introduced and used. This would allow and facilitate occupancy of site prior to PC, requiring the management of effects to construction.

Negotiations and agreements were put in place with all contracting parties. This included the approach to early occupancy and a commercial understanding between the Principal and the Contractor on the way this approach would be managed without disruptions for additional approvals or agreements.

This was identified as a significant programme risk and was well managed with respect to enabling commissioning overall.

INSURANCE

Key considerations were for both the principal and the contractor to ensure that their insurance obligations were met under this arrangement. This was particularly important for the main contractor, who remained in possession of the site and had overall control with respect to health and safety obligations. Activities not originally allowed for required insurance, while the implications of having various other organisations working on the site also needed to be covered.

Another key aspect was the overlapping period where the plant would provide water to supply, with construction activities still taking place, the Contractor in control of the overall site while the administration/control building was occupied by operations staff. One such examples was the risk of a fire in the administration building, occupied by operator staff, but with the site still in control of the contractor and the contractor still commissioning the fire protection system. Contractually this could have become very difficult, and robust thinking and management was required to address this and other similar risks..

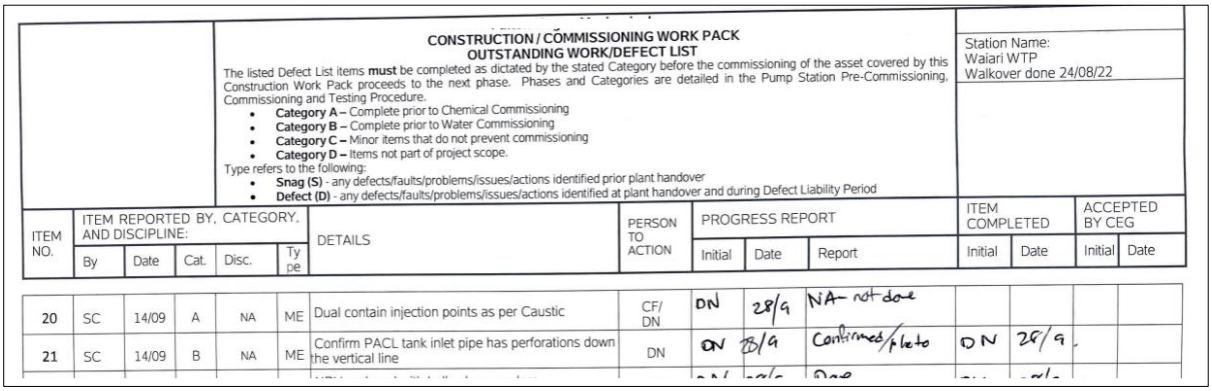
PROGRAMME ALIGNMENT AND FLOAT

Based on the construction programme the critical path, the commissioning programme was updated to align key handover dates from construction to

commissioning. A 10 working day period was allowed between construction completion and the start of commissioning to provide some construction float, and allow for preparation of quality documentation and sign off of health and safety processes, commissioning walkovers and to complete the associated I/O checks within the plant control system. This assessment identified that water could be produced to supply between six and eight weeks earlier than originally estimated.

HANDOVER REQUIREMENTS FOR COMMISSIONING

Upon completion of the construction works for each flow path being commissioned, a site walkover was held of the area. This involved the contractor, commissioning team, TCC operations, and H&S reps from the contractor and TCC was first undertaken. This was to assess and verify the construction completion against the process drawings, identify snags as low medium or high (with high requiring action prior to commissioning)(See Figure 3 for an example), confirm pressure testing had been completed, and check all upstream and downstream flow paths were safe for operation.



CONSTRUCTION / COMMISSIONING WORK PACK
OUTSTANDING WORK/DEFECT LIST

The listed Defect List items **must** be completed as dictated by the stated Category before the commissioning of the asset covered by this Construction Work Pack proceeds to the next phase. Phases and Categories are detailed in the Pump Station Pre-Commissioning, Commissioning and Testing Procedure.

- **Category A –** Complete prior to Chemical Commissioning
- **Category B –** Complete prior to Water Commissioning
- **Category C –** Minor items that do not prevent commissioning
- **Category D –** Items not part of project scope.

Type refers to the following:

- **Snag (S)** - any defects/faults/problems/issues/actions identified prior plant handover
- **Defect (D)** - any defects/faults/problems/issues/actions identified at plant handover and during Defect Liability Period

Station Name:
Waiari WTP
Walkover done 24/08/22

ITEM NO.	ITEM REPORTED BY, CATEGORY, AND DISCIPLINE: By	Date	Cat.	Disc.	Type	DETAILS	PERSON TO ACTION	PROGRESS REPORT Initial	Date	Report	ITEM COMPLETED Initial	Date	ACCEPTED BY CEG Initial	Date
20	SC	14/09	A	NA	ME	Dual contain injection points as per Caustic	CF/ DN	DN	28/9	NA- not done				
21	SC	14/09	B	NA	ME	Confirm PACL tank inlet pipe has perforations down the vertical line	DN	DN	28/9	Confirmed/plete	DN	29/9		

Figure 3 – Commissioning Outstanding Work/Defect List

Detailed work instructions, isolation plans and commissioning check sheets were developed and reviewed. These identified actions required work areas and interfaces for each of the commissioning stages of the WTP. These were then reviewed by both the contractor's and principal's representatives and were signed off prior to starting any commissioning activities. The isolation plans utilised the process drawing set to show required isolations and flow paths.

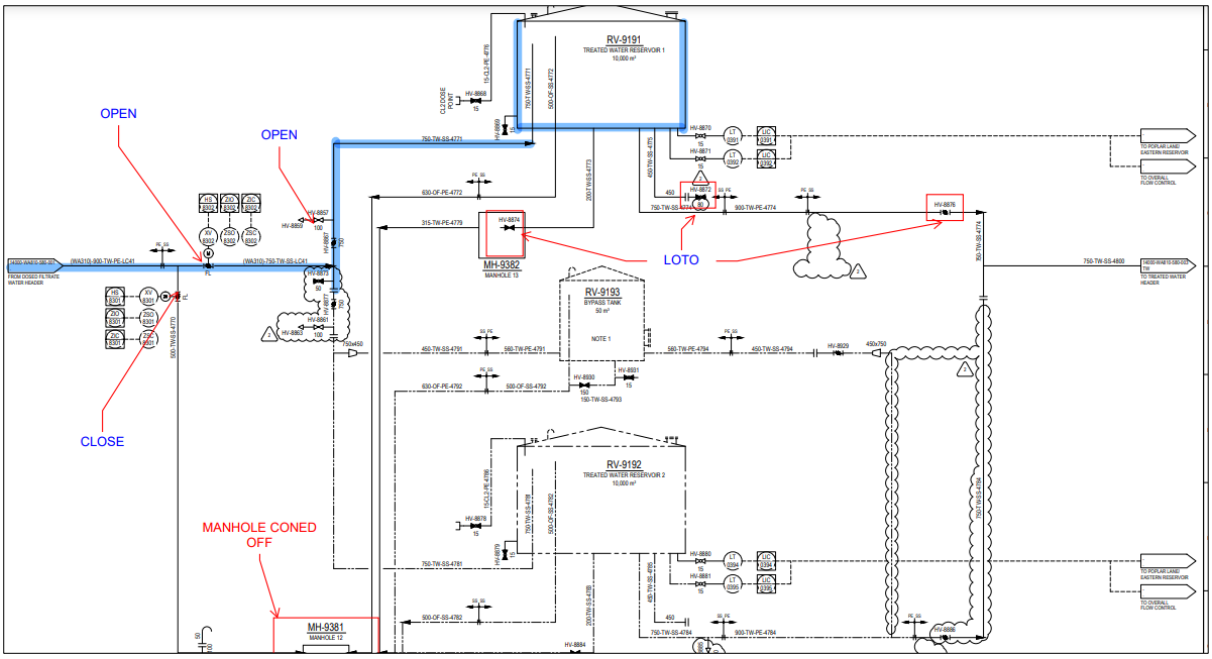


Figure 4 – Flow Path Isolation

HEALTH AND SAFETY

A collaborative and robust health and safety approach was developed between the contractor and principal which entailed:

1. Development of a centralised isolation process and procedure, which was used and followed by all parties. Isolation of equipment not available for commissioning was controlled by all the contractor.
2. Clear demarcation of areas for commissioning, using cordons where required. This include the required danger / hazard signs associated with the area / activity.
3. Communication at daily commissioning toolbox meetings and contractor toolbox meetings were held to communicate works being undertaken by all sub-contractors on site.

Figure 5 –*Example of Commissioning Area Demarcation*

COMMISSIONING TEAM

The core commissioning team was led by a core team with the following key roles:

- A commissioning manager who ran day to day progress meetings and kept a programme up to date.
- A commissioning technical lead who understood the complete process and made decisions on technical requirements and adaptations based on any delays to programme.
- A software and instrumentation engineer who led the pre-commissioning and I/O checks, then made any tweaks to the software as process commissioning progressed.
- A very proactive commissioning engineer who resolved a lot of construction challenges with the contractors to expedite the readiness of required equipment.

COMMISSIONING PROCESS

Key success factors for the commissioning of the WTP are:

- Experienced and knowledgeable people held the core roles of the commissioning manager and commissioning technical lead who were able to understand requirements and adapt the commissioning programme/approach as necessary.

- Looking at least one week ahead in the commissioning process and identifying early any potential future delays and engage in reducing these as much as possible.
- TCC had an in house instrumentation and PLC software champion. This meant that minor issues around instrument setup or wiring between the instrumentation and the PLC could be troubleshooted and resolved quickly and efficiently.

The 10 days float was almost always required for completion of construction, I/O checks and health and safety sign off. Often this may have been for something as simple as having a non-compatible plug connector shipped with a unit and any electrical or computer-based spares being in very short supply at the end of the COVID pandemic.

Commissioning was a continual adaptation of what could be achieved, often with commissioning occurring on a main flow path to enable other areas to be commissioned before then coming back to optimize the process with all instrumentation and controls available.

Significant collaboration and effort was required to complete pipeline flushing and disinfection in conjunction with the reservoir disinfection, saving water at least 5 working days with reduced water and chlorination/de-chlorination requirements. While the reservoir and pipeline disinfection was occurring, the concurrent trial operation to waste for the overall treatment process was occurring.

Overall, the commissioning process went relatively smoothly with water able to be delivered to supply prior to the required date for TCC, with an estimated saving of at least four weeks. However, certain elements (non-critical to water safety) required further commissioning and optimisation following this date.

LESSONS LEARNT

- Project success factors needs to be identified early in the project, even during project planning. It is widely accepted / understood that project success is coupled with commercial closure of the project, however, in high stake, complex and early post COVID projects, decoupling the practical completion from the hard logic of commissioning start have numerous advantages.
- Having the principal, engineer to contract and various contractors being able and willing to explore different commissioning approaches, adapting the contract to suit the approach is critical to the success of changing an agreed approach

- Empower key stakeholders to manage the commissioning execution. Remove politics/commercials from the commissioning teams priorities, and look to take the best for project approach.
- Establish clear communication protocols. This ensures a homogenous understanding of what is required of all stakeholders, creates an environment that is conducive to working together and getting things done.
- Well-run commissioning meetings with clearly defined goals, responsibilities and dates makes everything a lot smoother.

Figure 6 –*The First Water To Enter The WTP*

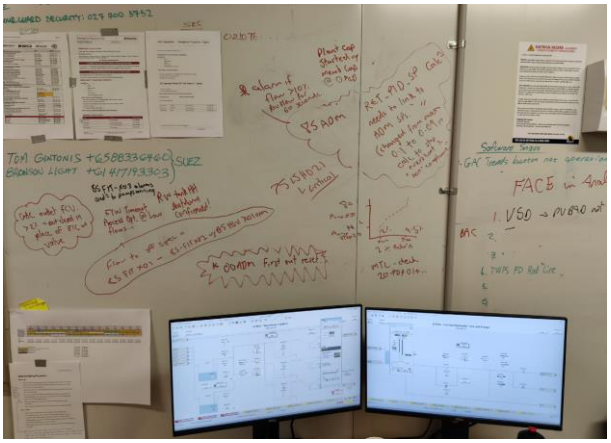


Figure 7 –*Example of a Functional Snag List*

- Tick things off as soon as possible, small items tested and commissioned when they are first able to be accelerates the completion of larger portions of work.
- Make sure someone is looking ahead and understand what is critical and what isn't. Communicate this to the commissioning team and respective stakeholders to ensure common goal setting.
- Don't assume contractors will communicate all commissioning related risks and hazards to sub-contractors. Commissioning team presence at weekly toolboxes improves the completeness of briefings and requires a presence on site, before, during and after commissioning.
- Extensive use of signage and hazard tape creates an obvious barrier, but creating a culture where communication and trust is very important.
- Question things you are unsure of – and remove your discipline blinkers when on site.
- There is ALWAYS something to do in periods of downtime – look ahead or get some documentation done
- Adapt to change, because change is certain.
- Project success comes from everyone, and everyone will also help you. Help can come from anywhere, and if you help others then some other things 'magically' appear or just happen.
- If something is a Contractor requirement but can be done a lot simpler by a commissioning team, then discuss it and do it (e.g. Reservoir disinfection).
- Don't override unexpected interlocks, stop, drain the tank and take a look. You might spend a day to save a week of repairs and more than a few dollars.

- Sequencing of site services – e.g. when do you need service water by? A temporary supply can be unsafe and unreliable.
- The most valuable purchase can be a packet of biscuits! Relationships are very important and we all need each other to make the project work.
- Form good relationships with the wider commissioning team. You'll be spending a lot of time with them.
- Spot and acknowledge good behaviours
- Have clear responsibilities on H&S and programme
- People are not interchangeable resources, you need the right people in the right places at the right time.
- Have the operations team involved, but not too early. Motivation is quickly lost if there is a lack of commissioning activity being actively undertaken.

CONCLUSIONS

The plant produced water in December 2022 to Tauranga City. Without the selection of this integrated approach, it is likely that this date would not have been met.

Overall, the commissioning process went relatively smoothly with water able to be delivered to supply prior to the required date for TCC, with an estimated saving of at least four weeks. However, certain elements (non-critical to water safety) required further commissioning and optimisation following this date.

Key success factors were the collaboration of all project stakeholders, and having an experienced team willing to work together and have some fun along the way. This meant that a best for project approach could be taken to achieve the goal and deliver water to TCC’s customers prior to the 2022 summer peak.

ACKNOWLEDGEMENTS

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