KAWANA STP UPGRADE: USING BIM FOR DESIGN, CONSTRUCTION AND OPERATION

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ABSTRACT (500 WORDS MAXIMUM)

The Kawana STP upgrade project will more than double the plant capacity to 200,000 EP. The design was undertaken in a fully coordinated BIM (Building Information Model) environment that incorporates all design elements into a single, interrogatable 3D virtual model. BIM formed the key source of design information for the wider project team and was used at regular meetings between key design and construction leads and formal design reviews with the client. This enabled timely and efficient decision making with full visibility of interfaces between process, mechanical, structural, civil, electrical and building elements as well as existing infrastructure constraints. This is the first project that Unitywater has commissioned that requires all designed new and retained works to be included in a BIM.

KEYWORDS

BIM, Asset Management, 3D modelling, visualisation

PRESENTER PROFILE

David is a civil engineer with over 30 years' design experience. He has extensive experience in hydrology and hydraulics, site construction supervision and contract management. For the past two decades, David has mainly concentrated on the design of major trunk pipelines, pumping stations and treatment plants for water supply and sewerage.

Simon is a Principal Designer with extensive experience leading the CADD/BIM delivery of multidiscipline projects within power, mining and water industries. He obtained his Graduate Certificate in Virtual Design and Construction (VDC) from Stanford University California and plays a key role in WSP's Digital Engineering implementation strategy across ANZ.

1 INTRODUCTION

The Kawana Sewage Treatment Plant (STP) is located on the Sunshine Coast, Queensland. The plant is being upgraded to increase its capacity from 90,000 EP (equivalent persons) to 200,000 EP. The design process has been undertaken using multidiscipline 3D plant design and modeling tools which are federated into a single Navisworks BIM model. Throughout the design and construction process, the BIM model has allowed for informed design review, clash detection and enhanced HAZOP and SID (safety in design) procedures. The BIM model provides an accurate, virtual representation of the complete plant and contains all equipment and pipework asset data that can be exported and read into the utility's asset management system.

Figure 1 Rendered image of Kawana STP including upgrade works

2 THE PROJECT

Unitywater, the water utility on the Sunshine Coast, are upgrading an existing STP to increase its capacity. The current capacity is approximately 90,000 EP and the original brief called for an upgrade to 150,000 EP. Monadelphous were engaged to undertake the Design and Construct project and they engaged Acciona Aqua to undertake the process design, Alliance Automation to undertake the electrical design and WSP to design the balance of plant design. WSP were also engaged to build, update and maintain the BIM model for the project.

The STP was originally built in 1980 and has been upgraded several times since then. The plant prior to this current upgrade comprised screening and de-gritting followed by aerobic treatment using the activated sludge process. The effluent was then clarified before chlorination and then pumping to an ocean outfall. The sludge was digested on site and then dewatered.

Although the original brief was for an upgrade to 150,000 EP, Monadelphous offered a process that would provide for up to 200,000 EP and this was accepted by Unitywater.

2.1 UPGRADE WORK SUMMARY

The upgrade works consists of the following items:

1. An upgrade to the existing wet-weather screening facility to fit a third band screen, two new screw wash compactors and two new 10 m^3 screenings bins;
2. Two new 8.6 m diameter vortex grit separators with air floatation to remove FOG (fats, oils and grease), two grit separators, two 10 m^3 grit bins and a wet weather bypass facility;
3. Two new Primary Lamella Settling Tanks,
4. Two MBBR (moving bed bio-reactor) trains consisting of an anoxic cell followed by three aerated cells and anoxic return pumps;

5. A new six-way flow splitter (four current use two for future upgrade);
6. Fitting out of the four existing secondary clarifiers with lamella tubes, new scrapers and covers to increase their flow capacity;
7. Conversion of an existing wet weather storage tank into a third chlorination contact tank;
8. A new facility to accept tankered commercial septic waste and TWAS (thickened waste activated sludge) form other Unitywater STPs;
9. Primary sludge thickening using RSTs (rotary screw thickeners)
10. A new anaerobic digester, 18 m diameter by 21 m high, with methane capture;
11. Digested sludge dewatering using two new centrifuges;
12. A facility to scrub and store the methane and a co-generation plant to generate power from burning the methane in an internal combustion engine where the waste heat is used to heat the sludge to optimum digestion temperature;
13. Various other facilities including a new blower building for the MBBR and new chlorination building using gaseous chlorine.

An overview of the BIM model is shown in Figure 2 which includes the location of the numbered items above.

Figure 2 Overall plant layout showing location of main upgrades

3 3D MODELLING AND BIM

Unitywater has the following objectives for the BIM[1].

a) Reduce project cost and duration;

b) Reduce the occurrence of project defects and the need for rework;

c) Improve plant operability and maintainability; and

d) Improve project quality and safety.

These objectives have been achieved by designing, validating and documenting the upgraded plant design in a multi-discipline 3D environment incorporating the existing plant point cloud model, potholing and survey information, design models, subcontractor models and vendor equipment models into one integrated BIM using Navisworks. The evolving model was issued weekly during the design period to allow all parties to view and interrogate the current state of the design and comment on any detected issues.

The existing above ground plant assets were incorporated into the BIM model to enable the new plant to be designed and coordinated with the existing assets that were to be retained, modified or demolished. The point cloud survey was converted to 3D objects to improve coordination with the new plant and provide objects that could can be documented in 2D. Additional BIM data, such as verification status was also appended to the models.

The original point cloud survey was also used as an overlay within Navisworks and used for verification of model geometry created to represent existing assets.

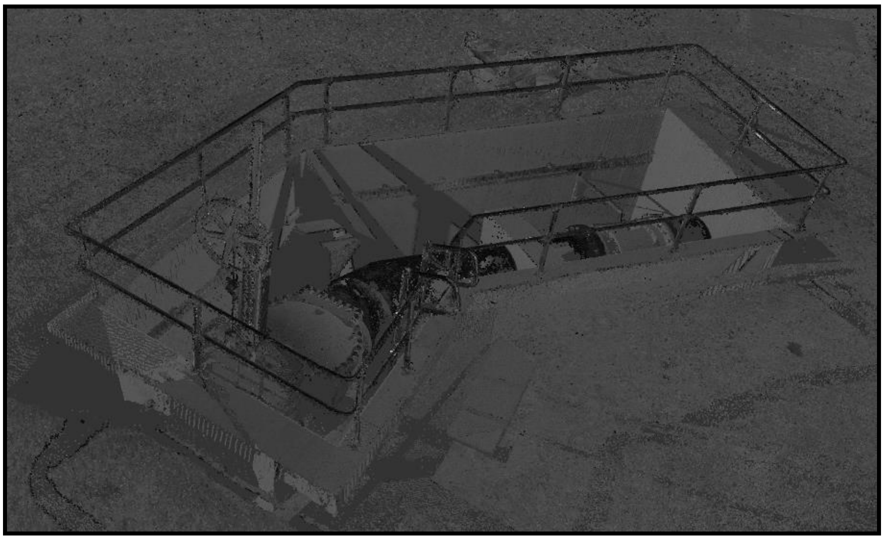


Figure 3 Point cloud survey

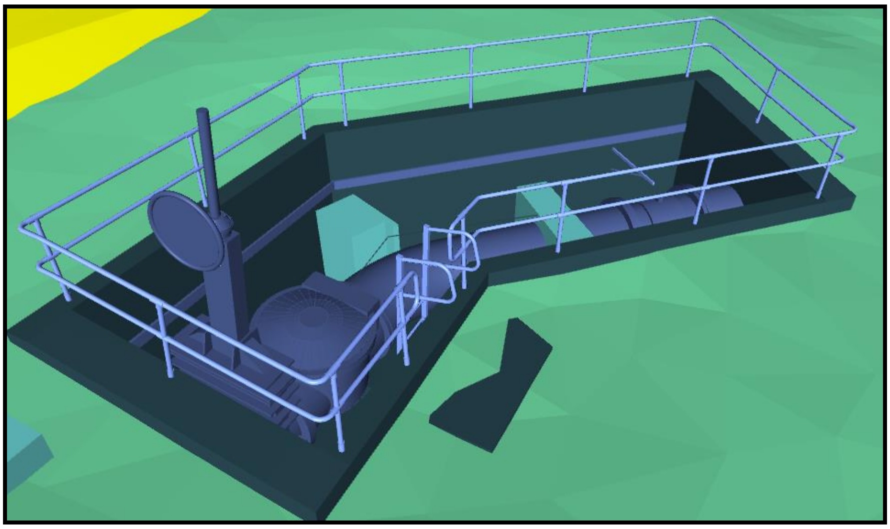


Figure 4 3D model of valve pit

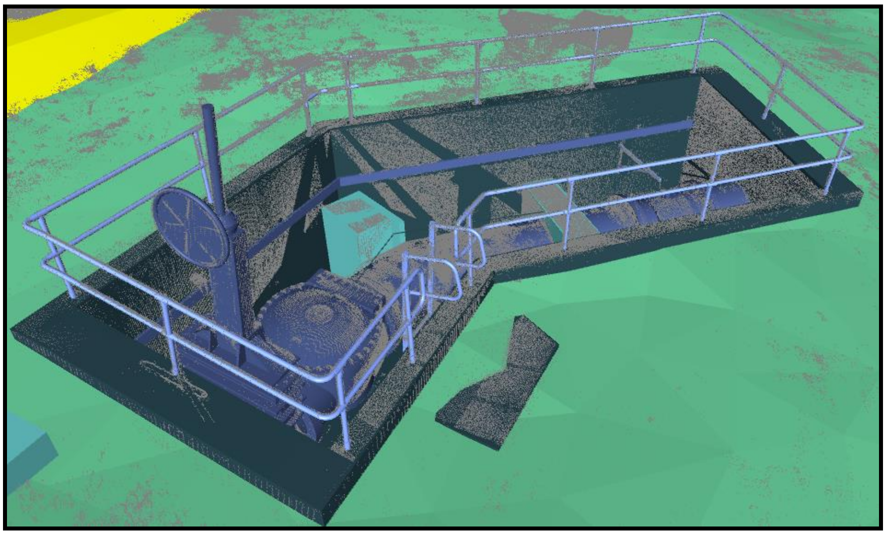


Figure 5 Point cloud overlain on the 3D model

The extensive existing underground assets were potholed and where required remodeled within Plant 3D using the survey strings to verify location, size and material. As construction progressed additional potholing and field verified survey was overlaid within the BIM model to assist with verification and coordination.

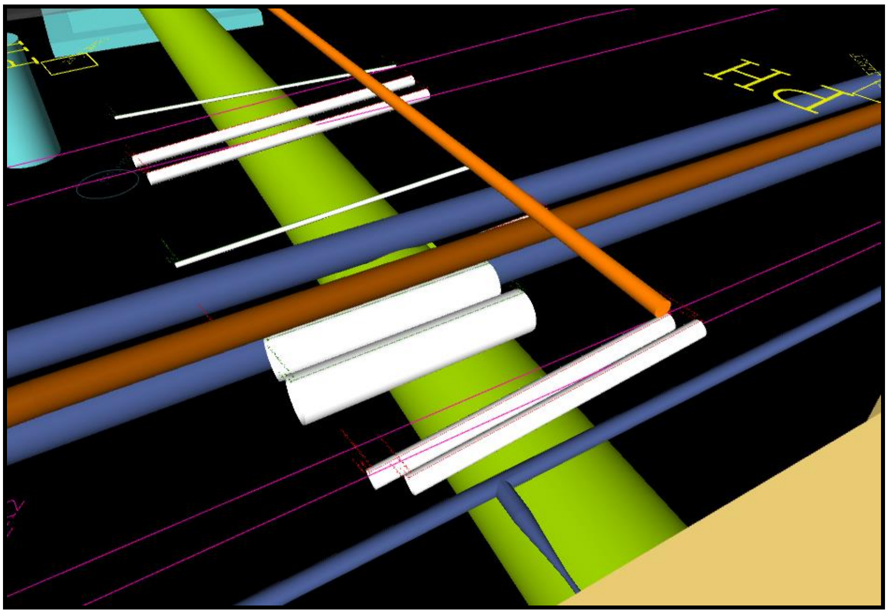


Figure 6 Pot holing survey

The BIM model is founded upon "Intelligent" P&IDs (Piping and Instrumentation Diagrams). They are intelligent because the diagrams are integrated with an SQL database that contains all the pertinent properties for each element. As elements are added to the PID, the database automatically updates to include the new elements. The relevant database fields are then populated by the design and construction team to include all the information that is necessary to uniquely identify and define the elements. This includes asset information which was specified by Unitywater to align with their asset management system. The P&ID database is also connected to the 3D Plant model which enables validation between the Process design and the 3D plant design.

This Process, Asset and Plant 3D data is embedded into the single BIM along with the 3D plant elements to form a single, virtual model with the current process design which is accessible to the wider project team.

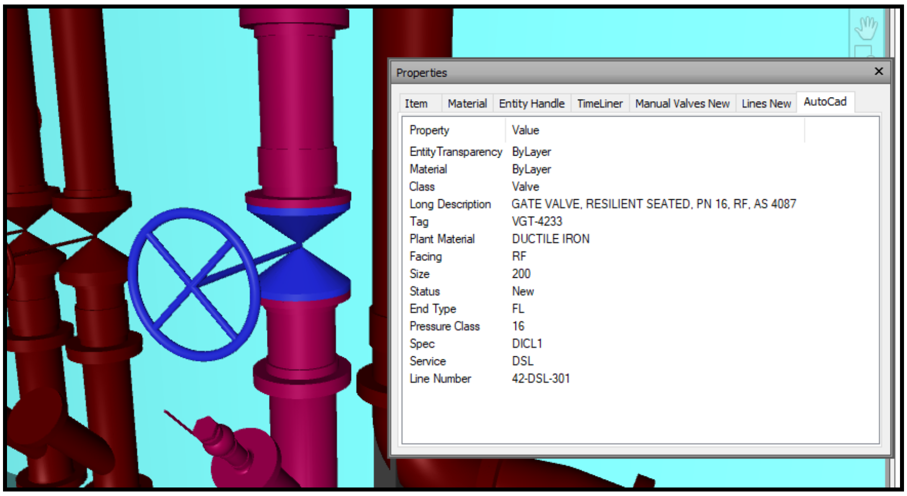


Figure 7 Element properties within BIM

The BIM is constructed from models created in various discipline specific 3D modelling packages as well as equipment vendor models supplied in generic file formats. The level of detail (LOD) adopted is LOD300 or better, which results in elements being accurately represented without going down to the detail of every nut, bolt and washer. This allows the use generic model representations for items such as valves, which were accurate in length, diameter and actuator, but used simple geometry to cut down on detail.

The decision about which LOD to adopt for a project involves a trade-off between the amount of detail included and the size of the resulting BIM. If everything was detailed to LOD400, the model would require time consuming detail to be added and would adversely impact computer performance and drawing creation performance resulting in increased cost and duration with little to no improvement in quality or design coordination.

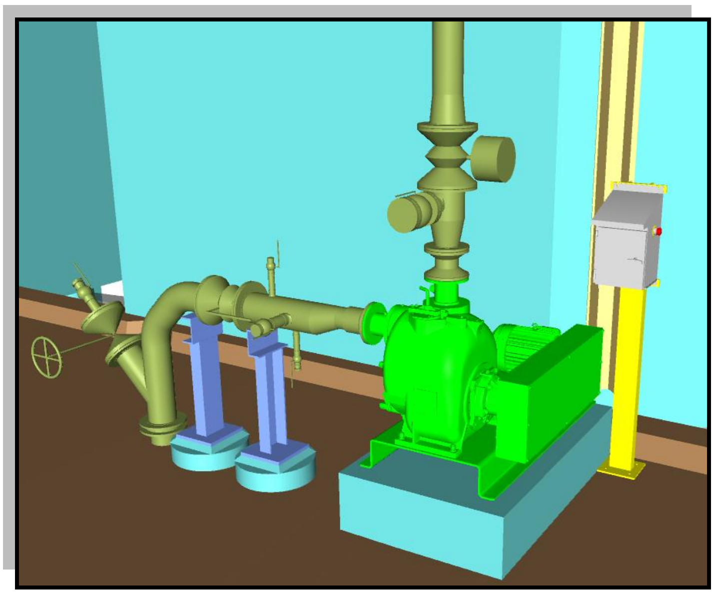


Figure 8 Generic valve model with detailed pump vendor model

Major equipment vendors were required to supply 3D models to LOD300 for inclusion in the BIM, although some vendors provided much more highly detailed models (LOD400) while others were unable or unwilling to supply any at all. This required the design team to simplify the highly detailed models for inclusion in the Plant 3D model or to generate 3D models based on traditional 2D vendor documentation to ensure the BIM was complete, accurate and usable.

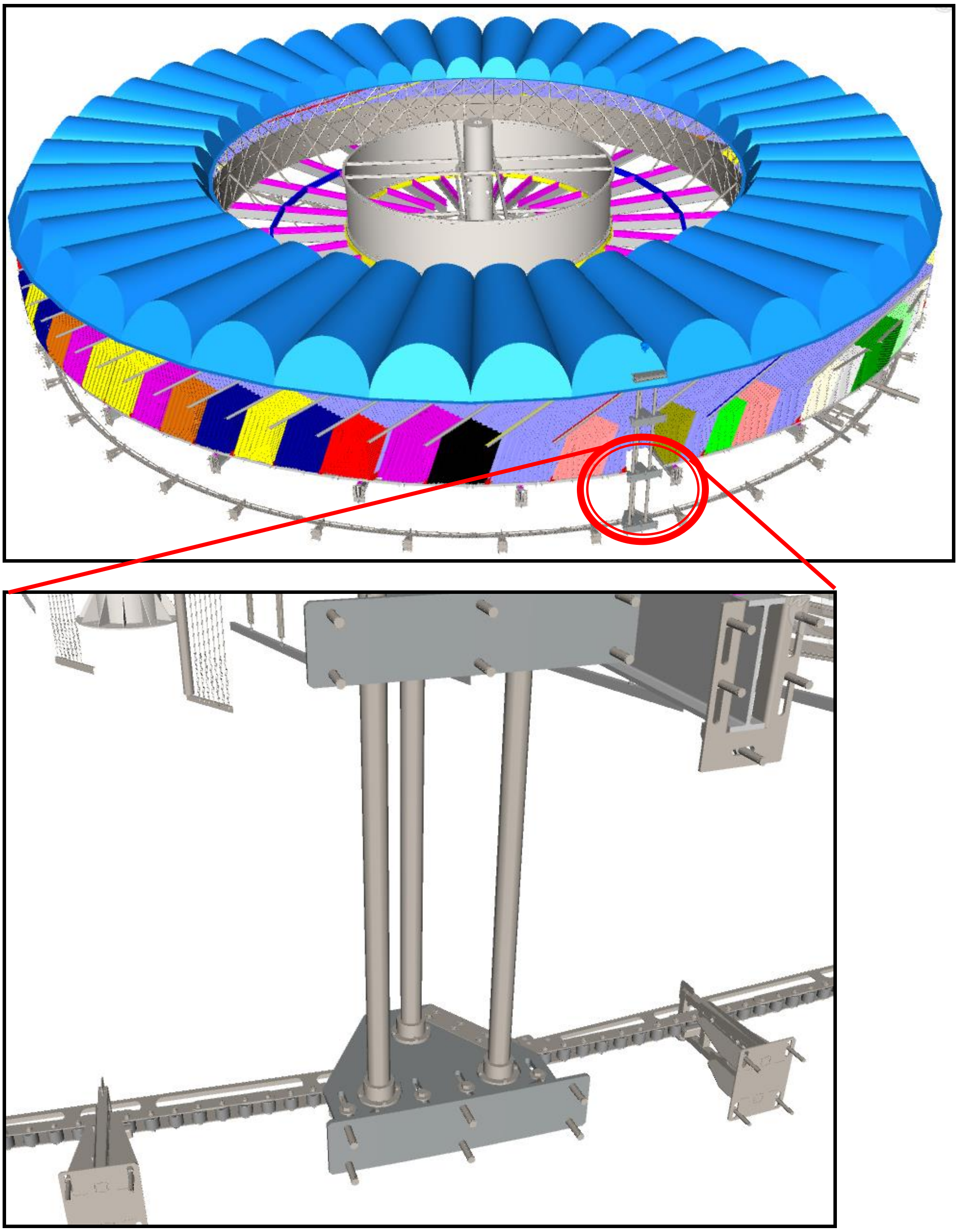


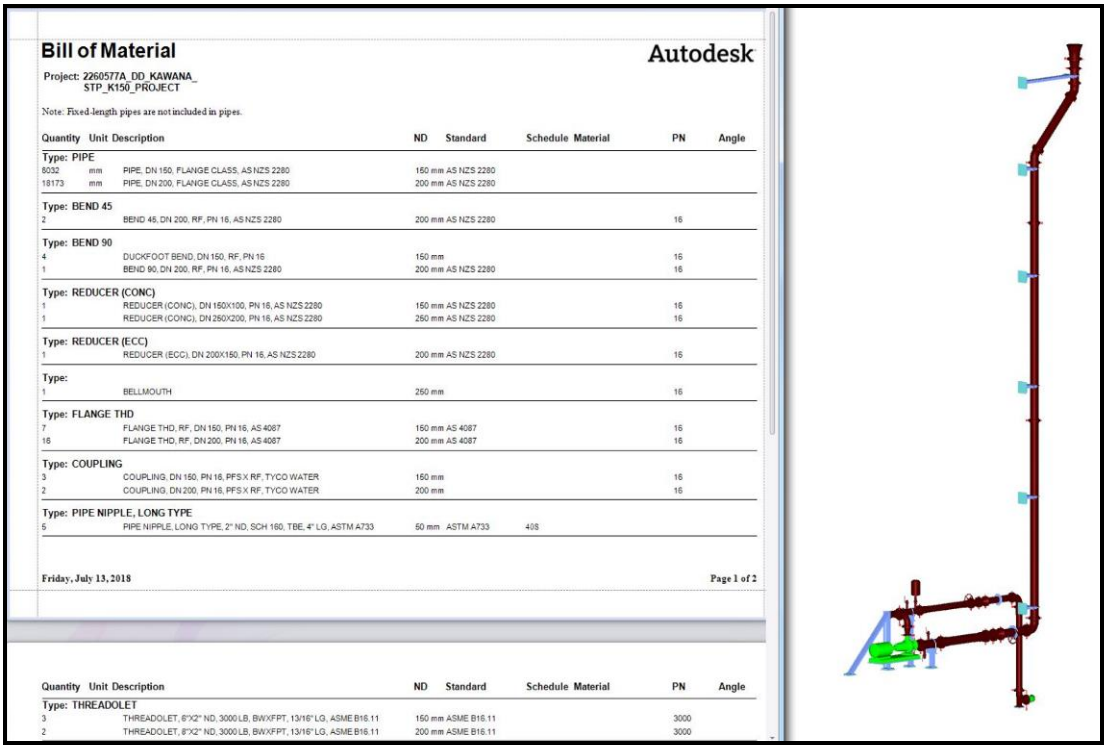
Figure 9 Highly detailed vendor supplied model

3.1 CLASH DETECTION

An important aspect of the modelling was clash detection and visualisation. The 3D environment allowed the designers to lay out a complex plant in a brown-field site and for the reviewers to assess compliance with the access requirements of the specification.

Adoption of the BIM environment has allowed for a more interactive design review process. Traditionally, 2D paper drawings were only provided for the client to review and this lead to many issues not being detected until the project was in construction stage. This often lead to compromise, particularly in terms of access for maintenance, with the operator forced to accept sub-optimal solutions. The adoption of BIM improved the early detection of clashes and co-ordination issues prior to construction, leading to a reduction in costly rework and an improved outcome in plant operability and maintainability.

Improved operability will result in reduced O&M costs. This will be the result of a database that contains all the information needed to order replacement parts and fittings (lower office costs) and a plant that is easy to maintain (lower on-site costs).



Bill of Material Autodesk

Project: 2260577A_DD_KAWANA_ STP_K150_PROJECT

Note: Fixed-length pipes are not included in pipes.

Quantity	Unit	Description	ND	Standard	Schedule	Material	PN	Angle
Type: PIPE								
8032	mm	PIPE, DN 150, FLANGE CLASS, AS NZS 2280	150 mm	AS NZS 2280				
18173	mm	PIPE, DN 200, FLANGE CLASS, AS NZS 2280	200 mm	AS NZS 2280				
Type: BEND 45								
2		BEND 45, DN 200, RF, PN 16, AS NZS 2280	200 mm	AS NZS 2280			16	
Type: BEND 90								
4		DUCKFOOT BEND, DN 150, RF, PN 16	150 mm				16	
1		BEND 90, DN 200, RF, PN 16, AS NZS 2280	200 mm	AS NZS 2280			16	
Type: REDUCER (CONC)								
1		REDUCER (CONC), DN 150X100, PN 16, AS NZS 2280	150 mm	AS NZS 2280			16	
1		REDUCER (CONC), DN 250X200, PN 16, AS NZS 2280	250 mm	AS NZS 2280			16	
Type: REDUCER (ECC)								
1		REDUCER (ECC), DN 200X150, PN 16, AS NZS 2280	200 mm	AS NZS 2280			16	
Type:								
1		BELLMOUTH	250 mm				16	
Type: FLANGE THD								
7		FLANGE THD, RF, DN 150, PN 16, AS 4087	150 mm	AS 4087			16	
16		FLANGE THD, RF, DN 200, PN 16, AS 4087	200 mm	AS 4087			16	
Type: COUPLING								
3		COUPLING, DN 150, PN 16, PFS X RF, TYCO WATER	150 mm				16	
2		COUPLING, DN 200, PN 16, PFS X RF, TYCO WATER	200 mm				16	
Type: PIPE NIPPLE, LONG TYPE								
5		PIPE NIPPLE, LONG TYPE, 2" ND, SCH 160, TBE, 4" LG, ASTM A733	50 mm	ASTM A733	40S			

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Quantity	Unit	Description	ND	Standard	Schedule	Material	PN	Angle
Type: THREADOLET								
3		THREADOLET, 6"X2" ND, 3000 LB, BWXFPT, 13/16" LG, ASME B16.11	150 mm	ASME B16.11			3000	
2		THREADOLET, 8"X2" ND, 3000 LB, BWXFPT, 13/16" LG, ASME B16.11	200 mm	ASME B16.11			3000	

Figure 10 Bill of Materials

3.2 VIRTUAL REALITY ENVIRONMENT

Another benefit of BIM is that it provides a model that can be readily used within an immersive VR (virtual reality) environment to enhance pre-construction design review. Unity Water produced a VR model using the BIM developed for the project. The VR model was used by Unity Water to allow their stakeholders to immerse themselves into the design (wearing a VR headset). This improved understanding of the scale and layout of the equipment and plant as well as its integration with the existing operating facility prior to construction. This was key to improving stakeholder review and validation of access and integration requirements.

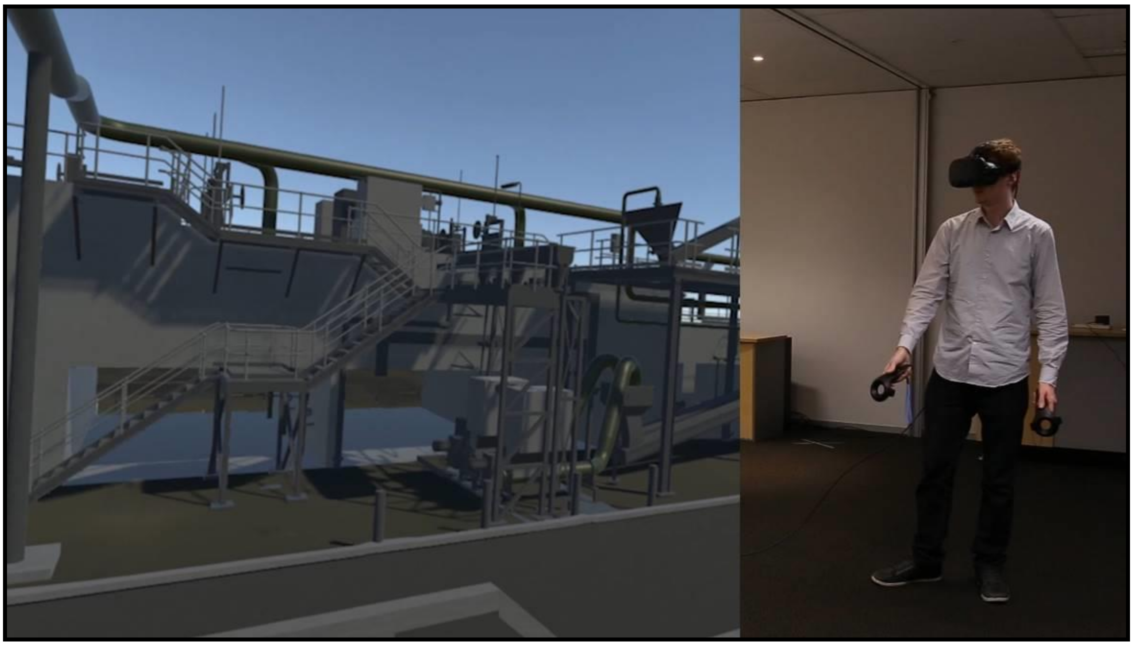

Figure 11 Virtual reality

4 LESSONS LEARNED/RECOMMENDATIONS

The implementation of BIM on this project, while beneficial in many aspects, has not been a painless process. If the reader is going to implement BIM on their project, then the following lessons should be heeded.

- Clearly define the process and asset data requirements at the start of the project including verified existing asset data and P&IDs.
- Accurate and usable survey and potholing is essential for inclusion in and verification of the BIM
- Well defined and documented engineering specifications are needed for input into BIM design software (e.g. complete piping specifications). Incomplete or inaccurate specifications are unsuitable for use within BIM plant design software.
- It's important that P&IDs are completed before 3D modelling is undertaken. If P&IDs need to change, then it is important that P&ID changes are completed and verified before model changes occur as this is the optimal workflow within the Plant design software and is necessary to maintain the integrity of the BIM.
- Have well defined software use and data/model exchange workflows
- Vendor data was often an issue. It is important to ask the following:
  - When will the design team receive it?
  - Will it be 3D and what 3D format and LOD can it be supplied in?
  - What level of asset tagging is required within a vendor model?
- A clearly defined BIM specification from the client is needed with appropriate supporting templates / content.
- Have a BEP (BIM Execution Plan) that clearly defines what is to be done, when, by whom and to what purpose. All team members need to be familiar and on-board with the intent of the BEP.
- Encourage the use of the BIM model to inform any review/decision making before making design changes or requesting drawing updates.

5 CONCLUSIONS

Adoption of a BIM has resulted in the following benefits;

- Improved design review and verification by conducting design review workshops in an accurate 3D environment
- Improved documentation accuracy by generating 2D drawing views and associated element tagging and bills of materials directly from the model
- Minimised construction costs by detecting clashes and clearance issues before construction proceeds
- Minimised O&M costs with intelligent drawings, models and databases that ease spares ordering
- Minimised O&M costs from a plant that is demonstrated to be operator friendly before it is built
- Asset data generated by the design and construction team can be readily integrated with the utility's asset management system

The adoption of BIM for the Kawana STP Upgrade Project has resulted in an improved design and review process and will result in a better finished plant. The adoption of the Unitywater asset management tagging protocol in the BIM and smart P&IDs will result in documentation that complies with the existing Asset Management Database. The 3D environment allows visualisation of the finished plant and detection of issues before they are built.

ACKNOWLEDGEMENTS

Unitywater, the owner and operator of Kawana STP.

Monadelphous, the constructor undertaking the upgrade work under a D&C contract.

REFERENCES

1. Principal's Project Requirements, Kawana STP K150 KAWSTP-D-TS-002, by Unitywater, undated.